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Original

Correlation of tooth mobility with systemic bone mineral density and periodontal status in Indian women

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Abstract: Imbalanced bone remodelling associated with osteopaenic or osteoporotic conditions can lead to a net bone loss throughout the skeleton, including the oral cavity, possibly leading to tooth mobility. This study investigated possible associations between systemic bone mineral density and both tooth mobility and periodontal status in peri-menopausal women. Subjects comprised 119 dentate, peri-menopausal Indian women between 40 and 54 years old. Clinical parameters recorded were systemic bone mineral density (BMD), tooth mobility in terms of Periotest value (PTV score), clinical attachment loss (CAL), pocket depth (PD), plaque index (PI) and sulcular bleeding index (SBI). Statistical analysis was performed to assess correlations between PTV score and T-score. PTV score correlated significantly ($P < 0.05$) with T-score, PD and CAL. The partial correlation coefficient between PTV score and T-score after adjusting for confounders was -0.3676 ($P < 0.05$). Results of one-way analysis of variance showed a significant difference between mean PTV scores for osteoporotic, osteopaenic and normal patients. In this population of peri-menopausal women, systemic bone mineral density represented an independent factor associated with tooth mobility. (J Oral Sci 54, 177-182, 2012)

Keywords: tooth mobility; bone mineral density; Periotest value.

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Introduction

The quality or viscoelastic properties of the periodontal tissues and anatomical characteristics such as the amount of supporting alveolar bone and the width of periodontal ligament are the critical factors associated with tooth mobility. The tooth displacement allowed by the resilience of intact or healthy periodontium on application of moderate force to the tooth crown can be used to quantify physiological mobility of the tooth (1,2). Increased tooth mobility is both an indicator and outcome of detrimental changes in the periodontium. Clinical and experimental observations have revealed hypermobility as a collective outcome of both loss of alveolar bone and associated qualitative and quantitative alterations in the periodontal ligament and supra-alveolar soft tissue (3). The extent of alteration in the periodontium can be objectively indicated from a Periotest evaluation. Periotest provides an effective means of reproducibly measuring levels of clinical and subclinical mobility using an ultrasonically vibrating probe. Periotest scores range from -8 to 50, registering slight changes in tooth mobility that might otherwise remain undetected using conventional indices of tooth mobility.

Changes in the periodontium leading to hyper-mobility of teeth may be associated with different physiological or pathological phenomena. Osteoporosis is an age-related condition defined as a systemic skeletal disease characterised by low bone mass and micro-architectural deterioration, with a consequent increase in bone fragility and susceptibility to fracture (4). This skeletal disorder is characterised by compromised bone strength predisposing to increased risk of fracture, with bone strength determined by both bone density and bone quality (5).

Despite being heterogenic and independent in nature,

the bone density, bone turnover rate and bone remodelling ability of different parts of the skeleton and alveolar bone have been found to be interrelated to some extent. Metabolic processes in bone tissue of the alveolar crest have also been suggested to be closely related to the intensity of systemic metabolic processes and to inner bone reorganisation in the whole skeleton (6). The imbalances in bone remodelling associated with osteopaenic or osteoporotic conditions can thus lead to a net loss of bone density throughout the skeleton, including the oral cavity, possibly leading to tooth mobility.

In post-menopausal women, osteoporosis-associated loss of crestal alveolar height (7-9) and increased frequency of crestal alveolar bone density loss have been reported (10). These findings may be attributed to increased local production of active alveolar bone cytokines interleukin (IL)-1β and IL-6 (11).

Periodontitis is one of the most prevalent diseases of bone and is one of the leading factors associated with both alveolar bone destruction and tooth mobility. Inflammation-mediated alterations in periodontium and tooth mobility might be expected to be magnified in the presence of generalised skeletal disturbance. The potential pathways linking periodontal destruction and tooth mobility with low skeletal bone mineral density (BMD) may include dietary intake, genetic factors and oestrogen deficiency, which may influence the production of inflammatory cytokines (12-15). However, the literature lacks evidence providing unequivocal conclusions on this issue. Whereas several studies have explored cause-effect relationships between skeletal BMD and alveolar bone loss (16-19), no studies appear to have clarified correlations between tooth mobility and skeletal BMD.

Considering the paucity of published data, this study investigated the possible association of tooth mobility (in terms of Periotest value) with systemic BMD, pocket depth, clinical attachment loss and inflammation of periodontal tissue in peri-menopausal Indian women.

