

Accepted Manuscript

Prediction of Hip and Hand Fractures in older persons with or without a diagnosis of Periodontitis

G. Rutger Persson, Johan Berglund, Rigmor E. Persson, Stefan Renvert

PII: S8756-3282(10)01704-7
DOI: doi: [10.1016/j.bone.2010.09.237](https://doi.org/10.1016/j.bone.2010.09.237)
Reference: BON 9039

To appear in: *Bone*

Received date: 27 April 2010
Revised date: 25 August 2010
Accepted date: 29 September 2010



Please cite this article as: Persson G. Rutger, Berglund Johan, Persson Rigmor E., Renvert Stefan, Prediction of Hip and Hand Fractures in older persons with or without a diagnosis of Periodontitis, *Bone* (2010), doi: [10.1016/j.bone.2010.09.237](https://doi.org/10.1016/j.bone.2010.09.237)

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Prediction of Hip and Hand Fractures in older persons with or without a diagnosis of Periodontitis

G. Rutger Persson^{1,2,3,4}

Johan Berglund^{5,6}

Rigmor E. Persson^{1,2}

Stefan Renvert^{4,5,7}

¹ Department of Periodontology, University of Bern, Bern, Switzerland

² Department of Oral Medicine, University of Washington, Seattle WA

³ Department of Periodontics, University of Washington, Seattle WA

⁴ Department of Health Sciences, Kristianstad University, Kristianstad, Sweden

⁵ Blekinge Institute of Technology, Karlskrona, Sweden

⁶ Department of Clinical Sciences, Lund University, Malmö, Sweden

⁷ School of Dental Sciences, Trinity College, Dublin, Ireland

Key words: osteoporosis, fracture, periodontitis, risk, older

Running Title: Osteoporosis and periodontitis

Number of words in abstract: 207

Number of words in manuscript: 2675

Tables: 2

Figures: 2

Abstract

Purpose: In a prospective study, we assessed if a diagnosis of osteoporosis and periodontitis could predict hip and hand fractures in older persons. **Materials and Methods:** Bone density was assessed by a Densitometer. Periodontitis was defined by evidence of alveolar bone loss. **Results:** 788 Caucasians (52.4 % women, overall mean age: 76 years, S.D. \pm 9.0, range: 62 to 96) were enrolled and 7.4 % had a hip/hand fracture in 3 years. Calcaneus PIXI T-values < -1.6 identified osteoporosis in 28.2 % of the older persons predicting a hip/hand fracture with an odds ratio of 3.3:1 (95 % CI: 1.9, 5.7, $p < 0.001$). Older persons with osteoporosis had more severe periodontitis ($p < 0.01$). Periodontitis defined by $\geq 30\%$ of sites with ≥ 5 mm distance between the cemento-enamel junction (CEJ) to bone level (ABL) was found in 18.7 % of the older persons predicting a hip/hand fracture with an odds ratio of 1.8:1 (95 % CI: 1.0, 3.3, $p < 0.05$). Adjusted for age, the odds ratio of a hip/hand fracture in older persons with osteoporosis (PIXI T value < -2.5) and periodontitis was 12.2:1 (95 % CI: 3.5, 42.3, $p < 0.001$). **Conclusions:** Older persons with osteoporosis and periodontitis have an increased risk for hip/hand fractures.

1. Introduction

Osteoporosis is defined as a skeletal disorder, and characterized by compromised bone strength predisposing a person to an increased risk of bone fractures. In older persons with osteoporosis the bone mineral density is reduced, and the bone architecture is disrupted. Osteoporosis is a disease that is more prevalent in older persons, and more prevalent among older persons in Scandinavia and the United States than elsewhere [1-4]. Several factors have been associated with an increased risk for osteoporosis, including female gender, age, ethnicity, diet, and lifestyle [5]. Studies using dual X-ray absorptiometry suggest that osteoporosis can be diagnosed in 49-72 % of Scandinavian women at the age of 70 [6]. The prevalence of osteoporosis depends on assessment criteria for peak bone mass and where bone density (i.e. hip, spine, and forearm) assessments are performed [6].

