Dental Research Journal

Original Article

Evaluation of the association between osteoporosis and periodontitis in postmenopausal women: A clinical and radiographic study

Saba Zamani[1], Farin Kiany[2], Leila Khojastepour[3], Ali Zamani[4], Zahra Emami[2]

[1]Student Research Committee, School of Dentistry, Shiraz University of Medical Sciences, [2]Department of Periodontics, Oral and Dental Disease Research Center, School of Dentistry, Shiraz University of Medical Sciences, [3]Department of Oral and Maxillofacial Radiology, School of Dentistry, Shiraz University of Medical Sciences, [4]Department of Endocrine and Metabolism Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

ABSTRACT

Background: This study aimed to assess the relationship between the osteoporotic condition and periodontitis in postmenopausal women.

Materials and Methods: Ninety-four women aged 50–80 years were studied in this cross-sectional study. Bone mineral density (BMD) of lumbar vertebra BMD (LBMD), total hip BMD (HBMD), and neck of femur BMD (NBMD) was assessed using standardized dual-energy X-ray absorptiometry (DXA) (normal: T-score ≥−1, osteopenic: −2.5 ≤ t-score <−1, osteoporotic: T-score <−2.5). Bleeding point index (BI), O'Leary plaque index (PI), and clinical attachment loss (CAL) were recorded. Cementoenamel junction, alveolar-crest distance (CEJ-AC) was measured from cone-beam computed tomography images. Periodontitis severity was represented by CAL and CEJ-AC distance. One-way analysis of variance followed by *Post hoc* Tukey was performed for examining differences among the groups for different variables. Pearson correlation coefficient® and backward regression analysis were used to investigate the effect of confounding variables on CEJ-AC as the dependent variable. Significance was considered at $P < 0.05$.

Results: Mean CEJ-AC was significantly higher in the osteoporotic and osteopenic groups compared to the normal group ($P = 0.001$). There was a significant positive correlation between CEJ-AC and NBMD and LBMD ($P < 0.001$). The associations between LBMD and CEJ-AC existed even after adjusting for confounding factors ($P = 0.002$). The differences in BI, PI, and CAL were not statistically different between the groups ($P > 0.05$).

Conclusion: Although osteoporosis is not the main cause of periodontitis, it can indirectly affect periodontal status by increasing CEJ-AC. Early diagnosis of osteoporosis followed by early referral to a dentist for the treatment of potential existing periodontal diseases is important to avoid complications among postmenopausal women

Key Words: Alveolar bone loss, cone-beam computed tomography, osteoporosis, periodontitis, postmenopause

Received: 14-Feb-2021
Revised: 11-Dec-2021
Accepted: 08-Jan-2022
Published: 01-Jun-2022

Address for correspondence:
Dr. Zahra Emami,
Department of Periodontics, Oral and Dental Disease Research Center, School of Dentisty, Shiraz University of Medical Sciences, Shiraz, Iran.
E-mail: zahra_emami63@yahoo.com

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Zamani S, Kiany F, Khojastepour L, Zamani A, Emami Z. Evaluation of the association between osteoporosis and periodontitis in postmenopausal women: A clinical and radiographic study. Dent Res J 2022;19:41.

INTRODUCTION

Periodontitis and osteoporosis affect millions of people worldwide.[1] Osteoporosis is a metabolic bone disease that affects the entire skeleton.[2] It is characterized by a low bone mass leading to an increased risk of bone fragility.[3] Periodontitis is an inflammatory disease characterized by tooth-supporting alveolar bone destruction, connective tissue attachment loss, and formation of periodontal pockets.[3,4]

Both periodontitis and osteoporosis are chronic diseases characterized by an imbalance between bone resorption and formation. They both require prevention, early detection, and adequate treatment to minimize the risk of complications such as bone fracture and tooth loss.[4] These two diseases are multifactorial and have common predisposing factors. Age, smoking, poor nutritional status (inadequate intake of calcium and Vitamin D), and immune deficiency are such factors.[5,6]

