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Femoral Neck Axis Drawing with Two Parallel Lines in Asymptomatic Adults

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Abstract

Introduction: *we are presentig and testing a method of femoral neck axis drawing with two parallel lines that do not depends of center of femoral head rotation which might be helpfull in measuring of paramethers in patients with femoral head tilt.*

Goal of this study was to present and test a method of femoral neck axis drawing using two parallel lines and to compare it with a standard femoral neck axis drawing, named colo-capital femoral neck axis, in healthy asymptomatic pearsons of both sexes.

Methods: *On the anteroposterior and lateral radiographs of the left and right hips of 78 examinee (286 hips alltogether), we have drown two femoral neck axes, one literaturs standard axis and secoond femoral neck axis drown with two parallel lines. On indexed axes we have drown, measured and compared alfa angle and offset index according with, in literature, proposed methods.*

Results: *We have found overlapping of the two drown axes in 60% on the anteroposterior hip images and in 67% on lateral hip images. The angle, marked γ, thay formed in the rest drown hips, had value 1-3°. There weren't significant diference in the data values of alfa angle and offset index drown on indexed axes (p>0,05), and also with, in the literature, accepted normal values of indexed parameters.*

Conclusion: *We have shown that using the method of two parallel lines of the medial third of the femoral neck, it is possible to draw the femoral neck axis, with the same validity as the most commonly used colo-capital axis of the femoral neck, with obvious advantage of the proposed method, since its drawing does not depend from the position of the femoral head and the position of the femoral head rotation center.*

Keywords: *femoral neck axis, drawing, two parallel lines, asimptomatic adults*

Introduction

The relationship between the head, neck and the femoral shaft is the subject of interest in orthopedic literature since the 19th century (1,2). The angle between the femoral shaft and neck in the frontal plane is known as a neck shaft angle and angle of the femoral neck and the frontal plane is known as a femoral neck anteversion. In the last decades, it is of interest to define the relationship between the femoral neck and head, and to test translation, rotation and convexity of the femoral head (3, 4, 5, 6, 7). Precise measurement of the hip radiographic parameters that define proximal femoral morphology, it is of great importance to accurate draw femorl neck axis (most often used in the literature is a line that connects femoral head rotation center with the midpoint of the line that connects the two opposite edges of the femoral neck). Drawn femoral neck axis depends on the points that belong to the inner third of the neck and to the center of the femoral head rotation. In the situations of the femoral head translation, center of the femoral head rotation center moves from the line of the femoral neck axis changing the values of the tested parameters. Murray (11) and Goodman (12) proposed methods of drawing femoral neck axis, which did not depended from the femoral head rotation center. Murray pointed out on the existence of femoral head tilt in relation to the femoral neck, that was the cause of hip arthritis, he assumed. To draw the femoral neck axis, on the anteroposterior radiographs of the hips, he connected the midpoint of the bytrochanteric line (grater and small trochanter) with the midpoint of the line that connects the upper and lower edges of the femoral neck in its narrowest part. If the drawn axis of the femoral neck passed through the center of the femoral head rotation, he considered that there was no inferior tilt of the femoral head, and if the axis passed above/belowe the center of the femoral head rotation, he considered that there would be an inferior tilt of the femoral head. The size of the femoral head tilt Murray expressed in millimeters of the distance from the femoral head rotation center to the drown femur neck axis. On cadaveric femur in his study, Goodman (12) drown the femoral neck axis that showed the existence of the so-called post-slip, or femoral head tilt, with obvious lack of the femoral head sphericity and bloomig of the femoral head- neck connection on the anterior, superior or both surfaces. Femoral neck axis drawing using two parallel lines(13,14) was used on cadaveric specimens, where axes was drown only on the anteroposterior projections of the specimens and their radiographic images. There is no data in the literature on the reliability and applicability of proposed method on the clinical material. Two parameters were used to test femoral head convexity and translation. The translational movements of the femoral head are measured using four offset parameters and their indexed relationship (6,8,9) and angle alpha that was defined by Nötzli in 2002 (10) to measure convexity of the femoral head on its connection to the neck. Its normal value on the nuclear magnetic resonance imaging of the healthy hips was 42.2 ± 2.2°. We have questioned if it is possible to draw femoral neck axis using two parallel lines on the hips radiographic images of asymptomatic adults with the same validity as the literary femoral neck axis gold standard (colo-capital axis of the femoral neck)? Based on this question we have hypothesised that it is possible to draw the femorla neck axis in adult asymptomatic pearsons using the method of two parallel lines which, in the tested parameters, is not significantly different from the colo-capital standard axis of the femoral neck.