Materials and Methods

Among 200 patients screened from the regular outpatient department (OPD) in the Department of Periodontics and Oral Implantology, Government Dental College, Postgraduate Institute of Medical Sciences, Rohtak, Haryana, 119 women fulfilling the inclusion criteria were recruited for this cross-sectional study. Exclusion criteria for the study included current and former smokers, known systemic risk factors for periodontal disease, history of periodontal treatment within the preceding one year, intake of anti-inflammatory, immunosuppressant or cytotoxic drugs during the preceding six months, or current treatment for osteoporosis (oestrogen, hormone-replacement therapy, calcium, calcitonin, vitamin D or bisphosphonates).

The study protocol was approved by the institutional review board and was carried out in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki, as revised in 2000. Informed consent was obtained from all participants prior to enrolment.

The study population consisted of 40- to 54-year-old dentate women with varying degrees of chronic periodontitis (clinical attachment loss (CAL) ≥ 2 mm and pocket depth (PD) ≥ 3 mm on ≥ 8 permanent teeth excluding the third molar, with a minimum of one tooth per quadrant).

BMDs of subjects were evaluated using dual-energy X-ray absorbtiometry (DXA) (Hologic QDR Explorer version 12.6:3; Hologic Inc., Bedford, MA, USA) in the lumbar spinal region (L_1-L_4) with an exposure of 0.07 mGy for 90 s. Calibrations were automatic and continuous using Hologic's patented automatic internal reference system. BMD was recorded in grams per square centimetre. T-scores, as the number of standard deviations above or below the mean for a 30-year-old of the same sex and ethnicity as the patient, were obtained for all subjects and charted as continuous variables.

Subjects were further subdivided based on BMD according to the World Health Organisation criteria, which are based on T-scores as follows:

Osteoporosis – T-score ≤ -2.5

Osteopaenia – T-score -1.0 to -2.5

Normal – T-score > -1.0

Tooth mobility was recorded at a fixed point (tip of the crown) as the Periotest value score (PTV Score) using a Periotest device (Medizintechnic Gulden, Bensheim, Germany), a device that dynamically measures the reaction of the periodontium to a defined percussive force applied to the tooth. Based on the contact time of the tapping head and tooth, the PTV score is calculated by the measuring unit and displayed. PTV scores range from -8 to 50. Very loose teeth for which PTV score could not be recorded by the device were not taken into account and were considered as missing. The different PTV scores have been related to Miller's mobility index (20) (Table 1).

Complete periodontal examination was performed on all teeth except third molars at four sites on each tooth (mesiobuccal, mid-buccal, distobuccal and midlingual) by a single examiner (A.S.) who was blinded to the BMD status of patients. Intra-examiner reproducibility was assessed using a calibration exercise performed on two occasions separated by an interval of 48 h. Reproducibility was > 90%.

Table 1 Relation between Miller's mobility index and PTV score

Miller's classification	Mobility index	PTV score
No distinguishable movement	0	-8 to 9
First distinguishable sign of movement	1	10 to 19
Crown deviates within 1 mm of the normal position	2	20 to 29
Mobility is easily noticeable and the tooth moves more than 1 mm in any direction or can be rotated in its socket	3	30 to 50

PTV score (24, 25)

Table 2 Descriptive statistics of the study population

Variables	Mean	SE mean	SD	Minimum	Maximum
CAL (mm)	3.908	0.126	1.378	1.030	7.570
PD (mm)	3.003	0.104	1.125	0.180	6.880
PI	1.839	0.047	0.514	0.110	3.000
SBI	2.242	0.081	0.890	0.083	4.240
T-score	-1.984	0.110	1.200	-4.800	1.200
AGE	48.092	0.388	4.233	40.000	54.00
PTV score	19.628	0.875	9.548	3.230	47.750

SE mean = standard error of mean, SD = standard deviation

PD was measured with a University of North Carolina probe (UNC-15; Hu-friedy, Chicago, USA) using gentle pressure as a distance from the gingival margin to the base of the pocket and rounded to the nearest millimetre.

CAL was calculated for each surface as the PD minus the distance from the cemento-enamel junction to the gingival margin if the gingival margin was coronal to the junction or as the PD plus the distance from the cemento-enamel junction to the gingival margin if the gingival margin was apical to the junction. If the gingival margin was lying on a junction, the CAL was considered equal to pocket depth.

Gingival inflammation was recorded as sulcular bleeding index (SBI), as proposed by Mühlemann and Son (21). Plaque score was recorded as Sillness and Löe plaque index (PI).

