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ORIGINAL ARTICLE

Relationship of Age, Body Mass Index, Bone Density, and Menopause Duration with Alveolar Bone Resorption in Postmenopausal Women

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Abstract

Objective: To analyze the relationship between age, body mass index (BMI), bone mineral density (BMD), and alveolar bone resorption with menopause duration in postmenopausal women. **Material and Methods:** A cross-sectional study was developed involving 59 subjects, aged 45 to 80 years and categorized the duration of menopause as ≤5 years and >5 years. Body mass index measurement and menopause duration were collected. Bone loss seen on radiography was measured by drawing a vertical line from the cementoenamel in the distal part of the 36 teeth and the mesial portion of 46 teeth to the base of the bone marked by the lamina dura intact. Categorical determinations of age, BMI, BMD, and alveolar bone resorption were based on receiver operating characteristic (ROC) curves. Were used Pearson correlation and Spearman correlation tests with the significance level set at 5%. **Results:** The majority of subjects (54.2%) with menopause duration >5 years were aged >54.5 years, most had BMI >24.2 kg/m² (39%), had bone resorption >2.95 mm (52.5%), and had bone density ≤73.89 (49.2%). Pearson and Spearman correlation tests showed no significant correlation between age, BMI, bone density, and alveolar bone resorption ($p>0.05$). **Conclusion:** The longer the duration of menopause showed a tendency for lower bone density and higher age, BMI, and bone resorption.

Keywords: Menopause; Bone Density; Body Weights and Measures.

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Introduction

Menopause is a phase of a woman's natural life that signifies the end of the menstrual cycle. It is diagnosed after a woman has not had a menstrual period for 12 months. The average natural menopause occurs at age 51.4 years in developed countries such as the United States and the U.K. but generally occurs between the ages of 40 and 58 years [1].

A woman's reproductive capacity stops at the time of menopause. The ovaries no longer have follicles and their function, as a steroidogenic endocrine organ does not work anymore. Many women experience symptoms and complaints due to these hormonal changes. Although it does not cause death, menopause can decrease quality of life and lead to degenerative diseases especially bone loss or osteoporosis [2].

Osteoporosis is characterized by bone mineral density (BMD), thus increasing bone fragility and fracture risk. Postmenopausal osteoporosis results from the estradiol hormone in the follicle. Estradiol is a type of estrogen that assists osteoblasts, suppresses cytokines, and inhibits osteoclast activity. Estradiol decreases during menopause; therefore, its work is replaced by another type of estrogen that can be produced by adipose tissue. But the mechanism of action of estrone is not like estradiol (ratio of estradiol:estrone = 10:5). The longer the duration of menopause, the more estradiol function decreases, which causes osteoclasts to become active in bone resorption [3].

Estrogen is not only produced by the ovaries but also in the adrenal glands and fat tissues (adipose tissue). Fatty tissue can convert androgen hormones into estrogen. The amount of fat tissue a woman has correlates with the amount of estrogen produced [4,5]. Body mass index (BMI) is an inexpensive and simple method for assessing an individual's nutritional status but it does not directly measure body fat. Measurements and assessments using BMI are associated with deficiency and excess nutritional status [6].

BMI is a mathematical formula expressed as weight (in kilograms) divided by the square of height (in meters). Based on the range value, BMI is divided into 3 categories: underweight (BMI ≤18.4), normal (BMI = 18.5-25), and overweight (BMI ≥25.1). This formula can only be applied to an individual with normal spinal structures, hence it is not appropriate to use in athletes or bodybuilders or pregnant or breastfeeding women [7].

It has been suggested that long menopause duration and BMI are directly related to BMD [8]. Low BMI is associated with low peak bone mass and high loss of bone mass [9]. However, BMI is not a good predictor of BMD [10]. Other studies have also shown that the effect of weight on bone mass is greater on the body parts supporting the weight, e.g., in the femur or tibia bone. It was reported that decreased fat mass resulted in decreased steroid hormone levels, which resulted in decreased BMD. Many of these opinions indicate that the relationship of BMI to bone density and menopause duration is still much debated [11].

