

The Risk Assessment Index for Tooth Mobility through Bone Density Analysis in the Pre-Elderly and Elderly

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Abstract

Bone mineral density is the amount of bone mineral content in cm^2 , and it can be classified as normal, osteopenia, and osteoporosis. This study conducted a risk assessment of tooth mobility using bone density analysis. Low bone density, which is associated with osteopenia/osteoporosis, can directly affect the alveolar bone's micro architecture and cause tooth mobility. This study consisted of 22 men and 56 women participants aged ≥ 50 years. Mandibular bone density measurements were performed using panoramic radiographs and periapical Direct Digital Intraoral Radiograph (DDIR) analysis. Bone mineral density measurements were performed using a Quantitative Ultrasound (QUS). The results showed a relationship between tooth mobility and both oral hygiene and bone mineral density ($P=.000$, $P=.035$, respectively). An index was created to estimate mobility greater than or equal to 50% of mandibular teeth.

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Introduction

Bone density or bone mineral density (BMD) is the amount of bone mineral content in cm^2 , and it can be classified as normal, osteopenia, and osteoporosis. According to World Health Organizations (WHO), osteopenia is defined as bone mineral density with a standard deviation value between 1 and 2.5 lower than the average peak value of young adults (t-score between -1.0 and -2.5). Osteoporosis occurs when the t-score is lower than -2.5.^{1,2}

Osteoporosis is a condition in which the bones become less dense and more likely to fracture. This disease can affect any bone in the body; however, the bones in the hip, spine, and wrist are affected most often. Osteoporosis is a world wide disease found especially in the elderly. According to data from chapters of the

Indonesian Osteoporosis Society (PEROSI), the prevalence of osteoporosis in 2007 reached 28.8 percent for men and 32.3 percent for women. This figure is also supported by the results of the data analysis of the risk of osteoporosis by Indonesia Ministry of Health (MoH) Nutrition Research in cooperation with Fonterra Brands Indonesia, LTD (2006) and that 2 out of 5 people at risk of osteoporosis. According to the International Osteoporosis Foundation, one of four Indonesian women aged 50–80 years risks suffering from osteoporosis, and women's risk is four times higher than men.²

Research suggests a link between osteoporosis and bone loss in the jaw. The bone in the jaw supports and anchors the teeth. When the jawbone becomes less dense, tooth loss is common, especially in older adults. Several studies have found a link between the loss of alveolar bone and an increase in loose teeth (tooth mobility) and tooth loss. Women with osteoporosis are three times more likely to experience tooth loss than those who do not have the disease.^{3,4} Low bone density in the jaw can result in other dental problems as well. For example, older women with osteoporosis may be

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more likely to have difficulty with loose or ill-fitting dentures and may have less optimal oral surgery outcomes.

Many studies showed that dental x-rays may be used as a screening tool for osteoporosis. They found that dental x-rays were highly effective in distinguishing people with osteoporosis from those with normal bone density.⁵⁻¹⁰ Because many people see their dentists more regularly than their doctors, dentists are in a unique position to help identify low bone density and to encourage their patients to talk to their doctors about their bone health. Dental concerns that may indicate low bone density include: loose teeth, loose of alveolar bone, and ill-fitting or loose dentures because most denture wearers are at an age that has a high risk for osteoporosis. Due to the risks associated with osteoporosis, it is important for dentist, especially prosthodontist, to understand this disease.

Advanced periodontitis can cause mobility in the teeth. One of the predisposition factors for this condition is poor oral hygiene. The alveolar bone condition can also affect tooth mobility. This research adopted the assumption that low bone density associated with osteopenia or osteoporosis can affect the bone micro architecture of the alveolar bone and cause tooth mobility. No previous research investigates the relationship between bone density and tooth mobility. Some risk factors for osteoporosis, such as age, gender, body mass index, smoking habits, coffee and soda consumption, calcium intake, and sun exposure time, were also considered to affect tooth mobility.¹⁰

The results of this study will be used to produce an index that will prove that tooth mobility is related to oral hygiene and bone density. This index will be useful for dentists as a tool to assess their patients' oral health and to educate them about oral hygiene and osteoporosis. This index can also be used to increase patients' oral hygiene awareness, so they will acknowledge and take the necessary action to prevent osteoporosis, which will further prevent tooth mobility.