Osteoporosis affects females at an earlier age than males. It is a physiologic condition in postmenopausal women when the decrease in estrogen levels results in an accentuated bone loss rate.[3] The hormonal imbalance and decreased bone density affecting postmenopausal women have been attributed to the increase in the incidence, severity, and progression of periodontal disease among them.[1,3,4,6-14] Moreover, studies have found a relationship between bone mineral density (BMD) and higher degrees of the cementoenamel junction, alveolar-crest distance (CEJ-AC) as a linear measurement of alveolar crestal height loss.[15-19] In contrast, some studies found no significant correlation between periodontal diseases and CEJ-AC with skeletal bone mass.[9,20-22]

To the best of our knowledge, only two-dimensional radiographic images such as bitewing, periapical, and panoramic images were used in previous studies that assessed the CEJ-AC.[9,15-22] These images could solely assess the mesial and distal CEJ-AC and they have limitations such as distortion and magnification.[9,15-21,23] In contrast, cone-beam computed tomography (CBCT) is the only method that allows an additional analysis of the buccal and lingual surfaces, and it has provided acceptable precision and reproducibility in the assessment of CEJ-AC.[24-26] In the present study, CBCT images were used for assessing CEJ-AC, and the relationship between systemic bone loss and periodontitis was evaluated while controlling for known confounding factors.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Periodontics, School of Dentistry, Shiraz, Iran. Mandibular teeth of all female patients aged 50–80 years, who had been referred for mandibular implant treatment from March 1, 2018, to March 1, 2019, were examined in our study. Being postmenopausal and having at least six natural teeth in the mandible (except for 3rd molars) formed the inclusion criteria of this study.

Patients suffering from parathyroid and thyroid diseases, diabetes, and metabolic bone diseases other than osteopenia and osteoporosis and those with a history of long-term use of steroid, bisphosphonate medication, hormone replacement therapy, radiotherapy, cancer, smoking, and alcohol use were excluded from the study.

Bone mineral density measurement

A dual-energy X-ray absorptiometry (DXA) test was prescribed for the patients who had not done this test during the previous year. This test is the gold standard for diagnosing osteoporosis and it measures BMD levels.[27] The BMD (T-score) of the lumbar spine (L1-L4) (LBMD), total hip BMD (HBMD), and neck of femur BMD (NBMD) were calculated with a Hologic Horizon-W DXA absorptiometer (Hologic, Inc., Bedford, MA, USA).

According to the World Health Organization criteria, individuals were divided into three groups: (1) osteoporotic group: Patients with DXA measurements of the hip or the lumbar spine that yielded T-scores of ≤ -2.5, (2) osteopenic group: Individuals with T-scores between -1.0 and -2.5, and (3) normal group: Participants with T-scores of ≥ -1.[28]

Periodontal examination

Bleeding point index (BI),[29] O'Leary plaque index (PI),[30] and mean clinical attachment loss (CAL) was calculated for all the teeth present in the mandibular dentition except the third molars. Besides, measurements were calculated separately for the anterior (incisors and canines) and posterior (premolars and molars) regions since some patients did not have either posterior or anterior teeth.

Measurement of cementoenamel junction, alveolar-crest distance in cone-beam computed tomography images

The images were acquired with the scanner NewTom VGi evo (QR SRL Co. Verona, Italy) operating at 110 kV, 32 mA, and 0.3 mm voxel size, and different fields of view (8 cm × 8 cm, 10 cm × 10 cm, 12 cm × 8 cm, 15 cm × 12 cm, and 16 cm × 16 cm).

CBCT images were displayed on NNT viewer software (NNT 8.2; Image Works, Verona, Italy). Cross-sectional images with a thickness of 0.3 mm and an interval of 0.3 mm perpendicular to the mesiodistal and buccolingual axes of each tooth were prepared [Figure 1]. For standardization purposes, there were 12 measurement sites for assessing the CEJ-AC in each tooth: 3 for each buccal, palatal, mesial, and distal aspect. The selected cross-sections were: (1) The first cross-section in which CEJ or crown margin was clearly visible (2) Mid-cross section (3) The last cross-section in which the CEJ or crown margin was clearly visible. For each tooth, the mean of 12 sites' values was calculated as the value of that tooth. The mean values for anterior teeth, posterior teeth, and all mandibular teeth except third molars were used in statistical analysis. CBCT images with unclear visibility of CEJ and/or alveolar bone crest or compromised visibility of the CEJ due to the presence of restorations, prostheses, and other artifacts were excluded.[31]

