A Radiographic Study on the Effect of Menopause on Proximal Femoral Angle Parameters

Menopozun Proksimal Femur Açı Parametrelerine Etkisi Üzerine Radyografik Bir Çalışma

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Abstract

Aim: In this study we aimed to investigate the effects of menopause on the femoral inclination angle (FIA) and femoral Alsberg angle (FAA) parameters in pelvic anteroposterior radiography.

Methods: The FIA and FAA data were retrospectively reviewed in a total of 133 female subjects with natural menopause (the menopause group) and regular menstrual cycles (the control group) who were admitted to our orthopedics and traumatology clinic and underwent anteroposterior pelvic X-ray examination between October 2019 and June 2020.

Results: There was a statistically significant difference between the menopause and control groups in terms of age ($p<0.001$), right-side FAA values ($p<0.001$), and right- and left-side FIA values ($p<0.001$ and $p=0.026$, respectively). Only the left-side FAA values did not differ significantly between the groups ($p=0.446$). All parameter measurements were higher in the menopause group.

Conclusion: The finding that the FIA and FAA values were higher in the menopause group could be attributed to the fact that menopause occurs in the later decades of life and brings along changes in lifestyle. We recommend that the presence of menopause as a factor that can affect bone structure and metabolism in various ways should also be considered in studies on bone morphometry.

Keywords: Alsberg angle; inclination angle; menopausal status; proximal femur; radiography

Öz

Amaç: Bu çalışmada menopozun pelvik anteroposteriyor radyografi parametrelerinden femur inklinasyon açısı (FİA) ve femur Alsberg açısı (FAA) üzerindeki etkisini incelemek amaçlanmıştır.

Yöntem: Ekim 2019—Haziran 2020 döneminde ortopedi ve travmatoloji kliniğimize gelen ve anteroposteriyor pelvik röntgeni çekilen menopozlu (menopoz grubu) ve düzenli menstrüel sikluslu (kontrol grubu) toplam 133 kadına ait FİA ve FAA verileri retrospektif olarak incelendi.

Bulgular: Menopoz ve kontrol grupları arasında yaş ($p<0,001$), sağ FAA değeri ($p<0,001$) ve de sağ ve sol FİA değerleri (sırasıyla $p<0,001$ ve $p=0,026$) bakımından istatistiksel olarak anlamlı farklılık vardı. Sadece sol FAA değerleri iki grup arasında anlamlı farklılık göstermedi ($p=0,446$). Tüm parametre ölçümleri menopoz grubunda daha yüksekti.

Sonuç: Menopozlu kadınlarda FİA ve FAA değerlerinin daha yüksek olması menopozun ileriki yaşlarda ortaya çıkmasına ve yaşam tarzında değişikliklere neden olmasına bağlanabilir. Kemik morfometrisine dair çalışmalarda kemik yapı ve metabolizmasını çeşitli şekillerde etkileyebilecek olan menopoz varlığının da dikkate alınmasını tavsiye etmekteyiz.

Anahtar Sözcükler: Alsberg açısı; inklinasyon açısı; menopoz durumu; proksimal femur; radyografi

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INTRODUCTION

Menopause, a natural part of the aging process, is described as the lack of oocytes in the ovaries and manifests clinically when a woman has not menstruated for one year (1,2). The main physiological changes in the menopausal transition are hormonal, with decreased levels of estrogen and increased levels of circulating androgen (2), which lead to various lipid metabolic disorders that can affect the post-menopausal lipid profile and cause changes in the body composition (2,3).

Previous studies on the menopausal changes in body composition mainly reported increased abdominal visceral adiposity with general adiposity (4,5). Abdominal visceral fat accumulation is increased by androgen hormones while ovarian estrogens (E2) increase the storage of peripheral fat in gluteal and femoral subcutaneous regions (6). Besides menopause, aging is associated with a decline in the basal metabolic rate and a decrease in lean body mass, bone mineral density, and physical activity (7–9). Studies investigating the menopause- and aging-related changes of bone structure and metabolism have focused on the risk of hip fracture in postmenopausal osteoporosis due to decreased bone mineral density (10–12). However, it appears that only a limited number of studies have addressed the relationship between menopause and morphometry of the proximal femur, which is an important component of the hip joint (13–15). Thus, in this study we aimed to radiographically evaluate the effects of menopause on femoral inclination angle (FIA) and femoral Alsberg angle (FAA) as two important parameters in proximal femur morphometry.