Osteodensitometry is the standard method for measuring bone mineral density. The World Health Organization (WHO) has defined the diagnosis of osteoporosis using bone mass density (BMD) as a bone density T value below 2.5 standard deviations (T value) below normal peak values for young persons [7,8]. The use of a standard T-value cut-off (WHO standard) to define osteoporosis by bone density measurements should be viewed with caution as differences in peak bone mass density may vary by ethnicity and country with earlier peak bone mass density at younger age in Scandinavians [9].

Calcaneus assessment of bone density is a convenient method to survey older persons at risk for osteoporosis [10,11]. Data also suggest that a calcaneus T-score <-1.6 is an adequate cut-off level to establish the prevalence of osteoporosis in population studies [12]. Different methods in assessing the risk for hip fractures as an effect of

osteoporosis have been tested. Bone mineral density measurement at the femoral neck with Dual X-ray absorptiometry (DXA) has been identified as a strong predictor of hip fractures both in men and women with a similar predictive ability [13]. Ultrasound assessments of the fingers can also identify men with risk for hip fractures [14]. Data suggest that assessments of peripheral (calcaneus) bone density (PIXI T-values) can predict future fractures in older women [15]. Data have also suggested that body mass index $< 24 \text{ kg/m}^2$ would be predictive of future fractures [16].

Periodontitis results in alveolar bone loss. High prevalence rates of periodontitis in older persons have been reported [17]. Several diseases including osteoporosis have been associated with periodontitis [18-22]. One explanatory mechanism why periodontitis may enhance the risk for osteoporosis could be a systemic up-regulation of pro-inflammatory cytokines resulting in osteoclast activation increasing the risk for osteoporosis [23]. Specific periodontal infections may explain not only alveolar bone loss, but may also be linked to systemic inflammation and body mass index (BMI) in postmenopausal women [20]. Tooth loss has also been linked to osteoporosis [22,24]. The perception of an association between osteoporosis and periodontitis is, however, controversial [25]. The risk for osteoporosis is generally believed to be higher in women. Studies have failed to confirm an association between osteoporosis and periodontitis in older men [26]. This may, in part, be the result of a high degree of undiagnosed osteoporosis in older men.

Hip and other fractures as the consequence of osteoporosis have serious impact on quality of life for older persons [27]. New methods to diagnose osteoporosis, to predict

risks for bone fractures, and allow preventive medications may therefore enhance life conditions for older persons.

The aim of the present study was to assess if individuals with both a diagnosis of osteoporosis and periodontitis were at higher risk for fractures than older persons with either a diagnosis of osteoporosis or periodontitis alone.

2. Materials and methods

The Ethics Committee at Lund University, Sweden approved the study. Informed consent was obtained from all participants who were examined. All of the participants signed consent allowing us to review medical records. The participants of the present study were participants of the Swedish National Study on Aging and Care Blekinge (SNAC-B). They were enrolled between 2001 and 2004. The study sample was selected randomly in persons between 60 and 96 years of age including 788 participants who were able to have a panoramic radiograph taken. The panoramic radiographs were taken at the research clinic center in Karlskrona using an orthopantomograph (Orthopantomograph OP 100, Tuusula, Finland, standard exposure 75 kV/10 mA). Routine medical and dental examinations were performed. A diagnosis of osteoporosis was defined by calcaneus bone density measurements. We defined a diagnosis of periodontitis by radiographs and assessments of ABL [28].

2.1. Bone densitometry

All study participants underwent DXA of the right and left heel using a Lunar PIXI densitometer (GE Lunar, Madison, WI). Mean values were calculated and used. The study participants were classified as having osteoporosis if they had a T-value < -2.5

(WHO standard). We also used the T-value < 1.6 to account for PIXI calcaneus values adjusting for the differences between DXA hip and PIXI calcaneus values.

2.2 Dental radiographic measurements

Periodontitis definition

Periodontitis was defined from panoramic radiographs, and based on inter-proximal measurements of the distance between the alveolar bone level and CEJ (ABL) at ≥ 4.0 mm, and ≥ 5.0 mm. If 30 % of sites presented with this extent of bone loss we assigned a diagnosis of periodontitis [28]. When conducting all assessments, the examiners did not have information on PIXI T-values or the diagnosis of osteoporosis.

2.3 Statistical methods

Descriptive statistics were used to present the study material. Independent T-test and the Mantel-Haenszel odds ratio were used to assess the data. The SPSS PASW statistical software 18.0 (SPSS Inc. Chicago IL) for MAC was used in the analysis.

