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**ORIGINAL ARTICLE**

# Osteoporosis and periodontitis in older subjects participating in the Swedish National Survey on Aging and Care (SNAC-Blekinge)

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**Abstract**

***Objective.*** We assessed the relationships between (I) ultrasonography calcaneus T-scores (PIXI) and mandibular cortex characteristics on oral panoramic radiographs in older subjects; and (II) osteoporosis and periodontitis. ***Material and methods.*** We examined 778 subjects (53% women) aged 59–96 years. Periodontitis was defined by alveolar bone loss assessed from panoramic radiographs. ***Results.*** PIXI calcaneus T-values ≤–2.5 (osteoporosis) were found in 16.3% of women and in 8.1% of men. PIXI calcaneus T-values <–1.6 (osteoporosis, adjusted) were found in 34.2% of women and in 21.4% of men. The age of the subjects and PIXI T-values were significantly correlated in women (Pearson's $r = 0.37$, $P < 0.001$) and men (Pearson's $r = 0.19$, $P < 0.001$). Periodontitis was found in 18.7% of subjects defined by alveolar bone level ≥5 mm. Subjects with osteoporosis defined by adjusted PIXI T-values had fewer remaining teeth [mean difference 4.1, 95% confidence interval (CI) –1.1 to –6.5, $P < 0.001$]. The crude odds ratio (OR) of an association between the panoramic assessment of mandibular cortex erosions as a sign of osteoporosis and the adjusted T-value (T-value cut-off <–1.6) was 4.8 (95% CI 3.1–7.2, $P < 0.001$; Pearson $\chi^2 = 60.1$, $P < 0.001$). A significant OR between osteoporosis and periodontitis was only found in women for the T-value cut-off ≤–2.5 (crude OR 1.8, 95% CI 1.1–3.3, $P < 0.03$). ***Conclusions.*** An association between osteoporosis and periodontitis was only confirmed in women. The likelihood that the mandibular cortex index agrees with adjusted PIXI T-values is significant.

**Key Words:** *Calcaneus PIXI, osteoporosis, panoramic radiography, periodontitis*

## Introduction

Periodontitis is an oral infectious disease resulting in alveolar bone loss (ABL), and is a leading cause of tooth loss. High prevalence rates of periodontitis in older adults have been reported [1]. Periodontitis is associated with a systemic upregulation of pro-inflammatory cytokines resulting in osteoclast activation [2]. An index has been developed to assess osteoporosis by considering the cortical area of the mandible using panoramic radiographs [3]. Horizontal ABL has been associated with both positive self-reported osteoporosis and assessment of the cortical area from panoramic radiographs [4–6]. Tooth loss has also been linked to osteoporosis [7]. A computer-based system has been developed based on a combination of mandibular cortical width measured from dental panoramic radiographs and the osteoporosis index of risk (OSIRIS) determined during the diagnosis of osteoporosis [8].

The World Health Organization (WHO) has defined a bone mass density for the diagnosis of osteoporosis. A T-value is defined as the number of standard deviations (SDs) above or below the mean bone mineral density (BMD) value for young adults of the same gender. Osteoporosis is defined as a BMD that is 2.5 SDs below the average peak bone density in young adults [9–11]. Studies using dual X-ray

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absorptiometry suggest that osteoporosis can be diagnosed in 49–72% of women at the age of 70 years [11]. Several factors have been linked to a risk for osteoporosis, including female gender, age, ethnicity, diet, and lifestyle [12]. Periodontitis has also been linked to osteoporosis (for a review, see Renvert [13]). Data suggest that a PIXI calcaneus T-score ≤1.6 is an adequate cut-off to establish the prevalence of osteoporosis in population studies [14].

It appears that current clinical data on probing pocket depth and clinical attachment levels are either weakly associated with osteoporosis or not associated at all [15–18]. Studies in men have failed to demonstrate an association between osteoporosis and periodontitis as defined by the European Workshop on Periodontology [19]. In contrast, radiographic evidence of ABL defined by different bone loss criteria has been associated with osteoporosis [5,16,18,20]. Due to the chronic nature of both osteoporosis and periodontitis it seems more reasonable to define periodontitis by the extent of ABL, and then to correlate such findings with measures of osteoporosis derived from bone density measurements. There are few studies that have assessed the impact of different criteria for the definition of ABL using intra-oral or panoramic radiographs [21].