MATERIALS AND METHODS

Sample selection

The FIA and FAA data were retrospectively reviewed in female subjects aged between 20 and 68 years who were admitted to the Orthopedics and Traumatology Clinic of the Bolu Abant İzzet Baysal University Medical Faculty and underwent anteroposterior (AP) pelvic X-ray examination between October 2019 and June 2020. The subjects were divided into groups: those with natural menopause (the menopause group) and those with regular menstrual cycles (the control group). We excluded women with any pathology that could affect the radiographic results, women with radiographs not taken in appropriate position, and those with a history of inflammatory arthritis, trauma, joint surgery, and congenital skeletal system diseases. Menopausal status was determined by asking questions to the women.

Parameter definition and measurement

The FIA and FAA were assessed bilaterally in the AP radiographs used. The measurements were performed three times by two experienced researchers, and the mean values were calculated and recorded. In addition to these measurements, the age and menopausal status data of each subject were also recorded in an Excel sheet.

***FIA*:** The inward angle at the intersection of the anatomical axis of the femur and the axis of the femoral neck (Figure 1).

***FAA*:** The inward angle at the intersection of the anatomical axis of the femur and the pineal line at the femoral neck and head intersection (13) (Figure 1).

***Pelvic X-ray technique*:** Digital AP view X-rays were taken according to a standard protocol, with the patellae facing vertically if allowed by the internal rotation of the hip. The focus of the X-ray source was the pubic symphysis. The distance between the source and subject was 900 to 1200 mm (16).

Statistical analysis

All statistical analyses were performed using the IBM SPSS (v. 21). Descriptive statistics were presented as mean (±standard deviation) for each variable. Normality of the data was checked using the Kolmogorov–Smirnov test and graphical methods. Intergroup differences were analyzed with significance test of difference between two means. The Pearson correlation coefficient was used to analyze the relationship between variables. Linear regression analysis was used for adjustment for age. $p<0.05$ was considered statistically significant.

Study ethics

The study protocol was approved by the Clinical Research Ethics Board of the Bolu Abant İzzet Baysal

Table 1. Descriptive statistics (N=133)

	Mean	SD	Median	Minimum	Maximum
Right-side FIA	136.37°	10.46°	135°	100.97°	159.52°
Right-side FAA	45.50°	8.72°	44.73°	22.0°	69.01°
Left-side FIA	132.19°	8.59°	131.85°	92.38°	155.02°
Left-side FAA	40.84°	7.64°	40.84°	21.40°	65.79°

FAA: femoral Alsberg angle; FIA: femoral inclination angle; SD: standard deviation

Table 2. The mean measurements in the groups

	Menopausal status		
	No (n=66)	**Yes (n=67)**	***p***
Age (years)	31.71±6.76°	55.55±5.72°	*<0.001*
Right-side FIA	131.03±8.99°	141.62±9.08°	*<0.001*
Right-side FAA	42.69±8.21°	48.27±8.37°	*<0.001*
Left-side FIA	130.53±9.47°	133.83±7.35°	*0.026*
Left-side FAA	40.33±7.91°	41.34±7.40°	0.446

FAA: femoral Alsberg angle; FIA: femoral inclination angle; SD: standard deviation

Table 3. The FIA–FAA correlation analysis

		FAA			
		Right-side		**Left-side**	
		r	***p***	**r**	***p***
FIA	**Right-side**	0.737	*<0.001*		
	Left-side			0.692	*<0.001*

FAA: femoral Alsberg angle; FIA: femoral inclination angle

Table 4. The univariate and multiple linear regression analysis adjusted for age

	Univariate			Age-adjusted		
	b	**t**	***p***	**b**	**t**	***p***
Right-side						
FAA	0.883 (0.743–1.023)	12.466	*<0.001*	0.779 (0.647–0.912)	11.621	*<0.001*
Left-side						
FAA	0.778 (0.638–0.918)	10.972	*<0.001*	0.773 (0.663–0.912)	10.944	*<0.001*

b: regression coefficient; FAA: femoral Alsberg angle; t: t-statistical value
FIA was taken as the dependent variable.