3. Results

A total of 788 Caucasians (52.4 % women) were enrolled. The mean age of these persons was 76 years (S.D. ± 9.0 , range: 62 to 96), and with 41.9 % of those being older than 79 years of age.

Over the three year study period, 4.1 % of these older persons (28/675) had a hip, and 3.7 % of them (25/675) had a hand fracture yielding a subject based 7.4 % combined incidence fracture rate. Those who reported that they were very careful (not walking in darkness, minor activities) included 116 older persons with 17 fractures (14.7 % of the

individuals). Those who reported that they were very active (climbing on ladders, walking in darkness, not specifically careful) included 526 older persons who experienced 33 fractures (6.2 % of the individuals).

3.1. Prevalence of osteoporosis, and relationship to body mass index (BMI)

In the present study population, the PIXI calcaneus T values appeared with normal distribution characteristics. With all the older persons included, a PIXI calcaneus T value < -2.5 (osteoporosis) was found in 10.4 % of the older persons, and in 28.2 % of them when the PIXI < -1.6 T value cut off level was used. A PIXI calcaneus T value < -1.6 was found in 34.2 % of the women, and in 21.4 % of the men. Analysis by independent t-test demonstrated significantly lower PIXI calcaneus T values among women (mean diff: -0.50, S.E. 0.1, 95% CI: -0.7, -0.3, $p < 0.001$), and confirming a higher prevalence of osteoporosis among women. In the older cohort of persons (≥ 80 years), the prevalence of osteoporosis by the cut off PIXI T-value < -2.5 was 16.9 %, and 44.8 % if the PIXI < -1.6 was used. Older persons had significantly lower calcaneus PIXI T-values (mean diff: -0.8 S.E. mean: 0.1, 95 % CI: -1.0, -0.6, $p < 0.001$).

The mean body weight of women and men were 70.2 kg (S.D. \pm 12.2), and 82.1 kg (S.D. \pm 11.6), respectively. The mean length of women and men were 160.7 cm (S.D. \pm 5.8), and 174.1 cm (S.D. \pm 6.5), respectively. The mean BMI for women was 27.2 Kg/m² (S.D. \pm 4.6, range: 17.3 – 46.8), and the BMI for men was 27.1 Kg/m² (S.D. \pm 3.7, range: 17.8-38.0).

Data analysis demonstrated that women with a PIXI T – value < -1.6 had a significantly lower BMI score than in women not diagnosed with osteoporosis (BMI mean diff: 3.3 Kg/m², S.E. mean: 0.4, 95 % CI: 2.4, 4.1, $p < 0.001$). A similar difference was also found in

men (BMI mean diff: 2.5 Kg/m², S.E. mean: 0.4, 95 % CI: 1.7, 3.3, $p < 0.001$). BMI in relation to a diagnosis of osteoporosis and periodontitis by gender is illustrated (Figure 1).

3.2 Prevalence of periodontitis and relationship to body mass index (BMI)

Based on measurements of the distance between CEJ to alveolar bone level ≥ 4 mm at ≥ 30 % of such sites, 34.4 % of the 675 older dentate persons in the present study had a diagnosis of periodontitis. If a 5 mm cut-off level was used, 18.7 % of the older dentate persons presented with evidence of periodontitis. Statistical analysis failed to demonstrate differences in the prevalence of periodontitis by gender. The older dentate persons (>79 years) had significantly more periodontitis than the younger older dentate persons ($p < 0.001$). Statistical analysis failed to demonstrate differences in BMI scores in relation to a diagnosis of periodontitis ($p = 0.65$ in women, and $p = 0.91$ in men).

3.3 Relationship between osteoporosis, and tooth loss

Data on calcaneus PIXI T- values, and the number of remaining teeth categorized by age are presented (Table1). The older dentate persons with osteoporosis (PIXI T values < -1.6) had, on average 16.6 teeth (S.D. ± 7.8), whereas non-osteoporosis older dentate persons (PIXI T values ≥ -1.6) had, on average 19.3 teeth (S.D. ± 7.3), (mean diff: 2.7, S.E. diff: 0.7, 95 % CI: 1.4, 4.0, $p < 0.001$).