Statistical analysis was performed using Minitab version 16.1.0 software (Minitab Inc. State College, PA, USA). Descriptive statistics were calculated for all variables, including means, standard deviations and ranges. Correlations were obtained between Periotest score and other clinical parameters of T-score, PD, CAL, SBI, PI and age in the form of Pearson's coefficients. Partial correlations were also obtained between PTV score and T-score after adjusting for confounders such as age, PI, CAL, PD and SBI. Variables found to correlate significantly with PTV score were further checked for associations via regression modelling. After checking the normal distribution of data using the Anderson-Darling test, inter-group (osteoporotic, osteopaenic and normal) variations in mean PTV scores of patients were assessed using one-way analysis of variance (ANOVA) followed by post hoc Tukey test.

Results

Of the 119 female patients recruited for the study, 52 were osteoporotic, 45 were osteopaenic and 22 were normal. Mean age of the population selected for this study was 48 years. Descriptive statistics for the various clinical parameters studied have been charted in Table 2. Among this population of peri-menopausal women, tooth mobility (as represented by PTV score) correlated significantly with T-score, CAL and PD ($P < 0.05$) with Pearson's correlation coefficients of -0.527, 0.696 and 0.635, respectively. Mobility tended to show weak positive correlations with PI, SBI and patient age, with none reaching the level of significance (Table 3). The correlation between PTV score and T-score after adjusting for age, PD, CAL, PI and SBI was significant, at -0.3676 ($P = 0.000$). The general regression equations using PTV score as a dependent variable and T-score, PD and CAL as independent variables were as follows:

PTV score = 11.30 − 4.195 T-score

PTV score = 0.78 + 4.82 CAL

PTV score = 3.36 + 5.41 PD

Since PI, SBI and age did not show any significant correlations, these variables were not included in the regression model. The coefficients of general regression

Table 3 Pearson's correlation coefficients for PTV score and different study variables

Variables	R	*P**
T-score	-0.527	0.000
PD	0.635	0.000
CAL	0.696	0.000
PI	0.053	0.567
SBI	0.065	0.485
AGE	0.112	0.227

*value of *P* is significant at $P < 0.05$

Table 4 Coefficients of linear regression using PTV score as the dependent variable

Predictor	Coef	SE Coef	*P**	R^2 adj
T-score	-4.1952	0.6250	0.000	27.2%
CAL	4.8239	0.4601	0.000	48.0%
PD	5.4082	0.6108	0.000	39.8%

Coef = coefficient, SE Coef = standard error of coefficient, R^2 adj = coefficient of determinant (adjusted), *value of *P* is significant at $P < 0.05$

Table 5 Results of post-hoc Tukey's test

Group comparison	Mean difference	*P**
Osteoporotic vs osteopenic	8.9185	0.000
Osteoporotic vs normal	11.0520	0.000
Osteopenic vs normal	2.1336	0.585

*value of *P* is significant at $P < 0.05$

are summarised in Table 4.

Results of one-way ANOVA (Table 5) revealed significant differences between mean PTV scores of osteoporotic, osteopaenic and normal subgroups of the study population. Furthermore, significant differences in mean PTV score were found between the osteoporotic and osteopaenic groups and between the osteoporotic and normal groups. However, no significant difference was identified between the osteopaenic and normal groups.

Discussion

Destructive and resorptive processes in alveolar bone have been found to occur synchronously with periods of active bone tissue reorganisation in the whole skeleton, when bone resorption prevails over osteogenesis. Correlations between oral bone loss and systemic BMD have long been investigated (16-19). Close correlations between systemic BMD and alveolar bone diminution rates in postmenopausal women have been revealed (7-10). Considering these facts, this study hypothesised

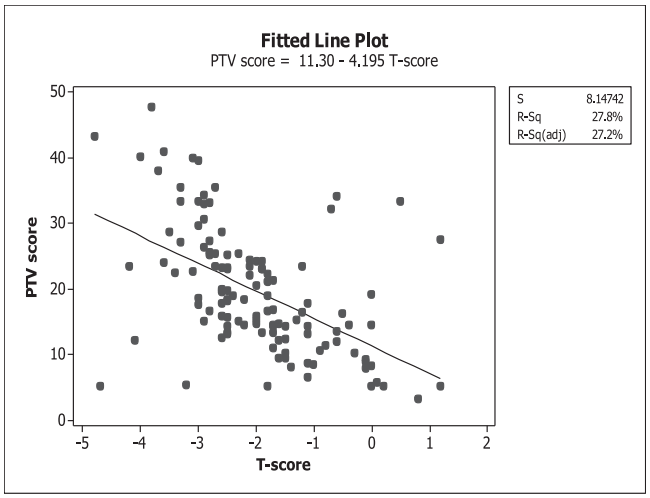

Fig. 1 Fitted line plot between PTV score and T-score.

that low systemic BMD associated with osteopaenic or osteoporotic conditions may directly affect the micro-architecture of alveolar bone, causing tooth mobility that could be objectively measured as a Periotest value. The Periotest value is a bio-physical parameter influenced by the periodontal attenuation characteristics (22,23) of individual teeth and their mobility. The different PTV scores have been related to Miller's mobility index (20,24).