Bone is a living tissue continuously undergoing formation and resorption due to mechanical response and hormonal changes. The process of bone formation is very active in young adults aged approximately 20 years and far beyond the process of bone resorption. Both processes are similarly active between the ages of 20 and 40 years, while the resorption process is more active than the bone

formation process at age >40 years; accordingly, bone mass becomes smaller. After peak bone mass between the ages of 25 and 35 years, bones shrink from 0.3% to 0.5% per year [12,13].

Bone mass is lower in women, and loss of bone mass occurs earlier in women than in men, thus women aged >45 years have an increased risk for fractures. Loss of bone mass due to estrogen deficiency occurs first in spongiosa while shrinkage does not occur in trabecular bone. Deterioration of bone mass is caused by an imbalance between bone resorption and bone formation [14].

Previous research suggests a significant relationship between cortical bone density of gonion and skeletal bone density in postmenopausal women [14]. This is supported by a previous study, in which it was verified that there is a correlation between mandibular bone density and bone density of the lumbar spine and femur in postmenopausal women [15]. Research has shown that bone resorption in other parts of the body is similar to that in alveolar bone, but the relationship between menopause duration and bone resorption remains unclear.

Postmenopausal women with high BMD find it easier to maintain teeth compared to women with low bone density or osteoporosis [16]. However, some studies suggest that attachment loss is associated with tooth loss but not with bone density; however, this research is still questionable, based on the findings of previous research, and sparks debate. Several studies have shown a possible link between jawbone density and density across the bone [17,18].

The relationship between duration of menopause, dry mouth, BMI, and age were used as parameters for identifying risk factors for postmenopausal osteoporosis [19]. Mandibular periapical radiographs are used to evaluate the level of alveolar resorption. It is very important for the dentist to know the amount of bone resorption in performing denture treatment so that denture treatment can last a long time in the mouth when used to function [20].

The purpose of this study was to analyze the relationship between age, BMI, BMD, and duration of menopause to alveolar bone resorption in postmenopausal women.

Material and Methods

Study Design

This cross-sectional study included 59 postmenopausal women aged 45-80 years. Patients were excluded if they had a history of bone disease, metabolic or endocrine disorders such as hyperthyroidism and hyperparathyroidism, diabetes mellitus, kidney and liver diseases, or medications known to affect bone metabolism (e.g., corticosteroids, anticonvulsants, and sodium heparin).

Subjects were determined by consecutive sampling technique. Those meeting the criteria underwent oral examination and were interviewed using a validated questionnaire, which contained demographic information including past and present medical history. BMI measurement was the results of the calculation of the ratio of body weight and height through the formula body weight / height^2 (kg/m^2), and menopause duration was estimated using a questionnaire. In this study, a woman was considered postmenopausal if she had not menstruated for 1 year, and duration of menopause was assessed via subject interviews.

Bone loss seen on radiography was measured by drawing a vertical line from the cementoenamel (CEJ) in the distal part of the 36 teeth and the mesial portion of 46 teeth to the base of the bone marked by the lamina dura intact, and the distance calculated (in mm) relative to the alveolar bone peak using the caliper. BMD evaluation and density on periapical radiography, including region of interest (ROI) of the mandibular cortex, was assessed using 5× magnification. ROI is a square made of mesial and distal interdental from 36 and 46 teeth about 1 mm from the alveolar peak and then forms a square of ± 3 mm². Measurements were made based on the results of the modified Taguchi method, where in Grade 1, trabeculation is not visible; Grade 2, trabeculated bone looks thin and only amounts to a small change; Grade 3, trabeculation looks like normal bone; Grade 4, thick trabeculation almost blankets the bone marrow; and Grade 5, trabeculation solid, bone trabeculae dense [21].

Data Analysis

Descriptive statistics were calculated and tested for normality using the Shapiro-Wilk test for distribution. Categorical determinations of age, BMI, BMD, and alveolar bone resorption were based on receiver operating characteristic (ROC) curves. The subjects' ages, BMI, BMD, and alveolar bone resorption were calculated using Pearson correlation and Spearman correlation tests. A p-value <0.05 was considered significant.