Statistical analysis

Data were evaluated using SPSS software (version 25; SPSS Inc., Chicago, IL, USA). Descriptive statistics, including means and standard deviations, were calculated for all variables. One-way analysis of variance followed by the *Post hoc* Tukey test was used to examine differences among the groups for different variables. Pearson correlation coefficient ® was determined for evaluating the relation between CEJ-AC and CAL with age, years since menopause, BMD of different sites, and each region's BI and PI. Variables with a P (P) $\leq$ 0.10 were entered into backward stepwise regression analyses with CEJ-AC as the dependent variable. $P < 0.05$ was considered significant.

RESULTS

Ninety-four postmenopausal women aged from 50 to 75 years (mean age 58.47 ± 5.87) and a total of 1058 teeth were examined in this study (27.7% osteoporotic, 40.4% osteopenic, and 31.9% normal based on DXA results).

Table 1 presents the study variables by the osteoporosis category. There were statistically significant differences across osteoporosis categories for all variables except CAL, PI, and BI in all sites. The CEJ-AC means for the osteoporotic and osteopenic groups were significantly higher than the CEJ-AC means for the normal group [Table 1].

Pearson's correlation coefficients between CEJ-AC and CAL and confounding factors are reported in Table 2. There was a significant correlation between CEJ-AC in different regions and age, years since menopause, BI, PI, LBMD, and NBMD. There was an inverse relationship between CEJ-AC and HBMD, which did not reach statistical significance. CAL in

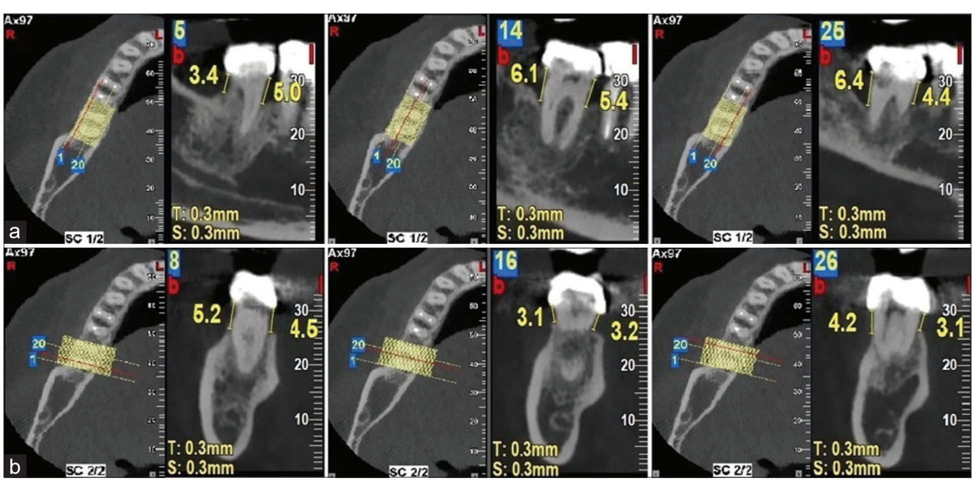

Figure 1: Measurement of cementoenamel junction, alveolar-crest distance in cone beam computed tomography images of tooth 31: (a) Three selected mesio-distal cross-sections; (b) Three selected buccal-lingual cross-sections.

different sites was significantly associated with age, years since menopause, BI, and PI (Except posterior CAL, which was not significantly associated with years since menopause). There was a relationship between CAL and BMD at different sites, but it was not statistically significant.