Materials and methods

This is a cross sectional study comprised of 95 subjects aged ≥ 50 years that met the inclusion criteria and signed a participant

informed consent form. The inclusion criteria were as follows: men or women aged 50 years or above who do not have diabetes, hypotension/hypertension, or COPD (Chronic Obstructive Pulmonary Disease); were not consuming steroids, anti-coagulants, anti-convulsion, or osteoporotic drugs; had no chemotherapy/radiotherapy in the previous six months, and who did not wear dentures on their mandibles. The subjects completed the osteoporosis interview questionnaire.¹⁰

Then, they underwent a clinical examination of their oral hygiene and tooth mobility as well as their mandibular and skeletal bone densities. The participants' height and weight were also measured. The mandibular bone density and porosity was assessed using a panoramic radiograph of the mandibular cortical bone⁵ and DDIR to see trabeculation in the mandibular bone (first molar region).¹¹

The skeletal bone density was measured using a QUS, which is widely accepted for osteoporosis screening because it has an 83.9–87.5% sensitivity to Dual-energy X-ray absorptiometry (DEXA).¹²

Oral hygiene in this study was assessed using the Oral Hygiene Index Simplified (OHI-S) from Greene and Vermilion (1964), which combined the debris and calculus indices.

Results

Of the 95 participants in the study, only 78 participants' data could be analyzed. The other 17 participants' did not complete the examination, so their data was incomplete. A descriptive overview of the clinical examination results are listed in Table 1.

Table 1 shows the participants' average age was 57 years (pre-elderly), and their BMI category was overweight (BMI of 26.5 kg/m²). The skeletal bone density results had a value of -1.9, which according to WHO, is classified as osteopenia. The mandibular bone density examination using the periapical DDIR revealed that the participants should be classified in the osteoporosis category.

Calcium intake and the time of sun exposure were adequate. The subjects with moderate oral hygiene had a low awareness of how to maintain their oral hygiene.

Table 1. Distribution of subject' examinations.

Variable	Mean	Standard deviation	Min	Max
Mandibular bone density through DDIR	73.7	18.67	44.77	150.51
Skeletal bone density	-1.9	0.78	-3.23	0.47
Age (years)	56.9	6.76	50	80
Body mass index (kg/m ²)	26.5	4.19	16.53	35.49
Calcium intake(mg/week)	2577.7	1157.66	696.10	5635.30
Time of sun exposure (minutes/day)	30.4	27.73	5	240
Oral hygiene index	2.9	1.51	0.00	6.00

Table 2. Bivariate analysis of bone density and risk factors with regard to tooth mobility.

Variables	< 50% mobility	%	≥ 50% mobility	%	P
Mandibular bone density					
DDIR					
Normal	5	6.4	2	2.6	.662
Osteoporosis	50	64.1	21	26.9	
Panoramic radiograph					
C1 (normal cortex)	20	25.6	5	6.4	.160
C2 (mid–severe cortex)	35	44.9	18	23.1	
Skeletal bone density					
Normal	9	11.5	1	1.3	.139
Osteoporosis	46	59.0	22	28.2	
Ages					
< 57 years	39	50.0	15	19.2	.405
≥ 57 years	16	20.5	8	10.3	
Gender					
Men	17	21.8	5	6.4	.298
Women	38	48.7	18	23.1	
Body mass index					
≥ 25 kg/m ²	35	44.9	16	20.5	.409
< 25 kg/ m ²	20	25.6	7	9.0	
Smoking habits					
No	39	50.0	17	21.8	.510
Yes	16	20.5	6	7.7	
Coffee consumption					
No	20	25.6	8	10.3	.554
Yes	35	44.9	15	19.2	
Soda consumption					
No	41	52.6	19	24.4	.324
Yes	14	17.9	4	5.1	
Calcium intake					
≥ 2500 mg/week	26	33.3	10	12.8	.478
< 2500 mg/week	29	37.2	13	16.7	
Time of sun exposures					
≥ 11.5 minutes	26	33.3	10	12.8	.478
< 11.5 minutes	29	37.2	13	16.7	
Oral hygiene index					
Good	43	55.1	7	9.0	.000*
Poor	12	15.4	16	20.5	

Description: Chi Square test, * p<.05 = significant

Table 2 shows a significant relationship between tooth mobility and the oral hygiene index. The mandibular bone density, skeletal

bone density, age, gender, body mass index, smoking, coffee and soda consumption, sun exposure time, and calcium intake variables did

not have a significant relationship with tooth mobility. The next stage was the multivariate analysis with a logistic regression. This analysis was done by inserting variables which had a

$P < .25$. The multivariate analysis is shown in Table 3.