The edentulous older persons ($n = 112$) had, on average a calcaneus PIXI T-value of -1.3 (S.D. ± 1.5 , range: - 4.8 to 6.0) whereas the older dentate persons ($n = 676$) had, on average a PIXI T-value of 0.7 (S.D. ± 1.3 , range: 1.3 to 4.7) (mean diff: 0.7, S.E. diff: 0.2, 95 % CI: -0.9, -0.3, $p < 0.001$). When the PIXI T < 2.5 was used as the cutoff level, 24.1 %

of the older edentulous persons were identified as having osteoporosis. When the PIXI T value -1.6 level was used as the cut-off level, 44.6 % of these older persons were diagnosed as having osteoporosis. When the PIXI T < 2.5 was used as the cutoff level, 9.6 % of the dentate older persons were identified as having osteoporosis whereas 26.3 % of them had osteoporosis if the PIXI T -value cutoff -1.6 level was used as the cut-off value. Dentate older persons had significantly higher PIXI T- values than edentulous older persons both at the T - 1.6 and the T- 2.5 cutoff levels ($p < 0.001$).

3.4 Periodontitis and evidence of osteoporosis

The differences in calcaneus PIXI T-values in women and men with, or without a diagnosis of periodontitis are illustrated (Figure 2). Using the calcaneus PIXI T < - 1.6 cut-off value for the definition of osteoporosis, the proportion of sites with ABL \geq 5 mm was higher in older persons with osteoporosis (mean diff: 4.5 %, \pm S.E. 3.1, 95 % CI: - 1.7, - 7.6, $p = 0.01$). The % of sites with ABL \geq 4 mm was also significantly higher among those with a diagnosis of osteoporosis (mean diff: 5.3 %, S.E. \pm 2.2, 95 % CI: -1.1, -9.5, $p = 0.01$).

3.5 Hip and hand fractures in relation to a diagnosis of osteoporosis and periodontitis

The distribution of fractures in women and men by osteoporosis and periodontitis diagnoses are presented (Table 1). The odds ratios of an association between osteoporosis (PIXI T-value cut off < - 1.6) and a fracture within the study period are presented as unadjusted and adjusted by gender, and age (Table 2). The odds ratios of an association between periodontitis (ABL \geq 5mm at 30 % of sites assessed) and an experienced fracture are presented as unadjusted and specifically adjusted by gender and age (Table 2). The combined osteoporosis and periodontitis definition yielded the

highest odds ratio in predicting a future fracture. This was specifically identified when the PIXI T < -2.5 cut-off level was used to define osteoporosis in combination with the periodontitis diagnosis in women.

4. Discussion

Early detection of a risk for osteoporosis is important to avoid fractures. The prevalence of osteoporosis identified in the present study is consistent with what has been presented elsewhere for the region [6]. In the present study, considering hip and hand fractures only, the incidence rate of fractures was 7.4 % over the three-year period. Those older persons who were most physically active experienced a lower rate of fractures than the less active/cautious older persons. The findings in the present study are consistent with other studies demonstrating that osteoporosis related fractures increases with age [29], and that older women are at higher risk for osteoporosis related fractures [16].

In the present study, a standard device for assessment of bone density was used in identifying older persons with osteoporosis. Medical records were reviewed for all older persons included in the study to identify those who had experienced fractures within the 3 year period. The low incidence rate of fractures among older persons with osteoporosis in the present study may be explained by the short follow up period.

Older persons with periodontitis had worse calcaneus PIXI T - values than those without periodontitis. This finding is consistent with several other studies [18-22]. Many studies assessing the relationship between periodontitis and osteoporosis have included persons who were younger than those included in the present study, or did not belong to

risk groups, which may explain why conclusions on the relationship between osteoporosis and periodontitis are disputed [30-34]. The present study identified a strong relationship between the periodontitis and osteoporosis, and especially for the risk of a future fracture if the older person had a diagnosis of both osteoporosis and periodontitis. Screening for osteoporosis using panoramic radiographs has been shown to be helpful in identifying postmenopausal women at risk for osteoporosis [35]. Radiographic evidence of changes in the mandibular cortical bone has been associated with periodontitis and linked to osteoporosis [36]. In the present study, we identified that specifically older men with periodontitis were at risk for fractures. This differs from the perception of a lack of association between periodontitis and osteoporosis in men [26].