To build models that could predict CEJ-AC, backward stepwise regression analyses were applied to the variables whose associations with CEJ-AC had $P \leq 0.10$ in the univariate analysis at different sites [Tables 2]. These variables included age, years since menopause, LBMDS NBMD, BI, and PI. Separate models were built for anterior, posterior, and overall CEJ-AC. In the final regression models, LBMD and BI were significant predictors of anterior and posterior CEJ-AC, and LBMD and PI were the significant predictors of overall CEJ-AC. In the

Table 1: Participant characteristics by osteoporosis category

Variables	Mean±SD			P*
	Osteoporosis	Osteopenia	Normal	
Age (years)	61.9±5.87[a]	58.55±5.48[b]	55.4±4.55[c]	<0.001
Years since menopause	15±7.57[a]	8.57±6.24[a]	6.2±6.29[b]	<0.001
Anterior CEJ-AC (mm)	3.34±0.75[a]	3.05±0.53[b]	2.65±0.55[b]	<0.001
Posterior CEJ-AC (mm)	2.71±0.64[a]	2.36±0.58[a]	2.18±0.43[b]	0.009
Overall CEJ-AC (mm)	3.05±0.66[a]	2.61±0.52[a]	2.48±0.54[b]	0.001
Anterior CAL (mm)	0.81±1.09	0.74±1.03	0.51±1.05	0.545
Posterior CAL (mm)	0.40±0.99	0.48±0.85	0.29±0.99	0.747
CAL (mm)	0.75±1.08	0.63±0.95	0.49±1.01	0.626
Anterior PI (%)	41.24±29.78	32.87±26.23	31.77±24.76	0.378
Posterior PI (%)	16.7±30.70	11.30±20.45	9.13±23.28	0.572
Overall PI (%)	35.03±29.05	23.8±23.35	25.73±21.88	0.184
Anterior BI (%)	31.35±34.51	31.15±32.1	25.62±27.19	0.734
Posterior BI (%)	24.25±39.87	20.41±32.66	11.30±26.68	0.409
BI (%)	28.81±34.68	27.20±30.32	25.06±23.97	0.894

*Comparison between groups by one-way ANOVA; [a, b, c]: *Post hoc* Tukey test for pairwise comparison; Mean values with the same letter in superscript were not statistically different. SD: Standard deviation; CAL: Clinical attachment loss; BI: Bleeding point index; PI: O'Leary plaque index; CEJ-AC: Cementoenamel junction, alveolar-crest distance; ANOVA: Analysis of variance

Table 2: Cementoenamel junction, alveolar-crest distance and clinical attachment loss correlation with age, years since menopause, lumbar bone mineral density, total hip bone mineral density, neck of femur bone mineral density, O'Leary plaque index, and bleeding point index

Variables	Age (years)	Years since menopause	LBMD	HBMD	NBMD	PI (%)*	BI (%)*
Anterior CEJ-AC (mm)							
r[†]	0.373	0.309	−0.428	−0.121	−0.337	0.361	0.364
P[‡]	<0.001	0.004	<0.001	0.266	0.002	0.001	0.001
Posterior CEJ-AC (mm)							
r	0.351	0.355	−0.387	−0.022	−0.290	0.382	0.417
P	0.001	0.001	<0.001	0.848	0.009	0.001	<0.001
Overall CEJ-AC (mm)							
r	0.395	0.416	−0.380	−0.069	−0.332	0.545	0.466
P	<0.001	<0.001	<0.001	0.508	0.001	<0.001	<0.001
Anterior CAL (mm)							
r	0.276	0.300	−0.154	−0.054	−0.204	0.586	0.619
P	0.010	0.005	0.156	0.624	0.059	<0.001	<0.001
Posterior CAL (mm)							
r	0.276	0.205	−0.116	0.015	−0.121	0.836	0.670
P	0.014	0.070	0.309	0.897	0.290	<0.001	<0.001
Overall CAL (mm)							
r	0.271	0.287	−0.154	−0.043	−0.178	0.713	0.684
P	0.008	0.005	0.139	0.683	0.086	<0.001	<0.001

[†]Pearson product-moment correlation coefficient; [‡]*P*-value for Pearson correlation testing; *For each region, PI and BI of that region was used for the analysis. CAL: Clinical attachment loss; BI: Bleeding point index; PI: O'Leary plaque index; BMD: Bone mineral density; LBMD: Lumbar BMD, HBMD: Total hip BMD, NBMD: Neck of femur BMD; CEJ-AC: Cementoenamel junction, alveolar-crest distance

Table 3: Linear regression analysis of cementoenamel junction, alveolar-crest distance controlling for confounding variables