University (2020/77). The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

The study included a total of 133 subjects with a mean age of 43.72±13.49 years. Of these, 67 were menopausal women and 66 were controls who met the inclusion criteria. Descriptive statistics for the FIA and FAA parameters are presented in Table 1.

There was a statistically significant difference between the menopause and control groups in terms of age (p<0.001), with the mean age being higher in the menopause group (55.55±5.72 years) than in the control group (31.71±6.76 years).

Similarly, a significant difference was found between the two groups in terms of right-side FIA

(p<0.001), left-side FIA (p=0.026), and right-side FAA (p<0.001). Although left-side FAA values were higher in the menopause group, the difference was not significant (p=0.446) (Table 2).

There were a highly positive significant correlation between the right-side FIA and right-side FAA values and a moderate positive significant correlation between the left-side FIA and right-side FAA values (Table 3). After adjustment for age (Table 4), the correlations between the right-side FAA and right-side FIA values and between the left-side FAA and left-side FIA values were found to be significant (p<0.001 for each comparison).

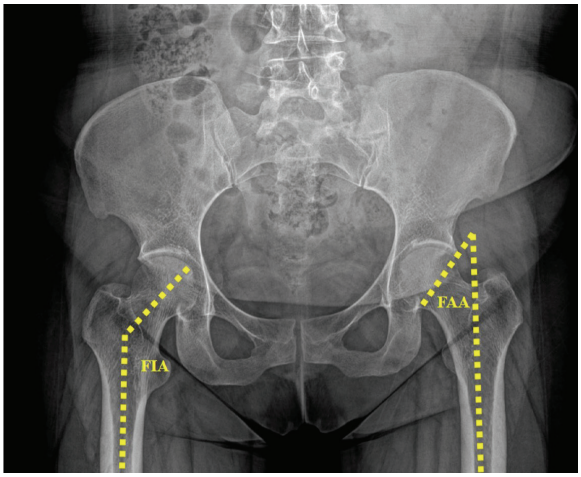

Figure 1. The FIA and FAA measurement methods

DISCUSSION AND CONCLUSION

E2 (17β-estradiol) has an effect on osteoblasts, and the level of circulating E2 decreases after menopause (17,18). Knowledge about the effects of menopause on the morphometric structure of bones will contribute to our understanding of the dynamic interaction of factors affecting bone structure and metabolism, on which the literature contains only limited data (13–15,19). A study on the relationship between proximal femur geometry and hip fracture risk investigated the parameters of hip axial length, femoral length (FL) and femoral neck width (FNW) and reported an increased FNW/FL ratio in the fracture group (20). Another study investigated the change in FNW as a bone loss marker in menopausal transition and found that FNW increased during the transition to menopause (21). A study on postmenopausal women with a mean age of 56.7±5.4 years reported a mean FIA measurement of 123.9±5.4° and concluded that FIA was effective in predicting the risk of hip fracture (22).

In the present study, we found a significant difference between the menopause and control groups in terms of right-side FIA, left-side FIA, and right-side FAA values. When compared with the values reported by Gnudi S et al. (22), our FIA measurements were found to be higher. We believe that this might have been due to ethnicity-related differences, although the mean ages of the subjects in the two studies were similar. A study where menopausal status was considered reported a mean right-side FIA of 143.87±7.33°, left-side FIA of 134.73±7.87°, right-side FAA of 50.60±8.24°, and left-side FAA of 43.35±8.82° (13) and, although close, our measurements were lower than these figures. We attribute this to possible differences in menopausal years and factors other than presence of menopause that could affect bone metabolism. A study (23) on women with advanced age whose menopausal status was not stated reported a mean right-side FIA of 125.8° (120.9°–132.9°) and left-side FIA of 125.7° (122.9°–134.6°), which are lower than our measurements, possibly due to age differences between the samples in the two studies despite their similarity in ethnicity.