Recent data suggest that the association between alveolar bone loss and osteoporosis is obvious for older women (+79). This association is less obvious in younger-old women [8]). A large number of factors, including genetic factors, nutrition, age and hormonal changes, socio-economic factors, smoking and alcohol intake have an impact on both osteoporosis and periodontitis [27]. The increased risk for fractures in subject with both osteoporosis and periodontitis remained also when adjusted for age.

The present study, also demonstrated that older persons with osteoporosis had fewer remaining teeth. This finding is in agreement with other studies [22, 24, 37-39].

This may, however, be explained in part by the fact that with increasing age older persons may lose teeth and perhaps to a greater extent due to periodontitis. Our data suggest that the combined periodontitis and osteoporosis diagnosis can identify older persons at risk for hip and hand fractures. It should, however, be recognized that

fracture trauma is not only a matter of osteoporosis but that many other factors can be explanatory to hand and hip fractures [4]. The present study showed that older persons with periodontitis also had a diagnosis of osteoporosis at a higher rate than older persons without a diagnosis of periodontitis. The fact that edentulous older persons had lower PIXI T values than dentate older persons may be explained by tooth loss due to periodontitis. When combining the diagnosis of periodontitis and osteoporosis at the PIXI T value < -2.5 the likelihood of a future fracture demonstrated a substantial increase.

The prevalence of hip/hand fracture in older women is high. Older persons with both osteoporosis and periodontitis are at greater risk for future fractures than those with either osteoporosis or periodontitis alone, or without a diagnosis of osteoporosis or periodontitis.

5. Source of funding:

The Ministry of Health and Social Affairs, Sweden, and the participating County Councils, Municipalities and University Departments supported the Swedish National study on Aging and Care, SNAC, (www.snac.org)

6. Acknowledgements

We are grateful to the participants, the participating counties and municipalities.

7. Conflict of interest

The authors listed comply with the ICJME guidelines for authorship and none of the authors have, in any aspect of the reported study, a conflict of interest.

References:

- [1] Smeets-Goevaers CG, Lesusink GL, Papapoulos SE, Maartens LW, Keyzer JJ, Weerdenburg JP et al. The prevalence of low bone mineral density in Dutch perimenopausal women: The Eindhoven perimenopausal osteoporosis study. *Osteoporos Int* 1998; 8:404-409.
- [2] Felsenberg D, Silman AJ, Lunt M, Armbrecht G, Ismail AA, Finn JD. Incidence of vertebral fractures in Europe: results from a European prospective osteoporosis study (EPOS). *J Bone Min Res* 2002;17: 716-724.
- [3] Langsetmo L, Hanley DA, Kreiger N, Jamal SA, Prior J, Adachi JD, et al. Geographic variation of bone mineral density and selected risk factors for prediction of incident fracture among Canadians 50 and older. *Bone* 2008; 43: 672-678.
- [4] Lewiecki EM, Baim S, Siris ES. Osteoporosis care at risk in the United States. *Osteoporos Int* 2008;19: 1505-1509.
- [5] Cummings SR. Treatable and untreatable risk factors for hip fracture. *Bone* 1996; 18:165S-167S.
- [6] Löfman O, Larsson L, Toss G. Bone mineral density in diagnosis of osteoporosis: reference population, definition of peak bone mass, and measured site determine prevalence. *J Clin Densitom* 2000; 3:177-186.
- [7] WHO. Assessment of osteoporotic fracture risk and its role in screening for postmenopausal osteoporosis. WHO Technical reports series WHO, Geneva

- [8] Blake GM, Fogelman I. Role of dual-energy X-ray absorptiometry in the diagnosis and treatment of osteoporosis. *J Clin Densitom* 2007; 10:102-110.
- [9] Ribom EL, Ljunggren O, Mallmin H. Use of a Swedish T-score reference population for women causes a two-fold increase in the amount of postmenopausal Swedish patients that fulfill the WHO criteria for osteoporosis. *J Clin Densitom* 2008;11:404-411.
- [10] Pearson D, Masud T, Sahota O, Earnshaw S, Hosking D. A comparison of calcaneal dual-energy X-ray absorptiometry and calcaneal ultrasound for predicting the diagnosis of osteoporosis from hip and spine bone densitometry. *J Clin Densitom* 2003;6:345-352.
- [11] Liang MT, Bassin S, Dutto D, Braun W, Wong N, Pontello AM, Cooper DM, Arnaud SB. Bone mineral density and leg muscle strength in young Caucasian, Hispanic, and Asian women. *J Clin Densitom* 2007;10:157-164.
- [12] Pérez-Castrillón JL, Martín-Escudero JC, del Pino-Montes J, Blanco FS, Martín FJ, Paredes MG, et al. Prevalence of osteoporosis using DXA bone mineral density measurements at the calcaneus: cut-off points of diagnosis and exclusion of osteoporosis. *J Clin Densitom*. 2005;8:404-408.