The aims of this study were to assess the relationships between (I) calcaneus PIXI T-scores using two different cut-off levels for the definition of osteoporosis with assessment of mandibular cortex characteristics on oral panoramic radiographs in older subjects; and (II) osteoporosis and periodontitis in older subjects.

## Material and methods

All subjects in this study were participants in the Swedish National Study on Aging and Care (SNAC), which is a population-based, multicenter, cohort study. The study has four participating centers in Sweden. One of the centers is Blekinge (SNAC-Blekinge), which also encompasses the Karlskrona community with 60,600 inhabitants. Briefly, the study sample was selected randomly in age cohorts of 60, 66, 72, and 78 years. In the age cohorts of 81, 84, 87, 90, 93, and 96 years, all inhabitants were included. The participants were invited by mail to take part in a medical, psychological, and dental examination by research staff in two sessions of 4-h each. The only inclusion criteria beyond the age restriction for participation in the study were: (I) completion of the medical examination and an available PIXI score; (II) having undergone a dental examination including a panoramic radiograph; and (III) not being edentulous.

The panoramic radiographs were taken at the research clinic center in Karlskrona using an orthopantomograph (Instrumentarium Dental, OP 100; Tuusula, Finland; standard exposure 75 kV/10 mA). The Research Ethics Committee at Lund University approved the study. All study subjects gave their signed informed consent. Subjects also signed an approved release form for their medical records. The study subjects were consecutively enrolled between September 2001 and April 2004.

### *Bone densitometry assessments*

All subjects underwent bone density assessment of the calcaneus area using a Lunar PIXI densitometer (Lunar, Madison, WI). Patients were classified as having osteoporosis by means of two different calcaneus T-value cut-off levels: (I) <–2.5 (WHO standard); and (II) <–1.6 (adjusted). The mean T-values for the left and right calcaneus were calculated and used in all the analyses performed.

### *Dental radiographic measurements from panoramic radiographs*

A modified panoramic bone score index was assigned based on the assessment of the cortical area below the mandibular foramen. The mandibular cortex on a panoramic dental radiograph was classified as '0', or a normal cortex, if it had an even, sharp endosteal margin. Osteoporosis was defined from the panoramic radiographs if evidence of lacunar resorption, endosteal cortical residues, or severe erosion (unequivocal porosity and diffuse cortical plate) was found. The examiner (R.E.P.) was experienced in analyzing panoramic radiographs [5,21,22], was not aware of the PIXI calcaneus T-values, and had no access to information about age, gender, smoking status, or the clinical periodontal conditions of the study subjects. The extent of ABL was measured at the mesial and distal aspects of all remaining teeth (root remnants excluded), and expressed both as the number and proportion of sites with an assessed distance between the alveolar bone level and the cement–enamel junction at the ≥5.0 mm cut-off level [21].

### *Statistics*

Descriptive and analytical statistics were used. Independent *t*-tests (equal variance not assumed), Pearson's correlation coefficients, and Mantel–Haenzel odds ratios (ORs) were also used in the analysis. Significance was declared at the $P < 0.05$ level. The SPSS PASW 18.0 program (SPSS Inc., Chicago, IL) was used for the analysis.

## Results

A total of 778 subjects (53% women) were enrolled in the study. All subjects were of Caucasian descent.

The mean age of the study population was 73.9 years (SD ± 9.4 years, range 59–96 years), and 65% were aged between 60 and 79 years. The subjects had, on average, 18.6 teeth (SD ± 7.5 teeth, range 1–32 teeth). In this study population, 48% reported a history of smoking.