Ethical Aspects

Patients gave their informed consent prior to participating in the study, and the research was approved by the ethics committee of the Faculty of Dentistry, Universitas Indonesia.

Results

Table 1 shows that subjects with duration of menopause >5 years had a higher mean age (61.28 ± 7.21 years) compared with subjects who had duration ≤5 years (54.37 ± 4.17 years). Mean values of BMI (26.83 ± 6.61) and bone resorption (4.38 ± 1.61) in subjects with duration >5 years were similar to those of BMI (26.88 ± 4.78) and bone resorption (4.21 ± 1.45) in subjects with duration ≤5 years. Mean value of BMD was higher in subjects with duration ≤5 years (73.19 ± 14.61) versus >5 years (69.71 ± 10.45).

Table 1. Distribution of participants according to BMI, BMD and alveolar bone resorption based on menopause duration.

Menopausal Duration	Mean (SD)	Minimum – Maximum
Age		
≤ 5 Years	54.37 (4.17)	48 years – 65 years
> 5 Years	61.28 (7.21)	48 years – 77 years
BMI (kg/mm²)		
≤ 5 Years	26.88 (4.78)	19.64 – 37.19
> 5 Years	26.83 (6.61)	17.55 – 43.88

BMD		
≤ 5 Years	73.19 (14.61)	45.62 – 93.34
> 5 Years	69.71 (10.45)	44.23 – 106.27
Alveolar Bone Resorption (mm)		
≤ 5 Years	4.21 (1.45)	2.05 – 6.90
> 5 Years	4.38 (1.61)	1.29 – 8.20

Age determination used a 54.50 cut-point value to divide the subjects into ages <54.50 years and >54.50 years (sensitivity 52.6%, specificity 80%, area under the ROC curve [AUC] 0.21). BMI determination used a cut-point of 24.25 to divide the subjects into BMI <24.25 kg/m² and >24.25 kg/m² (sensitivity 73.7%, specificity 57.5%, AUC 0.53). BMD determination used a cut-point of 73.89 to divide the subjects with BMD <73.89 and >73.89 (sensitivity 57.9%, specificity 27.5%, AUC 0.60), and determination of alveolar bone resorption used a cut-point of 2.95 to divide the subjects into bone resorption <2.95 mm and >2.95 mm (sensitivity 78.9%, specificity 77.5%, AUC 0.46) (Table 2).

Table 2 shows that the majority of subjects (54.20%) with duration of menopause >5 years were aged >54.50 years, most (39.00%) had BMI >24.25 kg/m², and the majority (52.50%) had bone resorption >2.95 mm, but most subjects (49.20%) with duration of menopause >5 years had BMD ≤73.89.

Table 2. Grading of age, BMI, BMD, and bone resorption based on duration of menopause.

Variables	Categories	≤5 Years Menopause		>5 Years Menopause	
		N	%	N	%
Age (Years)	≤ 54.50*	9	15.3	8	13.6
	> 54.50*	10	16.9	32	54.2
BMI (kg/m²)	≤ 24.25*	5	8.5	17	28.8
	> 24.25*	14	23.7	23	39.0
BMD	≤ 73.89*	8	13.6	29	49.2
	> 73.89*	11	18.6	11	18.5
Alveolar Bone Resorption (mm)	≤ 2.95*	4	6.8	9	15.3
	> 2.95*	15	25.4	31	52.5

*Cutoff value determinant based on ROC curve.

Data analysis using Pearson correlation test indicated that age (r = 0.16) and BMI (r = 0.18) were positively correlated with alveolar bone resorption, but BMD (r = -0.32) was negatively correlated. There was no significant correlation between alveolar bone resorption and age (p = 0.49), BMI (p = 0.44), or BMD (p = 0.18) in subjects with duration of menopause ≤5 years (Table 3).