Dependent variable	Independent variable	β	Standard β	SE	*P*	R^2
Anterior CEJ-AC (mm)	Constant	4.343		0.384	<0.001	0.28
	LBMD	−1.695	−0.391	0.405	<0.001	
	Anterior BI (%)	0.007	0.320	0.002	0.001	
Posterior CEJ-AC (mm)	Constant	3.495		0.368	<0.001	0.28
	LBMD	−1.347	−0.337	0.393	0.001	
	Posterior BI (%)	0.006	0.363	0.002	<0.001	
Overall CEJ-AC (mm)	Constant	3.382		0.339	<0.001	0.36
	LBMD	−1.122	0.485	0.35	0.002	
	Overall PI (%)	0.012	−0.274	0.002	<0.001	

BI: Bleeding point index; PI: O'Leary plaque index; β: Unstandardized coefficients B; Standard β: Standardized coefficients beta; SE: Standard error; CEJ-AC: Cementoenamel junction, alveolar-crest distance; LBMD: Lumbar vertebra bone mineral density

models, NBMD was not a significant independent predictor. The results showed that after controlling for confounding factors, 36% of overall CEJ-AC can be predicted by LBMD and PI (R^2 = 0.36) [Tables 3].

DISCUSSION

In this study, CEJ-AC and CAL were used as dependent variables for representing periodontal disease severity. Our results showed that CEJ-AC was strongly affected by the presence of osteoporosis. The CEJ-AC mean for the osteoporotic group was higher than the CEJ-AC means for the osteopenic and normal groups with high significance.

There was a significant correlation between CEJ-AC and the LBMD and NBMD. Furthermore, the results showed that after controlling for confounding factors, LBMD and PI were independent predictors of CEJ-AC. Statistical models containing these variables accounted for 36% of the variation in CEJ-AC. These results support the previously suspected association between osteoporosis and alveolar bone loss.[15-19] Moreover, studies done by Tezal *et al*.[19] and Brennan-Calanan *et al*.[15] showed significant relations between CEJ-AC and HBMD. However, our study could not establish a significant correlation between CEJ-AC and HBMD. This might be because of the limited number of people with osteoporosis of the hip in our study group.

On the contrary, some studies concluded that there was not a relationship between CEJ-AC and BMD. However, these studies have major differences from our study, which could explain the difference in the results. Specifically, In Juluri *et al*.'s[9] and Elders *et al*.'s[20] studies, CEJ-AC evaluations were limited only to the posterior teeth, and in Moeintaghavi *et al*.'s[21] study, panoramic radiography was used for evaluating CEJ-AC, which is a two-dimensional radiographic modality and has some limitations such as magnification and distortion.[23]

Mean CAL, PI, and BI were higher in the osteoporotic group compared to the osteopenic and normal group; however, the difference was not statistically significant. Moreover, the results showed a negative correlation between LBMD, HBMD, and NBMD with CAL, which did not attain statistical significance. These results are compatible with those of previous studies.[20-22]

Alternatively, Richa *et al*. found a relation between skeletal BMD and CAL and gingival bleeding. In their study, the community periodontal index and modified sulcus bleeding index were used for periodontal examination.[10]

Similarly, the results of Mashalkar *et al*.'s study on 94 postmenopausal women showed a statistically significant correlation between periodontitis and BMD. In their study, the average CAL was used to classify the chronic periodontitis subjects into three categories: Slight (1–2 mm), moderate (3–4 mm), and severe (≥5 mm).[3] The differences between the two aforementioned studies and our study can be explained by the differences in indices and classification methods deployed for periodontal diseases.

In a review article published in 2013 on the associations between osteoporosis and bone loss in the jaws and periodontal diseases, Guiglia *et al*. mentioned several studies on an epidemiologic basis that suggest a potential relationship between periodontal disease and osteoporosis. However, the authors concluded that a comprehensive analysis of reported data provides conflicting results. This might be due to the wide variation in the parameters used for assessing both osteoporosis and periodontal disease in epidemiologic studies. Besides, these studies were uncontrolled and cross-sectional and their sample sizes were restricted to only postmenopausal women.[13] Several cross-sectional studies conducted on postmenopausal osteoporotic females and elderly males suggest a correlation between systemic BMD and periodontal disease. However, studies conducted on premenopausal females and young male populations did not advocate such a relationship.[14]