*Evidence of periodontitis*

Overall, periodontitis, defined by ABL at ≥30% of measured sites, was found in 18.2% of the subjects. The proportion of sites with ABL ≥5.0 mm was significantly higher among those aged ≥80 years in comparison to the young-old subjects (age 60–79 years) for men (mean difference 10.9%, 95% CI 5.9–15.8%, $P < 0.001$) and women (mean difference 4.7%, 95% CI 0.0–9.7%, $P < 0.05$). Statistical analysis failed to demonstrate differences in the number of remaining teeth or in the extent of periodontitis by gender between the young-old subjects (Table I). In subjects aged ≥80 years, the extent of periodontitis was greater in men ($P < 0.01$), but with no gender difference for the number of remaining teeth (Table I).

*Evidence of osteoporosis according to PIXI calcaneus T-value and panoramic bone score*

The mean T-values in women and men aged <80 years were −0.7 (SD ± 1.2) and −0.4 (SD ± 1.3), respectively. This difference was significant (95% CI −0.1 to −0.6; $P < 0.01$).

The mean T-values in women and men aged ≥80 years were –1.7 (SD ± 1.4) and −0.8 (SD ± 1.4), respectively. This difference was also significant (95% CI −0.5 to –1.2; $P < 0.001$).

The proportional distributions of a diagnosis of osteoporosis by unadjusted and adjusted PIXI calcaneus T-value cut-off levels are presented in Table II. The PIXI calcaneus T-values were significantly lower in women (mean –1.0, SD ± 1.4) than in men (mean −0.5, SD ± 1.3) [mean difference 0.5, standard error (SE) of mean difference 0.1, 95% CI 0.03–0.07, $P < 0.001$]. Older women (≥80 years) and older men had lower PIXI calcaneus T-values than young-old women and young-old men ($P < 0.001$). Data on PIXI T-values by gender and age are presented in Table II. The relationships between PIXI calcaneus T-values and age and periodontal status are presented in Figure 1. The correlations between age and PIXI calcaneus T-values were significant for both women (Pearson's $r = 0.37$, $P < 0.001$) and men (Pearson's $r = 0.19$, $P < 0.001$).

The distributions of the adjusted PIXI calcaneus T-values by periodontal diagnosis and gender are presented in Figure 2. Analysis of the panoramic bone score index suggested that 18.5% of subjects would have osteoporosis (5.7% of the men and 29.9% of the women). Subjects with a panoramic bone score index suggesting osteoporosis had significantly lower adjusted PIXI calcaneus T-values (mean difference −0.34, SE of difference ± 0.0, 95% CI −0.3 to −0.4, $P < 0.001$). The diagnostic sensitivity that a panoramic bone score index correctly identified a calcaneus T-value of ≤2.5 was 0.48, with a specificity of 0.85. Thus, the positive predictive value was 0.29 and the negative predictive value was 0.91. The diagnostic sensitivity that a panoramic bone score index correctly identified a calcaneus T-value of <–1.6 was 0.56, with a specificity of 0.79. Thus, the positive predictive value was 0.36 and the negative predictive value was 0.89. The OR that the panoramic bone score index agreed with a T-value of <–2.5 was 4.2 (95% CI 2.7–6.6, $P < 0.001$; Pearson $\chi^2 = 43.9$, $P < 0.001$).

*Relationship between osteoporosis and tooth loss, smoking, and periodontitis*

Subjects with osteoporosis (PIXI calcaneus T-values <–2.5) had on average 12.1 teeth. Subjects who were not diagnosed as having osteoporosis had 16.6 teeth (mean difference 4.4, 95% CI 2.3–6.5, $P < 0.001$). Subjects with osteoporosis (PIXI calcaneus T-values <–1.6) had, on average, 13.0 (SD ± 9.2) teeth. Subjects who were not diagnosed as having osteoporosis had, on average, 17.1 (SD ± 9.3) teeth (mean difference 4.1, SE of difference 0.7, 95% CI 2.7–5.1, $P < 0.001$). Statistical analysis failed to demonstrate that the number of remaining teeth differed according to a history of smoking ($P = 0.77$). Statistical analysis also failed to demonstrate differences in PIXI T-values according to smoking history ($P = 0.34$). The extent of ABL was, however, associated with a history of smoking, with more severe bone loss among smokers ($P < 0.01$).