The aim of this study was to present and test a method of femoral neck axis drawing using two parallel lines and to compare it with a standard femoral necx axis drawing so called colo-capital femoral neck axis in healthy asymptomatic pearsons of both sexes.

Material

For the purposes of this study, we have tested 115 asymptomatic examinee (66 female and 49 male), aged 33.4 years (range 19-55). Including clinical criteria in the study were: painless hip, no skipping, no blockage, no operation or any treatement of the tested hip; negative impingement test (14, 15, 16, 17) and hips movements had to be within the physiological limits (flexion 90°, internal rotation greater than 20°) (18, 19, 20, 21, 22). Including radiographic criteria in the study were: no signs of hip arthritis, neck-shaft angle in the range of 125-135 °, angle α (10) less than 50 °, offset index in the literature values of 0.80 - 1.20. Using these criteria, the number of pearsons involved in the study was reduced on 78 and the number of tested hips (anteroposterior and lateral radiographic image, left and right hip) on 286.

Method

For all tested hips two groups of radiographs were used. First: Standardised anteroposterior (AP) hip image with the patient in supine position, feet in 15 ° internal rotation, central X-ray beam directed along the body central line at half distance between the byspinal line and the pubic symphysis. Secoond: Lateral hip image-Dunn Ripstein Müller (DRM-90) (23) with the patient in supine position, 90 ° hips and knees flexion, 20 ° hip abduction, neutral feet rotation, center X-ray beam directed on the middle of the pubic symphysis. Parameters we drown and measured on radiographic images were: a) in the literature "gold standard" femoral neck axis we marked with the letter *l* (Figure 1 and Figure 2): on the narrowest part of the femoral neck inner third, AB line was drown that connects femoral neck opposite edges on the AP and DRM-90 radiographs of the hips on which midpoint M was determined. Mosse concentric circles (24) were used to draw the center of the femoral head rotation (point O) that is merged with the point M of the AB line. Drawn OM line represents the femoraln neck axis. b) femoral neck axis drown with two parallel lines (13) we marked with the letter *p* (Figure 3 and Figure 4). At the narrowest part of the inner third of the femoral neck, at 3mm or more distances from the AB line and parallel with it, CD line is drown that also connects the opposite edges of the femoral neck on the AP and DRM-90 radiographic of the hip. Midpoint of the line CD (point N), is determinated and merged with the point M, of the line AB. MN line represented the femoral neck inner third axis (line *p*). Medialy opened angle marked with Greek letter γ, were formed with a vertex at the point M, if the axes *l* and *p* were not overlapped (Figure 5). The validity of the femoral neck axis drown by two parallel lines (*p*) was tested by determining standard femoral head-neck parameters thate measure femoral head convexity, angle α (10) and femoral head translation, offset index (25, 26, 27, 28). These two parameters were measured on the both femoral neck axes (*l* and *p*), than tested and compared. Angle α data on the axis *l* were marked with α-*1* and the data of the same angle along the axis *p* with α-*p* (Figure 6 and Figure 7). Offset index data on the femoral neck axis *l* were marked with OI-*1*, and on the femoral neck axis *p* with OI-*p* (Figure 8 and Figure 9).