- [13] Johnell O, Kanis JA, Oden A, Johansson H, De Laet C, Delmas P, et al. International variations in hip fracture probabilities: implications for risk assessment. *J Bone Min Res* 2002;17:1237-1244.
- [14] Ekman A, Michaëlsson K, Petréen-Mallmin M, Ljunghall S, Mallmin H. Dual X-ray absorptiometry of hip, heel ultrasound, and densitometry of fingers can discriminate male patients with hip fracture from control subjects: a comparison of four different methods. *Journal of Clinical Densitom* 2002;5: 79-85.
- [15] Barr RJ, Adebajo A, Fraser WD, Halsey JP, Kelsey C, Stewart A, Reid DM. Can peripheral DXA measurements be used to predict fractures in elderly women living in the community? *Osteoporos Int* 2005;16:1177-1183.
- [16] Schneider DL, Worley K, Beard MK, Iannini M, Ko M, McCallum J, Pulicharam R, Steinbuch M. The Primary Care Osteoporosis Risk of Fracture Screening (POROS) study: Design and baseline characteristics. *Contemp Clin Trials*. 2010 Apr 8. [Epub ahead of print]
- [17] Krustrup U, Petersen E. Periodontal conditions in 35-44 and 65-74-year-old adults in Denmark. *Acta Odont Scand* 2006;64:65-73.
- [18] Jeffcoat M,K. Osteoporosis: a possible modifying factor in oral bone loss. *Ann Periodontol* 1998;3:312-321.

- [19] Persson RE, Hollender LG, Persson GR. Assessment of alveolar bone levels from intraoral radiographs in subjects between ages 15 and 94 years seeking dental care. *J Clin Periodontol* 1998;25:647-654.
- [20] 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;87:323-327.
- [21] Swoboda JR, Kiyak HA, Darveau R, Persson GR. Correlates of periodontal decline and biologic markers in older adults. *J Periodontol* 2008;79:1920-1926.
- [22] Moedano DE, Irigoyen ME, Borges-Yáñez A, Flores-Sánchez I, Rotter RC. Osteoporosis, the risk of vertebral fracture, and periodontal disease in an elderly group in Mexico City. *Gerodontology* 2009 [Epub ahead of print]
- [23] Golub LM, Payne JB, Reinhardt RA, Nieman G.. Can systemic diseases co-induce (not just exacerbate) periodontitis? A hypothetical "two-hit" model. *J Dent Res* 2006; 85:102-105.
- [24] Vlasiadis KZ, Damilakis J, Velegrakis G.A., Skouteris, C.A., Fragouli, I., Goumenou, et al. Relationship between BMD, dental panoramic radiographic findings and biochemical markers of bone turnover in diagnosis of osteoporosis. *Maturitas* 2008;20:226-233.

- [25] Dervis E. Oral implications of osteoporosis. *Oral Surg Oral Med Oral Pathol Oral Radiol & Endodont* 2005;100:349-356.
- [26] Phipps KR, Chan BK, Madden TE, Geurs NC, Reddy MS, Lewis CE, et al. Longitudinal study of bone density and periodontal disease in men. *J Dent Res* 2007 86:1110-1114.
- [27] Hiligsmann M, Rabenda V, Gathon HJ, Ethgen O, Reginster JY. (2010) Potential clinical and economic impact of nonadherence with osteoporosis medications. *Calcif Tissue Int* 86:202-210.
- [28] Persson RE, Hollender LG, Persson GR. Assessment of alveolar bone levels from intraoral radiographs in subjects between ages 15 and 94 years seeking dental care. *J Clin Periodontol*. 1998;25:647-654.
- [29] Curran D, Maravic M, Kiefer P, Tochon V, Fardellone P. Epidemiology of osteoporosis-related fractures in France: A literature review. *Joint Bone Spine*. 2010 (in press).
- [30] 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;19:492-496.
- [31] Pilgram TK, Hildebolt CF, Dotson M, Cohen SC, Hauser JF, Kardaris E. Attachment loss with postmenopausal age and smoking. *J Periodont Res* 1997; 32:619-625.