Bone loss in women occurs most rapidly in the years immediately following menopause, when natural levels of oestrogen are greatly reduced in most women. Bone mass peaks in the third decade of life in women and declines thereafter (25-27). This decline in bone mass accelerates with the onset of menopause. Pre-menopausal osteoporosis may also lead to decreased bone mass in women, for idiopathic or secondary reasons. This was the basis of our selection of a mainly peri-menopausal study population. Smokers and subjects undergoing any active treatment for osteoporosis were excluded from this study to prevent positive or negative modifications to original bone quality by these factors.

To the best of our knowledge, this is the first study to assess correlations between tooth mobility as assessed by Periotest with systemic BMD. Pearson's correlation coefficients revealed a significant and strong negative correlation between tooth mobility and BMD ($r = -0.527$). However, this correlation might have arisen under the influence of various confounders that are known to both affect and represent the periodontal status of teeth. Considering this, potential confounders were adjusted in further statistical analyses.

The fact that increased tooth mobility is a common symptom of advanced forms of plaque-associated periodontal disease is well-established. In this study, tooth

mobility was found to show a strong positive correlation with CAL and PD, in accordance with the findings of Schulte et al. (28). While deriving the correlation between tooth mobility and BMD; CAL and PD representing periodontal status of the individual were considered as important confounders and were thus controlled.

Another important factor confounding this correlation was plaque, which is known to represent an aetiological factor for periodontitis. Although PI was not significantly correlated with PTV score ($P > 0.05$), the present study adjusted this factor for assessments of the relationship between PTV score and T-score.

SBI has been used as an objective and subjective indicator of periodontal inflammation. Since SBI was not significantly correlated with PTV score, inflammation does not appear useful as a predictor of tooth mobility. This finding is supported by the findings of Schulte et al. (28), Ferris (29), Hotz et al. (30) and Donze et al. (31).

After adjusting for CAL, PD, PI, SBI and patient age as possible confounders, the correlation between tooth mobility and BMD was again found to be significant ($P < 0.05$), although the strength of correlation was considerably reduced (r = -0.3676). Regression modelling showed a change in PTV score for unit changes in T-score, CAL and PD. Based on regression modelling, the association between PTV score and T-score was again found to be significant. Regression analysis revealed an association between tooth mobility and skeletal BMD, which was further confirmed by one-way ANOVA and post hoc Tukey test, which showed significant differences between mean PTV scores for osteoporotic, osteopaenic and normal subjects in the present study population.

Within the limitations of this study, we concluded that systemic BMD may be considered as a factor associated with tooth mobility in this group of peri-menopausal women, although the correlation was not particularly strong. Further longitudinal studies with a larger sample size are required to confirm this relationship.

References

1. Mühlemann HR (1951) Periodontometry, a method for measuring tooth mobility. Oral Surg Oral Med Oral Pathol 4, 1220-1233.
2. Mühlemann HR (1954) Tooth mobility. The measuring method. Initial and secondary tooth mobility. J Periodontol 25, 22-29.
3. Persson R, Svensson A (1980) Assessment of tooth mobility using small loads. I. Technical devices and calculations of tooth mobility in periodontal health and disease. J Clin Periodontol 7, 259-275.
4. Peck WA, Conference Participants (1993) Consensus development conference: diagnosis, prophylaxis, and treatment of osteoporosis. Am J Med 94, 646-650.
5. National Institutes of Health (2000) Osteoporosis prevention, diagnosis, and therapy. NIH Consens Statement 17, 1-45.
6. Mazur IP (2006) Features of bone tissue metabolic processes in patients with generalized periodontitis in the period of disease exacerbation. Gerontologija 7, 173-179.
7. Wactawski-Wende J, Grossi SG, Trevisan M, Genco RJ, Tezal M, Dunford RG, Ho AW, Hausmann E, Hreshchyshyn MM (1996) The role of osteopaenia in oral bone loss and periodontal disease. J Periodontol 67, 1076-1084.
8. Genko RJ, Grossi SG (1998) Is estrogen deficiency a risk factor for periodontal disease? Compend Contin Educ Dent 22, S23-29.
9. Inagaki K, Kurosu Y, Kamiya T, Kondo F, Yoshinari N, Noguchi T, Krall EA, Garcia RI (2001) Low metacarpal bone density, tooth loss, and periodontal disease in Japanese women. J Dent Res 80, 1818-1822.
10. Payne JB, Zachs NR, Reinhardt RA, Nummikoski PV, Patil K (1997) The association between estrogen status and alveolar bone density changes in postmenopausal women with a history of periodontitis. J Periodontol 68, 24-31.
11. Reinhardt RA, Payne JB, Maze CA, Patil KD, Gallagher SJ, Mattson JS (1999) Influence of estrogen and osteopenia/osteoporosis on clinical periodontitis in postmenopausal women. J Periodontol 70, 823-828.
12. Streckfus CF, Johnson RB, Nick T, Tsao A, Tucci M (1997) Comparison of alveolar bone loss, alveolar bone density and second metacarpal bone density, salivary and gingival crevicular fluid interleukin-6 concentrations in healthy premenopausal and postmenopausal women on estrogen therapy. J Gerontol A Biol Sci Med Sci 52, M343-351.
13. Assuma R, Oates T, Cochran D, Amar S, Graves DT (1998) IL-1 and TNF antagonists inhibit the inflammatory response and bone loss in experimental periodontitis. J Immunol 160, 403-409.
14. Morishita M, Miyagi M, Iwamoto Y (1999) Effects of sex hormones on production of interleukin-1 by human peripheral monocytes. J Periodontol 70, 757-760.
15. Wactawski-Wende J (2001) Periodontal diseases and osteoporosis: association and mechanisms. Ann Periodontol 6, 197-208.