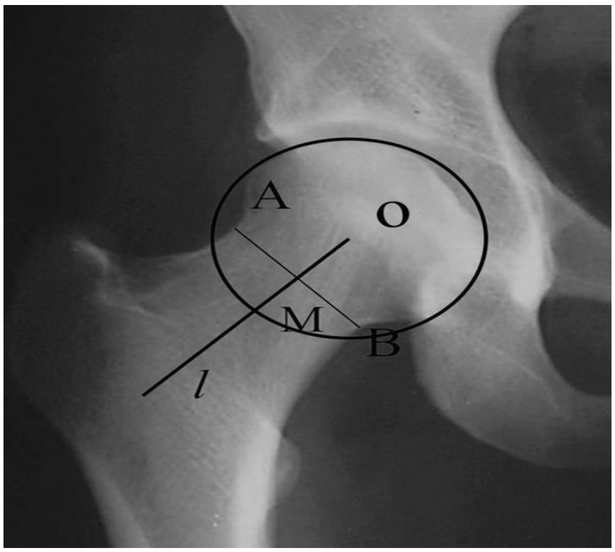

Figure 1. *Anteroposterior hip image shows femoral neck axis l ''gold standard'' femoral neck axis l , drown through two points, femoral neck point M and center of the femoral head rotation O.*

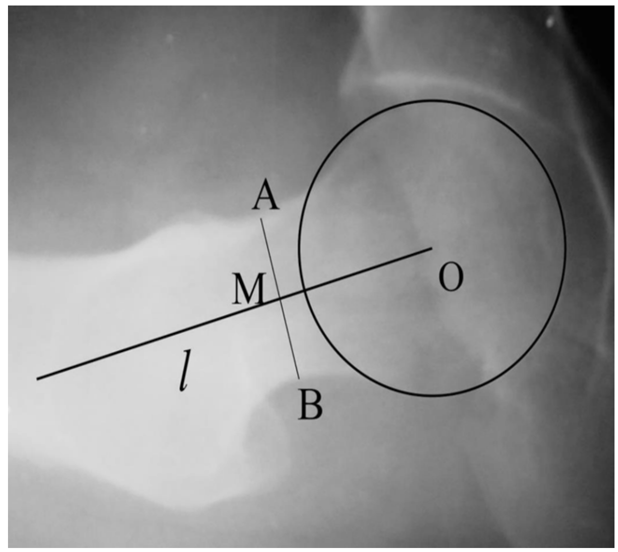

Figure 2. *Dunn-Ripstein-Müller radiograph hip image shows ''gold standard'' femoral neck axis l , drown through two points, femoral neck point M and center of the femoral head rotation O.*

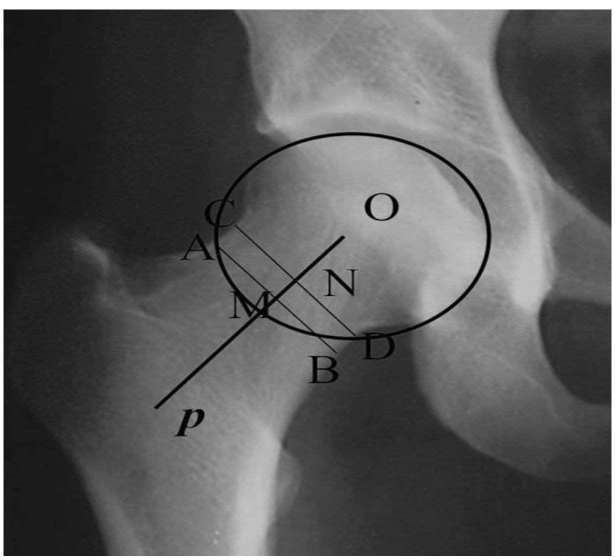

Figure 3. *Anteroposterior hip image shows femoral neck axis p, drown with two paraller lines*