Table 3. Correlation between age, BMI, BMD, and alveolar bone resorption in subjects with duration of menopause ≤5 years.

Variables	Bone Resorption (n = 19)	
	Correlation Coefficient	p-value
Age	0.16	0.49
BMI	0.18	0.44
BMD	-0.32	0.18

Pearson correlation test (significant p<0.05)

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Based on Pearson correlation test, there was no significant correlation between age and bone resorption (p = 0.38) in subjects with a duration of menopause >5 years. A Spearman correlation test revealed that BMI (r = -0.12) and BMD (r = -0.01) had no significant correlation with alveolar bone resorption in subjects with a duration of menopause >5 years (Table 4).

Table 4. Correlation between age, BMI, BMD, and alveolar bone resorption in subjects with duration of menopause >5 years.

Variables	Bone Resorption (n = 40)	
	Correlation Coefficient	p-value
Age	0.14	0.38[a]
BMI	-0.12	0.45[b]
BMD	-0.01	0.92[b]

[a]Pearson correlation test (significant p<0.05); [b]Spearman correlation test (significant p<0.05).

Discussion

After a tooth extraction, the alveolar bone is resorbed, leading to deformation and diminished alveolar bone size. Changes in alveolar bone shape not only on the surface of the alveolar bone in a vertical direction but also in a labiolingual/palatal direction from the initial position cause the alveolar bone to be low, rounded, or flat. Residual ridge resorption is influenced by different etiological factors in each individual [19,21].

In this study, the minimum age of subjects was 48 years with a maximum of 77 years. Increased bone loss occurred with age, especially in the elderly. This study divides the duration of menopause into 2 groups, i.e., ≤5 years and >5 years [12].

Duration of menopause is considered to be a more important factor for osteoporosis compared with age at menopause [3,4]. The majority of subjects in the group with menopause duration ≤5 years had an average age of 54.37 ± 4.17 years, which was in accord with previous study showing that the mean menopausal age was 51.3 years [4,18]. Based on the age-cutting value of the ROC curve, the majority of subjects were aged >54.50 years (Table 2), which agrees with the study of postmenopausal women and dividing the subject's ages to <50 and >50 years [4,22]. It has been demonstrated that menopause and age >50 years is a risk factor for the occurrence of osteopenia and osteoporosis [6,21]. According to previous studies, the age distribution of menopause ranges from 40 years to 54 years and generally clusters at the age of 45 to 55 years [23].

Subjects with duration of menopause ≤5 years and >5 years had a mean BMI >25 kg/m², thus all subjects in the present study were considered overweight (Table 1). In agreement with the ROC curve, the cutoff value dividing the BMI of subjects weighing ≤24.5 kg/m² and >24.5 kg/m², the majority of subjects have a BMI >24.5 kg/m², which means that the majority of subjects were overweight (Table 2). Currently, the mechanism of obesity with bone density is still unclear. This is thought to be because adipose tissue releases many adipokines that play a role in bone remodeling through the effects of bone formation and resorption. Bone also acts as an endocrine organ and affects the balance of glucose and body weight through the action of bone derivative factors such as osteoclast and osteopontin [24].

Postmenopausal obesity is associated with genetic and environmental factors and is exacerbated by lifestyle patterns that play an important role in increasing BMI and waist size [7,25]. Weight gain slows down after age 60 years. Major changes in fat distribution and function occur throughout life. Fat tissue and connective tissue increase with aging, but muscle tissue and body water content decrease. In the elderly, the body will be shorter than normal and there will be adverse changes in bone, cartilage, and muscle [8,23].

The majority of subjects with a duration of menopause >5 years had a BMD ≤73.89, while the majority of subjects with duration ≤5 years had BMD >73.89, which could indicate that those with a longer duration of menopause have lower BMD (Table 2). Age is strongly associated with BMD in women compared with men, but bone size is related more to male than female BMD [26]. A previous study categorized the duration of menopause into 3 groups of 0-3 years, 4-7 years and >7 years, showing that women with menopause duration >7 years had the highest risk of osteoporosis due to bone loss associated with estrogen deficiency [21].