Table I. Periodontal status according to ABL (bone loss ≥5 mm at 30% of assessed sites) among women and men at ages of 60–79 and ≥80 years.

| | Age 60–79 years | | | Age ≥80 years | | |
|---|---|---|---|---|---|---|
| | Women | Men | *P* | Women | Men | *P* (95% CI) |
| Number of teeth (mean ± SD) | 18.3 ± 8.8 | 19.2 ± 8.9 | 0.25 | 10.3 ± 8.8 | 11.7 ± 8.6 | 0.20 |
| ABL ≥5 mm (mean % of sites ± SD) | 11.1 ± 8.4 | 13.5 ± 19.9 | 0.44 | 16.9 ± 21.4 | 24.4 ± 22.2 | <0.01 (1.6–13.4) |

Table II. Proportions of all subjects according to gender at two different age cut-off levels with a diagnosis of osteoporosis according to unadjusted and adjusted PIXI calcaneus scores and a diagnosis of periodontitis defined as ≥30% of sites with bone level values ≥5 mm.

| Variable | PIXI unadjusted T-value < –2.5 | PIXI calcaneus adjusted T-value < –1.6 | Periodontitis (30% bone loss score) |
|---|---|---|---|
| All subjects | 12.4 | 28.2 | 18.2 |
| All women | 16.3 | 34.2 | 13.8 |
| All men | 8.1 | 21.4 | 23.1 |
| Women aged <80 years | 8.2 | 21.4 | 12.4 |
| Women aged ≥80 years | 31.3 | 58.2 | 17.1 |
| Men aged <80 years | 13.1 | 16.7 | 16.7 |
| Men aged ≥80 years | 5.4 | 30.0 | 36.3 |

The statistical analysis failed to demonstrate an association between osteoporosis defined by a T-value of ≤–2.5 and periodontitis defined by ABL ≥5 mm at ≥30% of sites for men. In women, the same definitions of osteoporosis and periodontitis approached a significant association, with a common OR of 1.8 (95% CI 1.1–3.3, $P = 0.03$). When the PIXI calcaneus T-value cut-off of <–1.6 was used to define osteoporosis, statistical analysis failed to define a significant common odds risk for periodontitis in relation to osteoporosis in both men and women.

Analysis by independent *t*-test (equal variance not assumed) demonstrated that women with periodontitis had lower PIXI calcaneus T-values than women who did not have periodontitis as defined by ABL ≥5 mm at ≥30% of sites (mean difference 0.6, SE ± 0.21, 95% CI −0.2 to –1.1, $P < 0.01$). A similar difference was found for men (mean difference 0.7, SE of difference ± 0.2, 95% CI −0.2 to –1.1, $P < 0.01$).

## Discussion

The present study presents clinical data in regard to osteoporosis and oral conditions collected from older subjects participating in a national study of health. The data represent all subjects who met the inclusion criteria. Due to the old age of many of the participants, transportation at no cost and access to a clinical research facility that could manage their needs