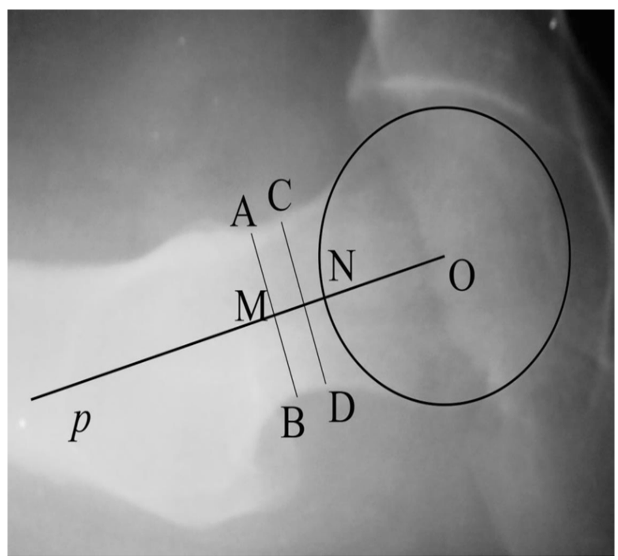

Figure 4. *Dunn-Ripstein-Müller radiograph hip image shows femoral neck axis p, drown with two paraller lines*

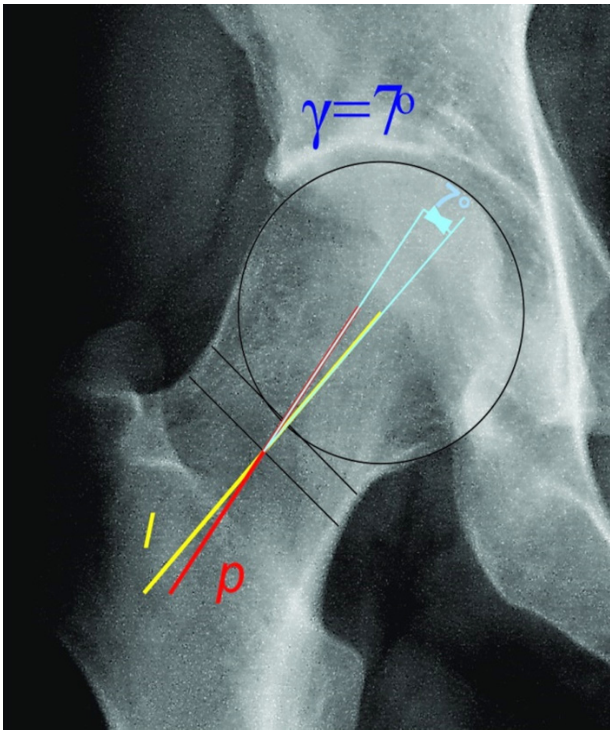

Figure 5. *Anteroposterior hip image shows gama angle measured on the femoral neck axes l and p that are not overlapped*

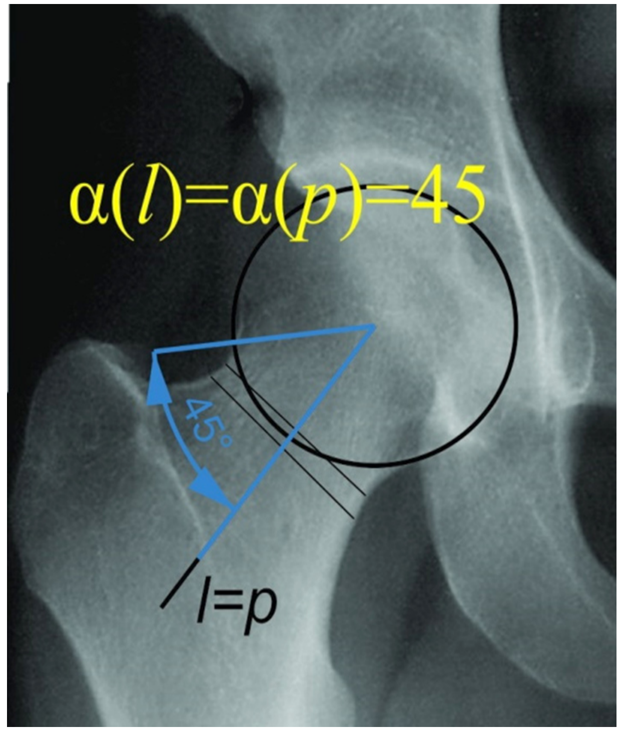

Figure 6. *Anteroposterior hip image shows alfa angle measured on the overlapped femoral neck axes l and p*