- [32] Pilgram TK, Hildebolt CF, Dotson M, Cohen SC, Hauser JF, Kardaris E., Tooth counts do not predict bone mineral density in early postmenopausal Caucasian women. EPIC study group. *Int J Epidemiol* 1998;27:479-483.
- [33] Takaishi Y, Okamoto Y, Ikeo T, Morii H, Takeda M, Hide K, et al. Correlations between periodontitis and loss of mandibular bone in relation to systemic bone changes in postmenopausal Japanese women. *Osteoporosis Int* 2005;16:1875-1882.
- [34] Geurs N. Osteoporosis and periodontal disease. *Periodontology* 2000 2007;44:29-43.
- [35] Taguchi, A., Asano, A., Ohtsuka, M., Nakamoto, T., Suei, Y., Tsuda, et al. Observer performance in diagnosing osteoporosis by dental panoramic radiographs: results from the osteoporosis screening project in dentistry (OSPD). *Bone* 2008;43:209-213.
- [36] Halling A, Persson GR, Berglund J, Renvert S. (2005) Comparison between the Klemetti index and heel DXA BMD measurements in the diagnosis of reduced skeletal bone mineral density in the elderly. *Osteoporosis Int* 2005;16:999-1003.
- [37] Mohammad AR, Bauer RL, Yeh CK. Spinal bone density and tooth loss in a cohort of postmenopausal women. *International J Prosthodont* 1997;10:381-385.

- [38] Drozdowska B, Pluskiewicz W, Michno M. Tooth count in elderly women in relation to their skeletal status. *Maturitas* 2006;55:126-131.
- [39] Meisel P, Reifenberger J, Haase R, Nauck M, Bandt C, Kocher T. Women are periodontally healthier than men, but why don't they have more teeth than men? *Menopause* 2008;15:270-275.

ACCEPTED MANUSCRIPT

Legends:

Figure 1.

Mean body mass index (BMI) and 95 % confidence interval in relation to a diagnosis of periodontitis and osteoporosis in older women and men.

Figure 2.

Mean calcaneus T-values and 95 % confidence intervals in women and men with or without a diagnosis of periodontitis defined by the extent of alveolar bone level (ABL).

ACCEPTED M.