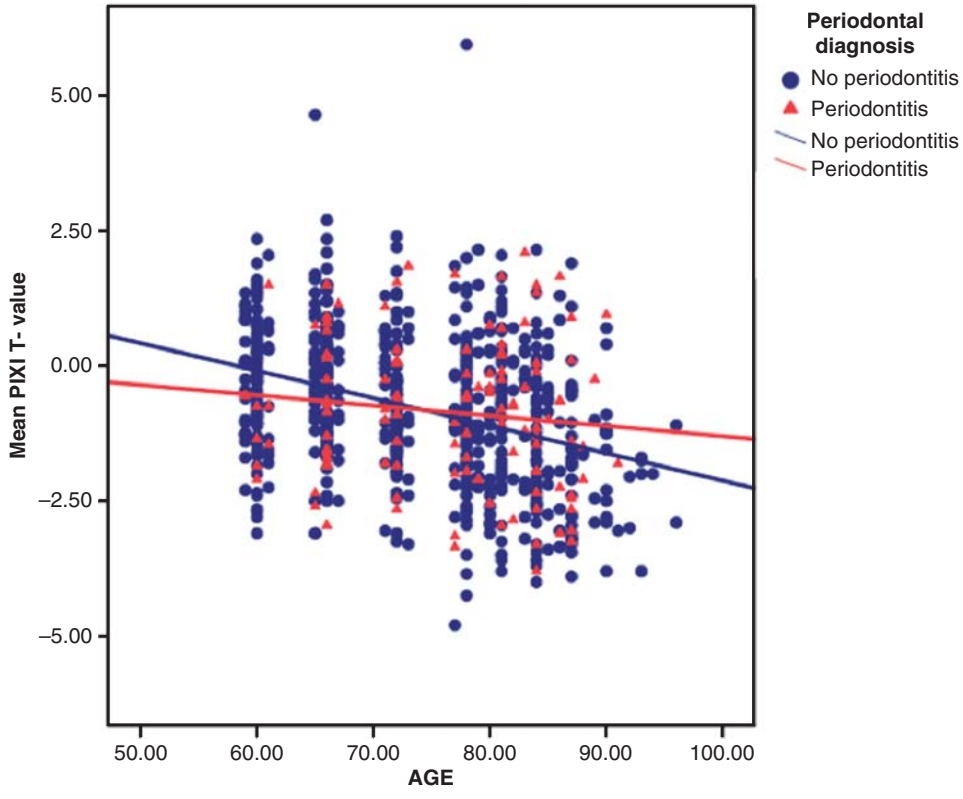


Figure 1. The relationship between PIXI calcaneus T-values and the age and periodontal status of the subjects is presented in a scatterplot diagram.

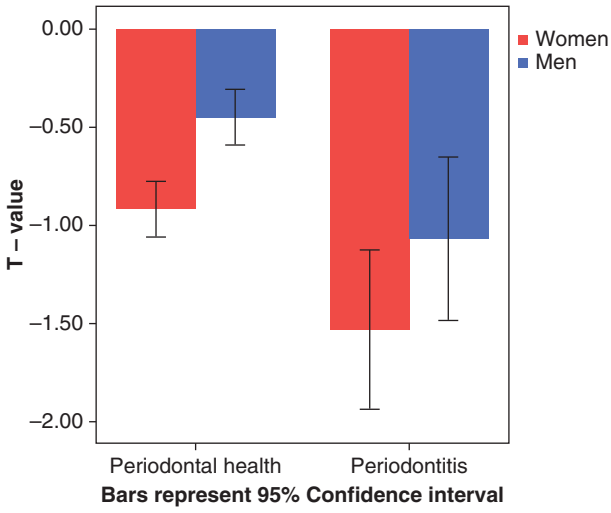


Figure 2. Distribution of PIXI calcaneus T-values by periodontal diagnosis and gender. Bars represent 95% CIs.

facilitated the study. Thus, the data represent older subjects who were mobile enough to participate in the study. This means that subjects who were immobile due to medical conditions were not included. This would suggest that the associations between periodontitis and osteoporosis might be greater than those reported here. Nevertheless, the present data represent those subjects who could be examined.

The prevalence of osteoporosis in the present study was consistent with other reports in which a PIXI calcaneus cut-off value of ≤–1.6 was used to define cases with osteoporosis [8,23,24]. The prevalence of osteoporosis observed in the present study was also in agreement with other data that have been presented elsewhere for a Scandinavian population [25]. Many studies of osteoporosis use lumbar spine and hip dual X-ray absorptiometry for the assessment of osteoporosis. In the present study we used calcaneus PIXI assessments. PIXI calcaneus bone assessments using a T-score threshold of ≤–2.5 for classification of osteoporosis represent the WHO definition of osteoporosis [9]. The adjusted T-score for PIXI (< –1.6) should be considered in order to avoid false-negative scores [26]. In the present study the use of the adjusted PIXI T-values demonstrated much higher prevalences of osteoporosis than when the T-value of ≤–2.5 was used as the cut-off for a diagnosis of osteoporosis. This was especially the case for older women and older men. In addition, further adjustments of the WHO criteria for populations of older Swedish women and men should most likely increase the proportion of subjects with a diagnosis of osteoporosis [27].