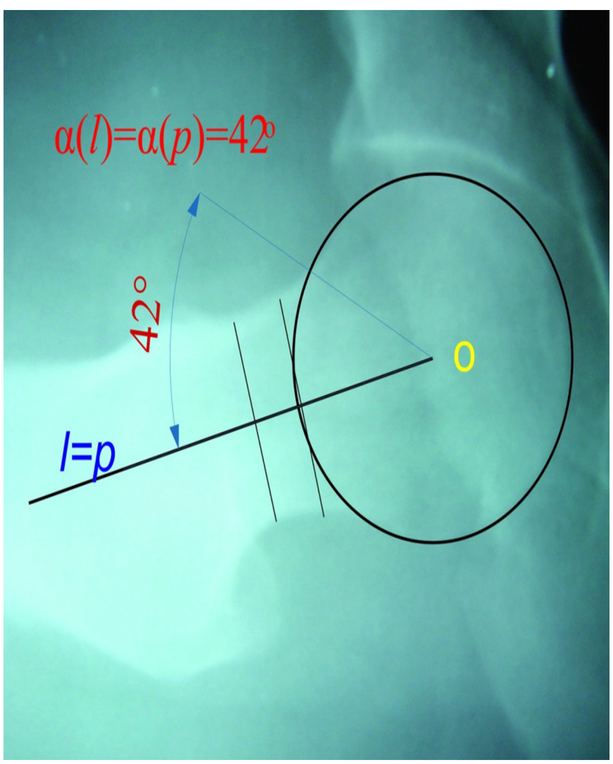

Figure 7. *Dunn-Ripstein-Müller radiograph hip image shows alfa ange measured on the overlaped femoral neck axes l and p*

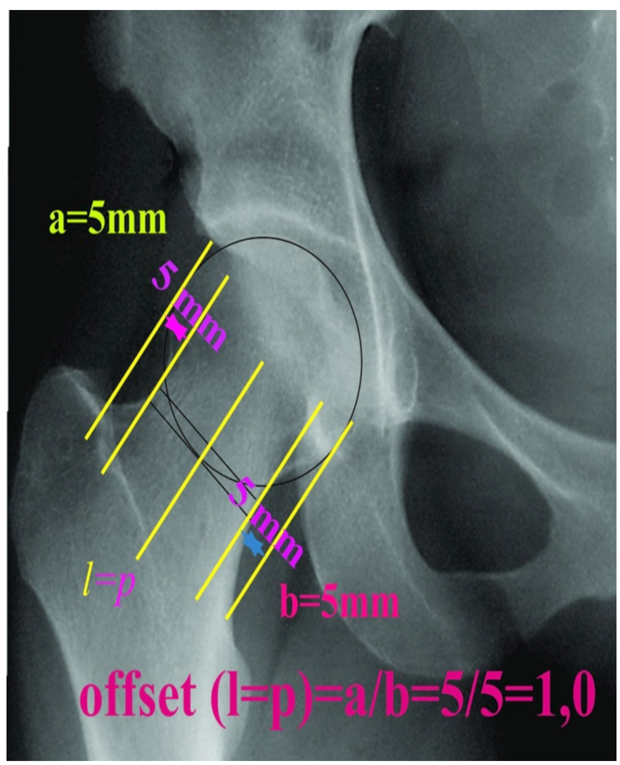

Figure 8. *Anteroposterior hip image shows offset index measured on the overlapped femoral neck axes l and p*