Subjects with duration of menopause ≤5 years had higher BMD compared to those with duration >5 years (Table 2), probably because the majority of subjects were overweight, where increased BMI or weight was significantly associated with bone acceleration in both women and men and low body weight was associated with low BMD [27].

The majority of subjects with duration of menopause >5 years had bone resorption >2.95 mm, thus it can be interpreted that longer menopause duration causes greater bone resorption (Table 2). Osteoporosis can occur in the mandible and may play an important role in residual ridge resorption [15]. Mandibles, like other body bones, have anatomic patterns that may serve as indicators in radiographs [28]. In this study, the mental foramen as seen on panoramic radiograph is recommended as a benchmark for measuring the magnitude of alveolar bone loss. Similar results were also used because the foramen position against the inferior mandibular border is relatively unchanged despite increasing age or occurrence of alveolar bone resorption above the foramen [25].

Some researchers claim that age affects bone resorption and bone density. Bone mass decreases in the elderly so that it will induce bone resorption [29], but the present study does not show a significant correlation between age and alveolar bone resorption ($p>0.05$) in subjects with duration of menopause ≤5 years and >5 years.

Previous research has shown that obese women have higher bone mass after menopause compared to women of the same age with normal weight, especially in the bones of the lumbar vertebrae and femoral columns. In contrast, obese postmenopausal women with high adipose mass can also have low BMD and vertebral fractures [28,30]. Some authors have claimed that loss of bone mass could occur in postmenopausal women at a bone weight of 0.5%–1% per year [4]. The present study shows no significant correlation between BMI and alveolar bone resorption ($p>0.05$) in subjects with duration of menopause ≤5 years and >5 years (Tables 3 and 4). Pregnancy and restrictions of women in their social environment cause more women to stay at home, and seldom participating in activities outside the home encourages overweight [31].

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In this study, BMD negatively correlated with alveolar bone resorption, which means the higher the bone density, the lower the bone resorption. Moreover, this shows that BMD did not significantly correlate with alveolar bone resorption in subjects with duration of menopause ≤5 years and >5 years (Tables 3 and 4), which is in line with previous study, which showed that there is no relationship between BMD and mandibular alveolar bone resorption in postmenopausal women [15,28] and this is supported by previous findings that showed that bone resorption does not increase as BMD decreases [18]. The possibility of bone density in postmenopausal women is due to many factors, not only because of estrogen levels from the ovaries but also because of estrogen from outside the ovaries such as from fat and the adrenal gland as well as from phytoestrogen foods such as tempeh and tofu, which can maintain and increase BMD after menopause [15].

Postmenopausal alveolar bone changes strongly correlate with BMD so that this relationship can be foundational in assisting the diagnosis of osteoporosis patients [32]. BMD changes are substantial at the end of perimenopause and continue to decline rapidly during the early postmenopausal period [29]. This assessment of BMD is important because determining when bone mass reaches a critical level is valuable in helping clinicians determine the right time to check postmenopausal osteoporosis [11,29].

Conclusion

Age, BMI, and BMD are risk factors for osteoporosis in postmenopausal women. Although there was no relationship between these 3 risk factors and alveolar bone resorption in this study, there was a tendency for a longer duration of menopause to be associated with higher age, BMI, and bone resorption but lower BMD.

Authors' Contributions: All authors contributed individually and significantly to the development of this article. SRP and LSK wrote and reviewed the manuscript, contributed to the intellectual conceptualization of the study and the entire research project; and also performed the statistical analysis. PW wrote and reviewed the manuscript and performed measurements for the assessments and outcome assessment analysis. SLCM, HBI and EIA contributed to the intellectual conceptualization of the study and reviewed the manuscript.

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References

[1] Kanis JA, Burlet N, Cooper C, Delmas PD, Reginster JY, Borgstrom F, et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2008; 19(4):399-28. https://doi.org/10.1007/s00198-008-0560-z

[2] World Health Organization. Prevention and Management of Osteoporosis: Report of a WHO Scientific Group. (WHO technical report series; 921). Geneva: WHO, 2003.