One novel aspect of this study was employing CBCT images for evaluating CEJ-AC. Previous studies have used periapical and bitewing radiographs and these two-dimensional imaging techniques suffer from significant limitations such as distortion and superimposition, which lead to under/overestimation of the bone loss.[23] Moreover, other studies have just considered posterior teeth for the assessment of CEJ-AC. Potential confounding factors were also controlled in our study. One limitation of this study is that only the mandibular teeth of postmenopausal women were included in this analysis. Further CBCT studies are required to investigate CEJ-AC in maxillary teeth and men population as well. Furthermore, despite the efforts to limit the effect of confounders in the analysis, factors such as calcium supplementation may still act as confounding variables. Furthermore, this was a cross-sectional study, and future longitudinal research is required to verify a definitive evidence of the present analysis.

One major obstacle for such a longitudinal study will be ethical issues because, during the analyses, subjects with periodontitis or osteoporosis should be left untreated.

CONCLUSION

The results of this study suggest that even though osteoporosis is not the leading cause of periodontitis, it may have an indirect effect on it by enhancing the CEJ-AC. An early diagnosis of osteoporosis by general practitioners and other specialists, followed by early referral to a dentist for the timely potential treatment of periodontal disease, will help reduce the morbidity of osteoporosis and the risk of periodontal diseases among postmenopausal women.

Acknowledgment

The authors thank the vice-chancellery of Shiraz University of Medical Sciences for supporting the research (Grant#97-01-99-18741). This manuscript is the relevant thesis of Dr. Saba Zamani. Furthermore, the authors thank Dr. Mehrdad Vosoughi from the Dental Research Development Center, for the statistical analysis.

Financial support and sponsorship

This study was supported by the Vice-Chancellery of Shiraz University of Medical Sciences (grant number 97-01-99-18741).

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Marcelo RM, Marco AD, Silvana PB. Periodontal disease and osteoporosis association and mechanisms: A review of the literature. Braz J Oral Sci 2015;2:137-140.
2. Albayati RM, Saliem SS, Al Nakib LH. Osteoporosis effect on posterior mandible in preimplanted area for postmenopausal females using cone-beam computed tomography. J Indian Soc Periodontol 2018;22:390-4.
3. Mashalkar VN, Suragimath G, Zope SA, Varma SA. A cross-sectional study to assess and correlate osteoporosis and periodontitis among postmenopausal women: A dual energy X-ray absorptiometry study. J Midlife Health 2018;9:2-7.
4. Savic Pavicin I, Dumancic J, Jukic T, Badel T. The relationship between periodontal disease, tooth loss and decreased skeletal bone mineral density in ageing women. Gerodontology 2017;34:441-5.
5. Pavlesen S, Mai X, Wactawski-Wende J, LaMonte MJ, Hovey KM, Genco RJ, *et al*. Vitamin D status and tooth loss in postmenopausal females: The buffalo osteoporosis and periodontal disease (OsteoPerio) study. J Periodontol 2016;87:852-63.
6. Penoni DC, Leão AT, Fernandes TM, Torres SR. Possible links between osteoporosis and periodontal disease. Rev Bras Reumatol 2017;57:270-3.
7. Penoni DC, Fidalgo TK, Torres SR, Varela VM, Masterson D, Leao AT, *et al*. Bone density and clinical periodontal attachment in postmenopausal women: A systematic review and meta-analysis. J Dent Res 2017;96:261-9.
8. Esfahanian V, Shamami MS, Shamami MS. Relationship between osteoporosis and periodontal disease: Review of the literature. J Dent (Tehran) 2012;9:256-64.
9. Juluri R, Prashanth E, Gopalakrishnan D, Kathariya R, Devanoorkar A, Viswanathan V, *et al*. Association of postmenopausal osteoporosis and periodontal disease: A double-blind case-control study. J Int Oral Health 2015;7:119-23.
10. Richa RY, Puranik MP, Shrivastava A. Association between osteoporosis and periodontal disease among postmenopausal Indian women. J Investig Clin Dent 2017;8:284-91.