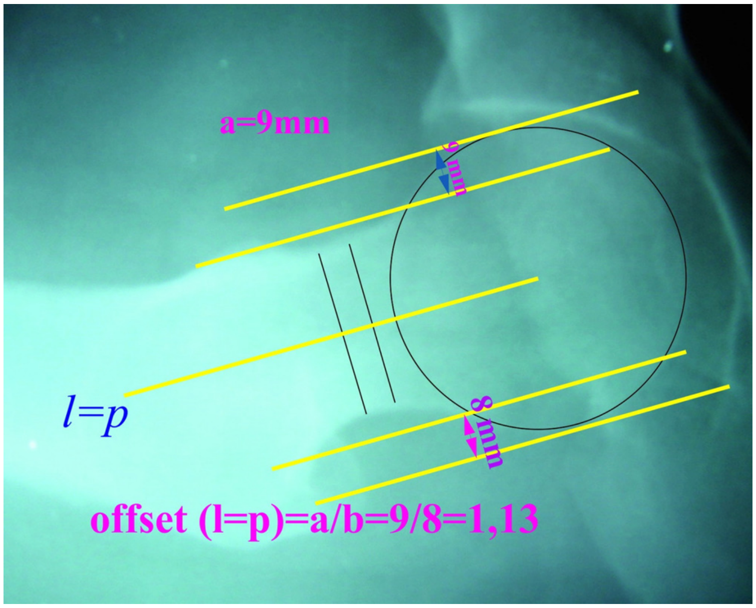

Figure 9. *Dunn-Ripstein-Müller radiograph hip image shows offset index measured on the overlaped femoral neck axes l and p*

Statistical Method

All data of the tested parameters were statistically processed, tabulated and graphically presented. Kolmogorov-Smirnoff test was used to check the distribution normality of the measured data. The data distribution frequency was tested with the χ^2 test and the Yates test correction was used when the data rate was less than 5. Two tailed t-test for paired data were used to test the significance of the difference of the arithmetic mean. Analysis of variance was used for intergroup and between group data variation and was checked by Fischer's least significant difference. Power of the test was set on 80% with a possible beta error of 0.20, and the significance level of the test with a possible error in conclusion of less than 5%, so that the zero hypothesis is discarded if the p value is less than 0.05. All obtained data were analyzed in the computer program for processing statistical data "SPSS 20 for Windows". Graphic processing of radiographic images was done in the Corell Draw 11 graphic processing program. Tables are constructed in Microsoft Word 2010.

Results

We have tested the hips of 115 examinee. In 27 examinee both hips did not fulfell, at least, one radiographic inclusion criteria and in 10 examinee, at least one hip did not meet inclusion criteria (3 right and 7 left hips). This study involved 78 examinee and analyzed 286 AP (142 hips) and DRM-90 (144 hips) radiographs of the hips in 41 female and 37 male, aged 32.4 ($\bar{x}$ = 32.4 ± 15.7). On the AP radiographic hip images femoral neck axis *l* and *p* were overlaped in 85 (60%) of tested hips; in 39 (27%) hips these two axes built the 1 ° γ angle, in 17 (12%) hips they built 2^0 γ angle and in one hip (0,7%) they built γ angle of 3^0. On the DRM-90 radiographic hip images, femoral neck axes *l* and *p* overlaped in 96 (67%) from 144 test hips, in 27 (19%) hips they built 1° γ angle, in 19 (13%) hips they built 2^0 γ angle and in two (1.39%) hips they built 3^0 γ angle. Interval of $35^0 < \alpha < 50^0$ were used to be upper and lower normal border of the α-angle for AP hip immages and for the DRM-90 radiographic images it was interval $30^0 < \alpha < 45^0$. On the AP radiographic images, α-*l* and α-*p* angle were approximately equal (32.18 ° ± <α (*l, p*) <42.88^0 ± 2.65) (Table 1) and no significant diference were found (p> 0.05) compared to the values of the α-angle listed in the literature (Nötzli: 42^0 ± x2,2^0). We did not found any significant diference between α-*l* and α-*p* angle of the right and left hips, and also between alfa angles of bot axes (p=0.874) on the DRM-90 radiographic hip images (Table 2). Femoral head translation index (offset index) on the AP and DRM-90 radiographic hips images was set in the literaly normal range: 0.80 <OI (*l,p*) <1.20. Our data has shown that the offset index of the left and right hip on both lines (*l* and *p*) on the AP radiographic images but on the DRM-90 radiographic images left and righ hips on axis *l* (p = 0.004) and on the axis *p* (p = 0.009) was significantly diferent giving significant intergroup variation (f=15.876, p=0.0006), but offset index *l* and offset index *p* did not differ significantly (p=0.290). We assumed that it was due to stronger study inclusion criteria that has given narrower offset index interval (0.978 <OI *l* (right hip + left hip), *p* (right hip + left hip) <1.16) than the literatures border values. For both femoral neck axes offset index border values were: 0.902 <OI *l* (right hip + left hip), *p* (right hip + left hip) <1.082.