Table 3. Multivariate analysis of tooth mobility with the skeletal bone density and oral hygiene index.

Variable	B	SE	P	OR	95% CI	
					Lower	Upper
Skeletal bone density	2.458	1.164	.035	11.680	1.19	114.38
Oral hygiene index	2.503	.610	.000	12.213	3.69	40.39
Constanta	-4.186	1.223	.001	.015		

Description: regression logistic test, $P < .05$ = significant; B = coefficient of regression; SE = standard error; OR = odds ratio; CI = confidence interval.

Table 3 shows that only the skeletal bone density and oral hygiene variables were associated with tooth mobility. The relationship between the oral hygiene and tooth mobility was the most significant, with an odds ratio of 12.213, which indicates that people with a higher oral hygiene index had 12.21 times greater mobility

rate of greater than or equal to 50% in the mandibular teeth than someone with a lower oral hygiene index. The relationship between skeletal bone density and tooth mobility had an odds ratio of 11.680. Based on the data from Table 3, the logistic regression equation is as follows:

Mobility $\geq 50\%$ on the mandibular teeth index

$$P(x) = \frac{1}{1 + e^{-L}} = \frac{1}{1 + e^{-(-4,19 + 2,46 \times BMD + 2,50 \times OHIS)}}$$

Description:

P (x) : Mobility $\geq 50\%$ on the mandibular teeth index;

BMD : Bone mineral density (0 if normal; 1 if osteopenia/osteoporosis);

OHIS : Oral hygiene index (0 if OHI-S score 0.00–3.09; 1 if OHI-S score 3.10–6.00).

Discussion

This study adopted analytic cross-sectional research design to identify the relationship between bone density and tooth mobility. This research was conducted because no previous research on this relationship exists. The study accepted the assumption that low bone density associated with osteopenia or osteoporosis can affect the bone micro architecture of the alveolar bone and cause tooth mobility.

The QUS skeletal bone density examination and the DDIR and panoramic radiographic mandibular bone density examination showed that participants over 50 years of age had osteopenia or osteoporosis. These results are consistent with research conducted by the Indonesian Center for Nutrition Ministry of Health and Fonterra Brands Indonesia,

LTD in 16 regions in Indonesia and the Indonesian White Paper issued by the Indonesian Osteoporosis Association (Perosi) in 2007.² During the participants' height inspection, some participants were surprised by their height loss, which is one symptom of advance osteoporosis. However, almost all the participants who had been diagnosed with osteopenia or osteoporosis claimed that they had never felt this symptom confirming that osteoporosis is a silent disease.

The multivariate analysis of the QUS showed a significant relationship between tooth mobility and skeletal bone density ($P = .035$). Singh et al. (2012) also found this relationship when the authors measured tooth mobility using the Perio test (PTV), bone density using Dual Energy X-ray Absorbtiometry (DEXA), and periodontal status (clinical attachment loss,

pocket depth, plaque index, and bleeding index circular) in 119 postmenopausal women aged 40–54 year. The authors found a significant relationship between the PTV value and the t-score ($P= -0.257$), pocket depth ($P=.696$), and Clinical Attachment Loss (CAL) ($P=.635$).¹³

In this study, the periapical DDIR and panoramic radiograph showed no relationship between mandibular bone density and tooth mobility. This result may be due to the device's condition, the radiographic film, or the analysis of panoramic radiographs, which was a subjective assessment conducted by a single analyst. The DDIR periapical results suggest that the normal radiometric cut off value may have been too high, so most of the participants were categorized as osteoporosis.

Sigh et al. (2012) found a weak relationship between tooth mobility and age.¹³ Kida et al. (2006) studied the elderly in Tanzania and proved that the presence of two or more cavities and two or more mobile teeth were more commonly found in women than men.¹⁴ This study did not find a relationship between tooth mobility and age or gender, which may be due to the gender (28% men and 72% women) and age distribution (24% pre-elderly and 76% elderly) of the participants.

This study also found no association between smoking and tooth mobility, but Munzyński et al. (2014) found that smokers lost connective tissue and bone at a greater rate than nonsmokers, increased tooth mobility, and a greater number of missing teeth.¹⁵ Coffee and soda consumption increases the risk of osteoporosis and has an impact on bone.¹⁶ However, this study did not find any association between tooth mobility and coffee ($P=.554$) or soda consumption ($P=.324$).