Although we found a significant difference between our menopause and control groups in terms of FIA and FAA values, no such difference was reported in the previously cited study (13) that compared groups of surgical and natural menopause. The fact that we compared menopausal and non-menopausal subjects in our study could offer an explanation based on the menopause-related difference of E2 levels. The finding of no significant difference in E2 levels is an expected result when groups of surgical (where the ovaries are removed) and natural (where oocytes are naturally lost) menopause are compared. The level of E2 can affect values of bone morphometry as E2 has been reported to play an important role in bone formation and remodeling, helping the prevention of bone loss (24). A lack of E2 leads to deteriorated synchronization and imbalance in the activity of osteoclasts and osteoblasts, which result in increased bone loss and then osteoporosis in postmenopausal women (25,26).

Finally, the limitations of the present study includes primarily the retrospective design. The magnification coefficient, which is important in radiography, could not be calculated, limiting the data to those on the two angle parameters. However, studies should also include analyses of bilateral femoral asymmetry, leg dominance, blood hormone levels, and body composition.

To our knowledge, there has been no study investigating the relationship between E2 and bone morphometry values in comparison by menopausal status. In our study, we observed higher FIA and FAA values in menopausal women. We believe that aging and menopause-related differences in E2 levels could have caused the changes in the morphometric structure of the femur. Accordingly, we recommend that menopausal status, sex hormone levels, and body composition changes should also be considered in future studies on bone morphometry.

Conflict-of-Interest and Financial Disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

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REFERENCES

1. Nusrat N, Nishat Z, Gulfareen H, Aftab M, Asia N. Knowledge, attitude and experience of menopause. J Ayub Med Coll Abbottabad. 2008;20(1):56–9.
2. Ko SH, Kim HS. Menopause-associated lipid metabolic disorders and foods beneficial for postmenopausal women. Nutrients. 2020;12(1):202.
3. Marchand GB, Carreau AM, Weisnagel SJ, Bergeron J, Labrie F, Lemieux S, et al. Increased body fat mass explains the positive association between circulating estradiol and insulin resistance in postmenopausal women. Am J Physiol Endocrinol Metab. 2018;314(5):E448–56.
4. Wildman RP, Tepper PG, Crawford S, Finkelstein JS, Sutton-Tyrrell K, Thurston RC, et al. Do changes in sex steroid hormones precede or follow increases in body weight during the menopause transition? Results from the study of women's health across the nation. J Clin Endocrinol Metab. 2012;97(9):E1695–704.
5. Liedtke S, Schmidt ME, Vrieling A, Lukanova A, Becker S, Kaaks R, et al. Postmenopausal sex hormones in relation to body fat distribution. Obesity. 2012;20(5):1088–95.
6. Stefanska A, Bergmann K, Sypniewska G. Metabolic syndrome and menopause: pathophysiology, clinical and diagnostic significance. Adv Clin Chem. 2015;72:1–75.
7. Lazzer S, Bedogni G, Lafortuna CL, Marazzi N, Busti C, Galli R, et al. Relationship between basal metabolic rate, gender, age, and body composition in 8,780 white obese subjects. Obesity. 2010;18(1):71–8.
8. Dubé MC, Lemieux S, Piché ME, Corneau L, Bergeron J, Riou ME, et al. The contribution of visceral adiposity and mid-thigh fat-rich muscle to the metabolic profile in postmenopausal women. Obesity. 2011;19(5):953–9.
9. Wee J, Sng BYJ, Shen L, Lim CT, Singh G, De SD. The relationship between body mass index and physical activity levels in relation to bone mineral density in premenopausal and postmenopausal women. Arch Osteoporos. 2013;8(1):1–8.
10. Sipilä S, Törmäkangas T, Sillanpää E, Aukee P, Kujala UM, Kovanen V, et al. Muscle and bone mass in middle-aged women: role of menopausal status and physical activity. J Cachexia Sarcopenia Muscle. 2020;11(3):698–709.
11. Barron RL, Oster G, Grauer A, Crittenden DB, Weycker D. Determinants of imminent fracture risk in postmenopausal women with osteoporosis. Osteoporos Int. 2020;31(11):2103–11.
12. Zhuang HF, Wang PW, Li YZ, Lin JK, Yao XD, Xu H. Analysis of related factors of brittle hip fracture in postmenopausal women with osteoporosis. Orthop Surg. 2020;12(1):194–8.
13. Sertel Meyvaci S, Bamaç B, Duran B, Çolak T, Memişoğlu K. Effect of surgical and natural menopause on proximal femur morphometry in obese women. Ann Anat. 2020;227:151416.
14. Lee DH, Jung KY, Hong AR, Kim JH, Kim KM, Shin CS, et al. Femoral geometry, bone mineral density, and the risk of hip fracture in premenopausal women: a case control study. BMC Musculoskelet Disord. 2016;17(1):1–6.
15. Gnudi S, Sitta E, Fiumi N. Bone density and geometry in assessing hip fracture risk in postmenopausal women. Br J Radiol. 2007;80:893–7.
16. Heep H, Xu J, Löchteken C, Wedemeyer C. A simple and convenient method guide to determine the magnification of digital X-rays for preoperative planning in total hip arthroplasty. Orthop Rev. 2012;4(1):e12.