Table 1. *Parameters value measured on standardized anteroposterior hip images*

	Offset index (l)			Offset index (p)			α-angle (*l*)			α-angle (*p*)º			γº- angle	
Right Left hip	R	L	R+L	R	L	R+L	R	L	R+L	R	L	R+L	R	L
number	74	68	142	74	68	142	74	68	142	74	68	142	74	68
$\overline{x}$	0.99	1.011	1.05	0.999	1.01	1.05	42.5	42.8	42.6	42.5	42.4	42.45	0.49	0.6
S.D.	0.05	0.055	0.07	0.049	0.05	0.0495	3.29	3.24	3.26	3.29	3.23	3.26	0.73	0.7
S.E.	0.01	0.007	0.08	0.006	0.01	0.08	0.38	0.03	0.20	0.38	0.03	0.20	0.01	0.01
CI	0.01	0.001	0.05	0.011	0.001	0.06	0.76	0.77	0.76	0.76	0.77	0.76	0.17	0.2
p<0,05	**0.287**			**0.348**			**0.541**			**0.472**			**0.338**	
	Offset index(*l*)≈ Offset index(*p*), p=0.488						**α (l)º≈ α(p)º, p=0.699**							
ANOVA		f=2.75, p=0.045						f=0.129, p=0.902						

Offset index(*l*): index values measured on femoral neck axis *l*; Offset index(*p*), index values measured on femoral neck axis *p*; α(*l* i *p*), alfa angle values measured on femoral neck axes *l* and *p*; γ, gama angle values opened medialy made by crossection of femoral neck axes *l* and *p*; $\overline{x}$-arithmetic mean; S.D.standard deviation; S.E.standard error of standard deviation; CI - 95% confidence interval.

Table 2. *Parameters values on lateral Dunn-Ripstein Müller radiographic hip images*

	Offset index (*l*)			Offset index (*p*)			α-angle (*l*)			α-angle (*p*)			γ - angle	
	R	L	R+L	R	L	R+L	R	L	R+L	R	L	R+L	R	L
number ispit.	73	71	144	73	71	144	73	71	144	73	71	144	73	71
$\overline{x}$	1.01	0.98	0.99	1.01	0.98	0.995	37.7	37.5	37.6	37.7	37.4	37.55	0.41	0.61
S.D.	0.04	0.03	0.04	0.04	0.04	0.04	2.54	2.81	2.675	2.54	2.80	2.67	0.70	0.819
S.E.	0.05	0.00	0.003	0.05	0.01	0.03	0.30	0.33	0.315	0.29	0.32	0.31	0.08	0.10
CI-95	0.01	0.01	0.01	0.01	0.01	0.01	0.48	0.53	0.505	0.48	0.53	0.505	0.16	0.19
p<0,05	**0.004**			**0.009**			**0.631**			**0.632**			**0.129**	
	Offset I (*l*) ≈ Offset I (*p*), p=0.290						**α (l)≈ α (p), p=0.874**							
ANOVA	**f=15.876, p=0.0006**						**f=0.226, p=0.878**							

Offset index(*l*): index values measured on femoral neck axis l; Offset index(*p*), index values measured on femoral neck axis p; α(*l* and *p*), alfa angle values measured on femoral neck axes *l* and *p*; γ, gama angle values opened medialy made by crossection of femoral neck axes *l* and *p*; $\overline{x}$-arithmetic mean; S.D.standard deviation; S.E.standard error of standard deviation; CI - 95% confidence interval.