[3] Zhao LJ, Yong JL, Peng-Yuan L, James H, Robert RR, Hong WD. Relathionship of obesity with osteoporosis. J Clin Endocrionol Metab 2007; 92(5):1640-6. https://doi.org/10.1210/jc.2006-0572

[4] Montazerifar F, Karajibani M, Alamian S, Sandoughi M, Zakeri Z, Dashipour AR. Age, weight and body mass index effect on bone mineral density in postmenopausal women. Health Scope 2014; 3(2):e14075. https://doi.org/10.17795/jhealthscope-14075

[5] Papakitsou EF, Margioris AN, Dretakis KE, Trovas G, Zoras U, Lyritis G, et al. Body mass index (BMI) and parameters of bone formation and resorption in postmenopausal women. Maturitas 2004; 47(3):185-93. https://doi.org/10.1016/S0378-5122(03)00282-2

[6] Kopiczko A, Gryko K. Body mass index, general fatness, lipid profile and bone mineral density in young women and men. Anthropol Rev 2017; 80(1):115-25. https://doi.org/10.1515/anre-2017-0008

[7] Silva HG, Mendonça LM, Conceição FL, Zahar SE, Farias ML. Influence of obesity on bone density in postmenopausal women. Arq Bras Endocrinol Metab 2007; 51(6):943-9. https://doi.org/10.1590/S0004-27302007000600008

[8] Migliaccio S, Emanuella A, Rachele F, Lorenzo MD, Andrea L. Is obesity in women protective against osteoporosis? Diabetes Metab Syndr Obes 2011; 4:273-82. https://doi.org/10.2147/DMSO.S11920

[9] Akahoshi M, Soda M, Nakashima E. The effects of body mass index on age at menopause. Int J Obes Relat Metab Disord 2002; 26(7):961-8. https://doi.org/10.1038/sj.ijo.0802039

[10] Robbins J, Schott AM, Azari R, Kronmal R. Body mass index is not a good predictor of bone density: Results from WHI, CHS, and EPIDOS. J Clin Densitom 2006; 9(3):329-34. https://doi.org/10.1016/j.jocd.2006.02.005

[11] Sheng Z, Xu K, Ou Y, Dai R, Luo X, Liu S, et al. Relationship of body composition with prevalence of osteoporosis in central south Chinese post menopause women. Clin Endocrinol 2011; 74(3):319-24. https://doi.org/10.1111/j.1365-2265.2010.03941.x

[12] Kim YS, Han JJ, Lee J, Choi HS, Kim JH, Lee T. The correlation between bone mineral density/trabecular bone score and body mass index, height, and weight. Osteoporos Sarcopenia 2017; 3(2):98-103. https://doi.org/10.1016/j.afos.2017.02.001

[13] Wu SF, Du XJ. Body mass index may positively correlate with bone mineral density of lumbar vertebra and femoral neck in postmenopausal females. Med Sci Monit 2016; 22:145-51. https://doi.org/ 10.12659/MSM.895512

[14] Panchbhai AS. Quantitative estimation of vertical heights of maxillary and mandibular jawbones in elderly dentate and edentulous subjects. Spec Care Dentist 2013; 33(2):62-9. https://doi.org/10.1111/j.1754-4505.2012.00301.x

[15] Kusdhany LS, Auerkari EI, Suryandari DA, Rahardjo TB, Hogervoorst E, Talbot C. Estrogen receptor β gene polymorphisms and osteoporosis risk in postmenopausal women in need of dentures. Int J Clin Prev Dent 2011; 7(1):15-8.

[16] Ziagham S, Sayhi M, Azimi N, Akbari M, Davari Dehkordi N, Bastami A. The relationship between menopausal symptoms, menopausal age and body mass index with depression in menopausal women of Ahvaz in 2012, Jundishapur. J Chronic Dis Care 2015; 4(4):e30573. https://doi.org/ 10.17795/jjcdc-30573

[17] Mishra AK, Gajjar K, Patel K. Association between body mass index and bone mineral density among healthy women in India. Int J Med Res Health Sci 2016; 5(4):156-60.