Some studies, which will be describes below, suggest a link between calcium and vitamin D deficiency and the occurrence of periodontal disease, which is a major cause of tooth loss. Garcia et al. (2011) found that calcium (≥ 1000 mg/day) and vitamin D (≥ 400 IU/day) supplementation has a modest positive effect on periodontal health, and consistent dental care improves the clinical parameters of periodontal disease.¹⁷ Therefore, the intake of calcium and vitamin D may prevent osteoporosis and protect teeth from mobility. However, no relationship between tooth mobility and either sun exposure duration or calcium intake was found in this study.

Table 3 shows that the majority of the participants ranked medium or poor on the oral hygiene index, which suggests that the participants lacked awareness about their dental and oral hygiene. Based on a report by the Indonesia Ministry of Health in 2007, the prevalence of dental caries and periodontal disease was high (74.41%), and approximately 4–5% of the population was suffering from advanced stage periodontal disease, which can cause mobile and missing teeth. One cause of periodontal disease is calculus, which was found in 46.2% of the population.¹⁸ Calculus is difficult to clean, attracts bacteria, and can cause gingivitis. If untreated, this condition can progress to periodontitis and tooth mobility. Based on the results of our study, the oral hygiene had a statistically significant relationship with tooth mobility ($P=.000$).

Osteoporosis leads to bone mass reduction, while periodontal disease causes resorption of the alveolar bone. Both conditions have common risk factors, such as smoking, poor nutritional status, age, and immune deficiency. The bone changes caused by osteoporosis seem to aggravate periodontal disease; however, the pathogenesis of this process is not yet fully understood.^{19,20} Since both osteoporosis and periodontal diseases destroy bone, it has been hypothesized that osteoporosis may be a risk factor for the progression of periodontal disease. Esfahanian et al. (2012) reviewed articles that analyzed the relationship between osteoporosis and periodontitis.²⁰ Among 508 articles from PubMed from January of 1998 to June 2010, 17 articles were selected for a full-text reading based on the inclusion and exclusion criteria. The authors found that 11 studies showed a positive relationship between osteoporosis and periodontal disease, but six studies found no significant relationship between osteoporosis and periodontal disease. These data showed a greater propensity of participants with osteoporosis, especially those with pre existing periodontitis, to lose alveolar bone, which indicates that osteoporosis or low systemic BMD should be considered a risk factor for periodontal disease progression.²⁰

The multivariate analysis found a mobility rate of greater than or equal to 50% of teeth in the mandible. The results of this study will produce an index that will prove tooth mobility is

related to oral hygiene and bone density. Dentists can assess the prognosis of teeth in the next few years using this index. When patients suffer osteopenia or osteoporosis, they will be examined using the oral hygiene index to determine mobility of 50% or greater of teeth in the mandible. The risk of tooth mobility in people with a higher OHI-S value and osteoporotic conditions is higher than someone with a lower OHI-S value and normal bone density. Therefore, dentists should educate their patients about maintaining their oral hygiene, promote calcium intake, and adopt practices that can increase bone strength to avoid the risk of tooth mobility, which can cause tooth loss. This index will also help patients increase their oral hygiene awareness, so they can adopt the actions necessary to prevent osteoporosis, thus preventing tooth mobility.

The weakness of this study was that most of the participants were considered pre-elderly (57 years old). The type of osteoporosis that occurs in pre-elderly individuals is Type I primary osteoporosis (postmenopausal osteoporosis), which increases bone remodeling and trabecular bone loss. Whereas type II primary osteoporosis (senile osteoporosis), which occurs in the elderly, does not increase bone remodeling and attacks the trabecular and cortical bone. Therefore, elderly individuals suffer from Type II primary osteoporosis and Type I primary osteoporosis. Elderly subjects are expected to suffer a greater impact on their mandibular bones due to osteoporosis.

Conclusion

A significant association between skeletal bone density, oral hygiene, and tooth mobility in the pre-elderly and elderly was found. An index was created to estimate the tooth mobility in the mandible using the following equation:

$$P(x) = \frac{1}{1 + e^{(-4,19 + 2,46 \times \text{BMD} + 2,50 \times \text{OHI-S})}}$$

This index can be used clinically to assess the prognosis of teeth in the jaw in the next few years. People with higher OHI-S values and osteoporotic conditions have a higher mandibular teeth mobility rate than someone with a lower OHI-S value and normal bone density.

Using this index, patients should be able to increase their oral hygiene awareness, so they will adopt the actions necessary to prevent osteoporosis and tooth mobility.

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