17. Cervellati C, Bergamini CM. Oxidative damage and the pathogenesis of menopause related disturbances and diseases. Clin Chem Lab Med. 2016;54(5):739–53.
18. Kisakol G, Kaya A, Gonen S, Tunc R. Bone and calcium metabolism in subclinical autoimmune hyperthyroidism and hypothyroidism. Endocr J. 2003;50(6):657–61.
19. Kim KM, Brown JK, Kim KJ, Choi HS, Kim HN, Rhee Y, et al. Differences in femoral neck geometry associated with age and ethnicity. Osteoporos Int. 2011;22:2165–74.
20. Dinçel VE, Şengelen M, Sepici V, Çavuşoğlu T, Sepici B. The association of proximal femur geometry with hip fracture risk. Clin Anat. 2008;21:575–80.
21. Shieh A, Ishii S, Greendale GA, Cauley JA, Karvonen-Gutierrez C, Karlamangla AS. A bone resorption marker as predictor of rate of change in femoral neck size and strength during the menopause transition. Osteoporos Int. 2019;30(12):2449–57.
22. Gnudi S, Sitta E, Pignotti E. Prediction of incident hip fracture by femoral neck bone mineral density and neck-shaft angle: a 5-year longitudinal study in post-menopausal females. Br J Radiol. 2012;85:467–73.
23. Farinelli L, Baldini M, Bucci A, Ulisse S, Carle F, Gigante A. Axial and rotational alignment of lower limb in a Caucasian aged non-arthritic cohort. Eur J Orthop Surg Traumatol. 2021;31(2):221–8.
24. Costa SMB, Feltran GS, Namba V, Silva TM, Hallur RLS, Saraiva PP, et al. Infraphysiological 17β-estradiol (E2) concentration compromises osteoblast differentiation through Src stimulation of cell proliferation and ECM remodeling stimulus. Mol Cell Endocrinol. 2020;518:111027.
25. Nicks KM, Perrien DS, Akel NS, Suva LJ, Gaddy D. Regulation of osteoblastogenesis and osteoclastogenesis by the other reproductive hormones, activin and inhibin. Mol Cell Endocrinol. 2009;310(1–2):11–20.
26. Weitzmann MN, Pacifici R. Estrogen deficiency and bone loss: an inflammatory tale. J Clin Invest. 2006;116(5):1186–94.