[18] Ozola B, Slaidina A, Laurina L, Soboleva U, Lejnieks A. The influence of bone mineral density and body mass index on resorption of edentulous jaws. Stomatologija 2011; 13(1):19-24.

[19] Akhlaque U, Ayaz SB, Akhtar N, Ahmad N. Association of bone mineral density and body mass index in a cohort of Pakistanis: Relation to gender, menopause and ethnicity. Egyptian Rheumatol 2017; 39(1):39-43. https://doi.org/10.1016/j.ejr.2016.05.006

[20] Taguchi A, Tanimoto K, Akagawa Y, Suei Y, Wada T, Rohlin M. Trabecular bone pattern of the mandible. Comparison of panoramic radiography with computed tomography. Dentomaxillofac Radiol 1997; 26(2):85-9. https://doi.org/10.1038/sj.dmfr.4600209

[21] Najmutdinova DK, Nurmukhamedova LS, Alieva DA, Maksudova DS, Nosirova ZA. Study of the effects of the age at menopause and duration of menopause on bone mineral density in postmenopausal women in Uzbekistan. Int J Biomed 2016; 6(1):38-40. https://doi.org/10.21103/Article6(1)_OA7

[22] Ceylan B, Ozerdogan N. Factors affecting age of onset of menopause and determination of quality of life in menopause. Turk J Obstet Gynecol 2015; 12(1):43-9. https://doi.org/10.4274/tjod.79836

[23] Mythili S, Athisha G. Association of body mass index with bone acceleration on impulse response in men and women of South Indian population. Biomed Res 2014; 25(4):471-5.

[24] Jonasson G, Rythén M. Alveolar bone loss in osteoporosis: A loaded and cellular affair? Clin Cosmet Investig Dent 2016; 8:95-103. https://doi.org/10.2147/CCIDE.S92774

[25] Naeem A, Pai U. Evaluation of the amount of intact alveolar bone in dentulous mandibular ridges in institution of rural area: A radiographic study. Int J Dental Sci 2009; 7(2):1-4.

[26] Yang S, Shen X. Association and relative importance of multiple obesity measures with bone mineral density: The National Health and Nutrition Examination Survey 2005-2006. Arch Osteoporos 2015; 10:14. https://doi.org/10.1007/s11657-015-0219-2

[27] Ardakani FE, Marmohamadi SJ. Osteoporosis and oral bone resorption: A review. J Maxillofac Oral Surg 2009; 8(2):121-6. https://doi.org/10.1007/s12663-009-0030-y

[28] Springe B, Slaidina A, Soboleva U, Lejnieks A. Bone mineral density and mandibular residual ridge resorption. Int J Prosthodont 2014; 27(3):270-6. https://doi.org/10.11607/ijp.3283

[29] Finkelstein JS, Brockwell SE, Mehta V, Greendale GA, Sowers MR, Ettinger B, et al. Bone mineral density changes during the menopause transition in a multiethnic cohort of women. J Clin Endocrinol Metab 2008; 93(3):861-8. https://doi.org/10.1210/jc.2007-1876

[30] Ng AC, Melton III LJ, Atkinson EJ, Achenbach SJ, Holets MF, Peterson JM, et al. Relationship of adiposity to bone volumetric density and microstructure in men and women across the adult lifespan. Bone 2013; 55(1):119-25. https://doi.org/10.1016/j.bone.2013.02.006

[31] Nazli R, Akhtar T, Khan MA, Lutfullah G, Haider J, Aslam H. Prevalence of obesity and associated risk factors in a female population of rural Peshawar-Pakistan. Khyber Med Univ J 2015; 7(1):19-24.

[32] Majumder MI, Harun MASI. Alveolar bone changes in post-menopausal osteopenic and osteoporosis women: An original research. Int J Dent Med Spec 2015; 2(2):9-14. https://doi.org/10.5958/2394-4196.2015.00010.2