Discussion

Murray (10), Goodmann (11), Soutwick (29), Bonneau (30), were drowing femoral neck axis, but thay did not use the center of the femoral head rotation as a referent point to belong that axis . Murray used only AP radiographic hip images on which plotting of the greater trochanter apex was often quite difficult. Goodman did not accurately described hes method of drowing the femoral neck axis on the pictures and schemes of cadaveric specimens, nor the method of quantifying he observed femoral head translation in relation to the neck. Sautwick method were used in childhood, only before closure of the proximal femoral growth plate and could not be used in adults. Bonneau method to drow femoral neck axis in the three dimensional reconstruction of the proximal femur is complex and highly demanded. Drowing of the femoral neck inner third axis on radiographs of the hips using two parallel lines(13,) were encountered in only one clinical stady (14). Femoral neck axes overlapping (*l* and *p*), α-angle, and offset index were radiographic parameters we measured and statistically tested (8, 10, 13, 14, 25, 29, 30). It was of interest to test the applicability method of drowing femoral neck axis using two parallel lines (13, 14) on both AP and DRM-90 radiographic images of asymptomatic hips and to compare this method with the most commonly used colo-capital femoral neck axis drowing method (8, 9, 10, 19, 20, 26, 29, 30). Colo-capital femoral neck axis *l* were used with an untested assumption that the head of the femur is, in healthy and in the pathologically altered hips, ideally centered on the neck of the femur and that the center of femoral head rotation lies in the femoral neck axis.

On the AP radiographic hip images femoral neck axes *l* and *p* were overlapped in 60% of hips and in the remaining 40% these two axes built an angle γ of 1-3 °, opened medially. On the DRM-90 radiographic hip images axes *l* and *p* overlaped in 67% of the hips, and in the remaining 33% of hips, these two axes built the angle γ of 1-3 °. We assumed that the angle γ was produced due to error in drowing two parallel lines, or this angle might be produced by minimal translation of the femoral head, in the group of “ideally healthy” asymptomatic subjects. Murray measured more than 1mm distance between femoral neck axis and centar of femoral head rotation in arthrotic hips with obvious vemoral head inferior tilt. Bonneau has found 0.4-5.5mm deviation of the femoral head rotation center from the drown femoral neck axis, on the 3D reconstruction of the cadaveric femur (30). This unusual relationship of *l* and *p* femoral neck axis in group of healthy adults, requires further testing angle γ on the clinical material in patients with femoral head tilt and cam pathological findings on the femoral head and neck junction. Resulting data for α-angle and offset index measured ond the femoral neck axes, *l* and *p* ,were not significantly different among the drowed axes and compared with, in the literature, accepted values. This finding encourages us to assume that the femoral neck axis *p* drown by two parallel lines could be used, with the same validity as the femoral neck axis *l* in the asymptomatic adult examinee. Proposed femoral neck axis *p* is defined by two parallel lines that belong to the medial third of the femoral neck, while the axis *l* is definee by two points, one of which is the center of the femoral head rotation. This is the advantage of the *p* axis that is independent from the center of femoral head rotation and more precisely determines femoral neck axis inner third that is directly connected to the femoral head and in relation to which the femoral head translation occurs. This method is easily applied to AP and lateral radiographic hip images and requires further clinical research in patients with femoral head translation and in patients with femoral head-neck junction cam-osteochondral pathological supstrat who are potential candidat for preventiv hip surgery. Disadvantage of the proposed method is that the axis *p* does not represent the axis of the entire neck of the femur whose anatomy is very complex (30), but the axis of the medial third of the femoral neck (13, 14).

Conclusion

Using the method of two parallel lines on the medial third of the femoral neck, it is possible to draw the femoral neck axis, with same validity as the most commonly used colo-capital axis of the femoral neck, with obvious advantage of the proposed method, since its drawing does not depend from the position of the femoral head and the position of the femoral head rotation center.

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