Varying definitions of both periodontitis and osteoporosis have hindered studies on the relationship between these two conditions [28]. The use of ABL at the 4- and 5-mm cut-off levels as a definition of periodontitis was based on data demonstrating that these cut-off levels identify subjects with periodontitis (i.e. >2 SDs above the mean value for subjects aged >50 years) [22]. It has been assumed that differences in magnification factors would mean that a 4-mm distance between the cement–enamel junction and the bone level on intra-oral radiographs would correspond to a 5-mm distance when panoramic radiographs are being used [21]. In the present study the 5-mm distance was used and this should be considered as a conservative measure to avoid underestimating periodontitis in older subjects. We have used the 4-mm ABL at ≥30% of assessed sites in studies on the association between acute coronary syndrome and periodontitis using intra-oral radiographs and have found this method for the definition of periodontitis to be useful [22].

The prevalence of periodontitis defined as ABL in the present study cohort was similar to what has been reported elsewhere among older subjects [29–31]. The extent of ABL in the present study differed more between young-old and old-old men than between young-old and old-old women. Why older men seem to progress to greater periodontitis than older women as they get older is difficult to explain. It is possible that bone loss may start earlier in life in women as an effect of hormonal changes and then level off, whereas men will experience ABL later in life as a result of hormonal changes and effects on bone remodeling [32].

Many studies assessing the relationship between periodontitis and osteoporosis have included younger subjects than those included in the present study [7,33–35]. The ORs of an association between periodontitis and osteoporosis have, in most publications, not been strong. This might be a consequence of the fact that many studies have not included a sufficient number of older subjects. The difference in periodontitis did not seem to differ as much between the younger and older groups of women, although the severity of osteoporosis as reflected by the T-scores was significantly higher in older women.

The biological plausibility that periodontitis can be a factor in the development and progression of osteoporosis has been considered. The prevalence of specific bacterial infections in periodontitis has been found specifically among postmenopausal overweight women with ABL [35]. The infectious etiology of periodontitis may induce an explanatory systemic cytokine response to bone changes [2]. One of the links between periodontal inflammation and osteoporosis may be the systemic release of osteoclast-activating cytokines, such as interleukin (IL)-1, -6, -11, and 17, prostaglandin $E_2$, and tumor necrosis factor-α [36]. Cytokine regulation in infection might be involved in both postmenopausal osteoporosis and inflammation-induced remodeling in periodontitis [37].

Some cross-sectional studies have failed to demonstrate that tooth loss is associated with

osteoporosis [38–40]. The present study demonstrated that subjects with osteoporosis had fewer remaining teeth, which is in agreement with other studies [33,34,41]. The reason why periodontitis was weakly associated with osteoporosis in the present study may be that subjects with less than full dentition had lost those teeth due to periodontitis. They were therefore identified as periodontally healthy subjects, whereas they had had underlying periodontitis, which should have linked them with their status of osteoporosis.

The mandibular cortex index has been used in several studies using panoramic radiography to identify subjects who might have osteoporosis [3–6]. Clearly, this index is not the gold standard for assessment of osteoporosis [9–11]. Panoramic radiography provides an overview of hard tissues in the facial region and is common in dentistry. The mandibular cortex index described by Klemetti [3] utilizes access to the mandibular cortex area to assess for one density using an index system similar to other three- or four-scale indices common to dentistry. The index should be considered as a screening tool and not as a definitive measure of osteoporosis. Recent data confirm that an eroded appearance of the inferior mandibular cortex in panoramic radiographs is associated with low skeletal BMD [42,43].

Panoramic radiography is commonly available in dentistry. In addition to traditional assessments of teeth and jaw conditions, such radiographs can also be used to screen for evidence of osteoporosis. In conclusion, the association between osteoporosis and periodontitis was only confirmed in women. The likelihood that the mandibular cortex index agrees with adjusted PIXI T-values is significant.

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