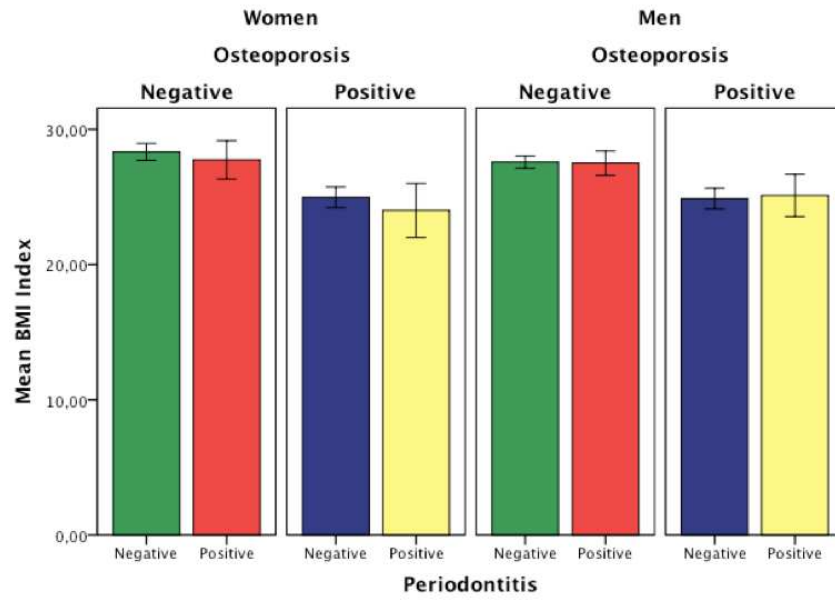


Fig. 1

ACCE

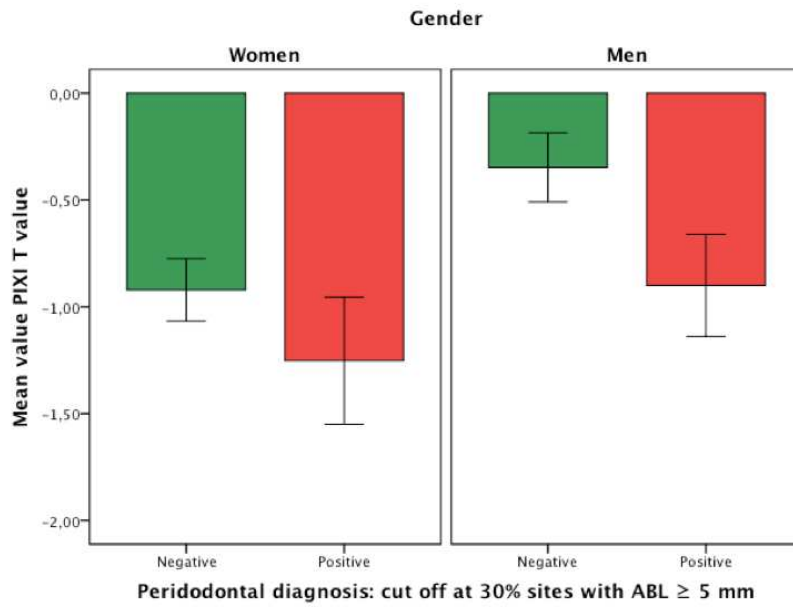


Fig. 2

ACCEPTED

Table 1

Distribution of fractures over three years by gender and diagnosis of osteoporosis, periodontitis and both conditions merged.

Diagnosis	Women	Men
Osteoporosis positive (T value < -1.6)	14.6 %	6.1 %
Osteoporosis negative (T value > -1.6)	5.6 %	3.3 %
Periodontitis positive (ABL ≥ 30 %)	16.7 %	11.4 %
Periodontitis negative (ABL < 30 %)	9.2 %	2.4 %
Combined osteoporosis and periodontitis pos.	18.4 %	9.5 %
Combined osteoporosis and periodontitis neg.	9.1 %	3.4 %

Table 2.

Odds ratios for an associated risk of fracture by gender, age and diagnosis.

Variable:	Adjusted	Odds ratio	95 % CI	Significance
Fracture versus: Osteoporosis defined by calcaneus PIXI T value <- 1.6	Unadjusted	3.3:1	1.9, 5.7	p < 0.001
	Women only	2.6:1	1.4 5.0	p < 0.001
	Men only	1.9:1	0.6 6.3	p = 0.28
	Gender	2.6:1	1.4 4.8	P < 0.001
	Age category	2.4:1	1.4 4.8	p < 0.001
Periodontitis defined by ABL ≥ 5 mm at 30 % of assessed sites	Unadjusted	1.8:1	1.0 3.3	p < 0.05
	Women only	1.7:1	0.8 3.8	p = 0.18
	Men only	5.2:1	1.7 15.7	p < 0.001
	Gender	2.9:1	1.5 5.5	p < 0.001
	Age category	2.1:1	1.1 4.0	p < 0.05
Osteoporosis defined by calcaneus PIXI T value <- 1.6 and Periodontitis defined by ABL ≥ 5 mm at 30 % of assessed sites	Unadjusted	4.6:1	2.2 9.9	p < 0.001
	Women only	5.3:1	1.9 14.4	p < 0.001
	Men only	5.1:1	1.5 17.4	p < 0.01
	Gender	2.3:1	1.2 4.4	p < 0.01
	Age category	3.6:1	1.5 8.6	p < 0.001
Osteoporosis defined by calcaneus PIXI T value <-2.5 and Periodontitis defined by ABL ≥ 5 mm at 30 % of assessed sites	Unadjusted	12.6:1	3.7 42.7	p < 0.001
	Women only	78.0:1	6.9 878.0	p < 0.001
	Men only	3.3 :1	0.5 24.3	p = 0.19
	Gender	11.7:1	3.5 38.4	p < 0.001
	Age category	12.2:1	3.5 42.3	p < 0.001