16. Elders PJ, Habets LL, Netelenbos JC, van der Linden LW, van der Stelt PF (1992) The relation between periodontitis and systemic bone mass in women between 46 and 55 years of age. J Clin Periodontol 19, 492-496.
17. May H, Reader R, Murphy S, Khaw KT (1995) Self-reported tooth loss and bone mineral density in older men and women. Age Ageing 24, 217-221.
18. Earnshaw SA, Keating N, Hosking DJ, Chilvers CE, Ravn P, McClung M, Wasnich RD (1998) Tooth counts do not predict bone mineral density in early postmenopausal Caucasian women. Int J Epidemiol 27, 479-483.
19. Weyant RJ, Pearlstein ME, Churak AP, Forrest K, Famili P, Cauley JA (1999) The association between osteopaenia and periodontal attachment loss in older women. J Periodontol 70, 982-991.
20. Miller SC (1938) Textbook of periodontia (oral medicine). P Blakiston, Philadelphia, 91.
21. Mühlemann HR, Son S (1971) Gingival sulcus bleeding – a leading symptom in initial gingivitis. Helv Odontol Acta 15, 107-113.
22. Schulte W, d'Hoedt B, Lukas D, Mühlbradt L, Scholz F, Bretschi J, Frey D, Gudat H, König M, Markl M, Quante F, Schief A, Topkaya A (1983) Periotest – a new measurement process for periodontal function. Zahnarztl Mitt 73, 1229-1240. (in German)
23. Schulte W (1988) The new Periotest method. Compend Suppl, S410-417.
24. Yankell SL (1988) Review of methods for measuring tooth mobility. Compend Suppl, S428-432.
25. Holbrook TL, Barrett-Connor E, Wingard DL (1988) Dietary calcium and risk of hip fracture: 14-year prospective population study. Lancet 2(8619), 1046-1049.
26. Vico L, Prallet B, Chappard D, Pallot-Prades B, Pupier R, Alexandre C (1992) Contribution of chronological age, age at menarche and menopause and of anthropometric parameters to axial and peripheral bone densities. Osteoporos Int 2, 153-158.
27. Bonaiuti D, Shea B, Iovine R, Negrini S, Robinson V, Kemper HC, Wells G, Tugwell P, Cranney A (2002) Exercise for preventing and treating osteoporosis in postmenopausal women. Cochrane Database Syst Rev 3, CD000333.
28. Schulte W, d'Hoedt B, Lukas D, Maunz M, Steppeler M (1992) Periotest for measuring periodontal characteristics – correlation with periodontal bone loss. J Periodont Res 27, 184-190.
29. Ferris RT (1966) Quantitative evaluation of tooth mobility following initial periodontal therapy. J Periodontol 37, 190-197.
30. Hotz P, Son S, Mühlemann HR (1971) The effect of marginal gingivitis on tooth mobility. Helv Odontol Acta 15, 103-106.
31. Donze Y, Krüger J, Ketterl W, Rateitschak KH (1973) Treatment of gingivitis with Cavitron or hand instruments: a comparative study. Helv Odontol Acta 17, 31-37.