11. Wang CJ, McCauley LK. Osteoporosis and periodontitis. Curr Osteoporos Rep 2016;14:284-91.
12. Martínez-Maestre MA, Machuca G, González-Cejudo C, Flores JR, Cardoso RT, Castelo-Branco C. Osteoporosis, fragility fracture, and periodontal disease: A cross-sectional study in Spanish postmenopausal women. Menopause 2013;20:79-84.
13. Guiglia R, Di Fede O, Lo Russo L, Sprini D, Rini GB, Campisi G. Osteoporosis, jawbones and periodontal disease. Med Oral Patol Oral Cir Bucal 2013;18:e93-9.
14. Oztürk Tonguç M, Büyükkaplan US, Fentoglu O, Gümüs BA, Çerçi SS, Kirzioglu FY. Comparison of bone mineral density in the jaws of patients with and without chronic periodontitis. Dentomaxillofac Radiol 2012;41:509-14.
15. Brennan-Calanan RM, Genco RJ, Wilding GE, Hovey KM, Trevisan M, Wactawski-Wende J. Osteoporosis and oral infection: Independent risk factors for oral bone loss. J Dent Res 2008;87:323-7.
16. Hildebolt CF, Pilgram TK, Yokoyama-Crothers N, Vannier MW, Dotson M, Muckerman J, *et al*. Alveolar bone height and postcranial bone mineral density: Negative effects of cigarette smoking and parity. J Periodontol 2000;71:683-9.
17. Payne JB, Reinhardt RA, Nummikoski PV, Patil KD. Longitudinal alveolar bone loss in postmenopausal osteoporotic/osteopenic women. Osteoporos Int 1999;10:34-40.
18. Wactawski-Wende J, Hausmann E, Hovey K, Trevisan M, Grossi S, Genco RJ. The association between osteoporosis and alveolar crestal height in postmenopausal women. J Periodontol 2005;76:2116-24.
19. Tezal M, Wactawski-Wende J, Grossi SG, Ho AW, Dunford R, Genco RJ. The relationship between bone mineral density and periodontitis in postmenopausal women. J Periodontol 2000;71:1492-8.
20. Elders PJ, Habets LL, Netelenbos JC, van der Linden LW, van der Stelt PF. The relation between periodontitis and systemic bone mass in women between 46 and 55 years of age. J Clin Periodontol 1992;19:492-6.
21. Moeintaghavi A, Pourjavad M, Dadgar S, Tabbakh NS. Evaluation of the association between periodontal parameters, osteoporosis and osteopenia in post menopausal women. J Dent (Tehran) 2013;10:443-8.
22. Weyant RJ, Pearlstein ME, Churak AP, Forrest K, Famili P, Cauley JA. The association between osteopenia and periodontal attachment loss in older women. J Periodontol 1999;70:982-91.
23. Venkatesh E, Elluru SV. Cone beam computed tomography: Basics and applications in dentistry. J Istanb Univ Fac Dent 2017;51:S102-21.
24. Cetmili H, Tassoker M, Sener S. Comparison of cone-beam computed tomography with bitewing radiography for detection of periodontal bone loss and assessment of effects of different voxel resolutions: An *in vitro* study. Oral Radiol 2019;35:177-83.
25. Choi IG, Cortes AR, Arita ES, Georgetti MA. Comparison of conventional imaging techniques and CBCT for periodontal evaluation: A systematic review. Imaging Sci Dent 2018;48:79-86.
26. Menezes CC, Janson G, da Silveira Massaro C, Cambiaghi L, Garib DG. Precision, reproducibility, and accuracy of bone crest level measurements of CBCT cross sections using different resolutions. Angle Orthod 2016;86:535-42.
27. Morgan SL, Prater GL. Quality in dual-energy X-ray absorptiometry scans. Bone 2017;104:13-28.
28. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. World Health Organ Tech Rep Ser 1994;843:1-129.
29. Lenox JA, Kopczyk RA. A clinical system for scoring a patient's oral hygiene performance. J Am Dent Assoc 1973;86:849-52.
30. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. J Periodontol 1972;43:38.
31. Zhao H, Li C, Lin L, Pan Y, Wang H, Zhao J, *et al*. Assessment of alveolar bone status in middle aged Chinese (40-59 Years) with chronic periodontitis – Using CBCT. PLoS One 2015;10:e0139553.