

RADIOGRAPHIC EVALUATION OF OSTEOPOROSIS THROUGH DETECTION OF JAW BONE CHANGES: A SIMPLIFIED EARLY OSTEOPOROSIS DETECTION EFFORT

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Abstract

Osteoporosis has become a worldwide problem and has been known as a silence disease. Nowadays, there are a lot of diagnostic tools for detecting osteoporosis. Eighty eight postmenopausal were included and underwent digital panoramic, digital periapical, and conventional radiography. Ultrasound bone densitometry of os calcis used as gold standard. Correlation between stiffness index (SI) with a digital dental, digital panoramic and conventional dental radiography are 0.170 ($p = 0.11$), -0.382 ($p = 0.001$) and 0.246 ($p = 0.021$) respectively. Significant relationship was found between the SI only with digital panoramic and conventional dental. The highest correlation was found between SI values with mandibular Inferior Cortex on digital panoramic (-0.382, Pearson Correlation Tests). Correlation between digital panoramic radiographs and the SI values was the highest of the three radiographic modalities in this study. This indicates that evaluation of cortical bone is more accurate than cancellous bone. Bone quality evaluation in patients at high risk for osteoporosis using panoramic and dental conventional radiograph by dentist, contributes in preventing further occurrence of osteoporosis which in turn could reduce mortality and morbidity of osteoporosis in Indonesia.

Keywords: dentist, osteoporosis, radiographic modalities

Introduction

In accordance with the increasing age and population growth as well as many other factors, the number of patients with osteoporosis has been increased significantly. Currently osteoporosis has become a worldwide problem with estimated patients has reached 75 million people in Europe, America and Japan.¹ Data on the examination in five major cities in Indonesia in 2002 showed that 36% of the subjects suffered from osteopenia, and 29% suffered from osteoporosis.² In Indonesia, osteoporosis that occurs at age below 50 years were 14%, then increased to 28% at age 50-60 years, and 47% at age 60-70 years.³

One of the main complication of osteoporosis such as fractures, is a major cause of its mortality and morbidity. Approximately 75% of all hip fractures occur in women and 25% in men.^{4,5} Although the prevalence of broken bones are much more experienced in women, the risk of fractures occur in men are more associated with mortality,^{6,7} causing morbidity and loss of function of the body normal movement.⁸ While with the 50-year-old female patient, 2.8% risk of death from fractures are associated with fractures at the base of the thigh.

This risk is as high as breast cancer risk, and four times higher than in endometrial cancer.⁹ Fractures in the groin are causing increased morbidity with the mortality rates reaching 20-24% in the first year,^{10,11} and the pain will last for five years after the fracture in the groin.¹² In the survival group, the loss of normal movement and disability were found with a prevalence of 40% those were not able to walk alone, and 60% requires assistance a year later.¹³ Of these, 33% would be totally dependent or are in nursing homes in the following years after the groin fracture occurs.^{14,15}

Osteoporosis is also known as silence disease because bone loss which occurs without any symptoms. In some cases, the first symptom is a broken bone. Although nowadays there are many diagnostic tools for detecting osteoporosis, most patients do not know that they are suffering osteoporosis until their bones become so weak and then finally fell with a broken hip or a collapse of the backbone.¹⁶ Research has shown that many women who suffer fragility fractures due to osteoporosis happened in connection with the undiagnosed illnesses.^{17,18} Individuals with the risks of fractures were 80%, they were those who have never experienced fracture at least once, or not identified and not treated properly.¹⁹

In dentistry, suspicion of osteoporosis is usually only appears after a broken jaw due to operative procedure, the looseness of dentures in a short time after insertion, and other cases that should have been anticipated before the treatment is done. Therefore, early detection of osteoporosis is the first priority for these patients in an effort to prevent broken bones or other treatment complications caused by osteoporosis.

Many methods as well as equipment, which basically uses X-rays to evaluate the bone quality in diagnosing osteoporosis has been established. Usually the evaluation is done on the pelvic bones. Examination that can determine the exact and accurate diagnosis of osteoporosis, are generally using special equipment that also requires special expertise, with the consequence of high costs. In addition, using X-ray examination also involves exposing the patients with a relatively large radiation. Many efforts have been made lately to detect the possibility of osteoporosis in the context of early detection, before the need for a special examination to diagnose the presence of osteoporosis.^{20,21}

Research to detect a variety of systemic diseases manifest in the oral cavity has been carried out.²² The research to study diseases that manifest in the jaw bone, has also begun to be developed in Indonesia.²³ Several studies have shown that osteoporosis is also associated with jaw bone quality, in this case to be further explored radiographically is the bone density,²⁴ the condition of the inferior mandibular cortex,^{20,25} and the alveolar bone condition.²¹ Related research efforts for early detection of osteoporosis through the evaluation of mandibular bone quality have also been conducted in Indonesia by considering the influence of various risk factors. In the study, mandibular bone quality was analyzed by digitized radiographs, i.e. by scanning the radiograph, and then analyzed with the help of software that are available in a computer device.²⁶ Research in other countries regarding the early detection of osteoporosis by using conventional panoramic radiograph has been found,^{20,21} whereas the study using conventional dental radiographs and dental digital radiographs has not been widely performed.²⁷ In Indonesia the dental radiographs are the most commonly used by dentists. Conventional dental devices have been available in almost all health centers at the sub district levels. Therefore, this study had used three types of radiograph, and then analyzing the correlations of bone osteoporosis assessment using the X-ray modalities, with the assessment of osteoporosis using ultrasound bone Densitometry (the os calcis densitometry). From this study it was expected to obtain the most correlated bone quality value from the radiographs, to the value assessed by the os calcis ultrasound bone Densitometry.²⁸

The Panoramic and periapical radiographs have been used extensively in dentistry to detect and diagnose oral

and dental diseases.²⁹⁻³¹ Panoramic and periapical radiographs, each with their advantages and disadvantages, could show the radiographic appearance of the jawbone quality, which is expected to be very useful for early detection of osteoporosis. The misdiagnosed of osteoporosis in patient care, will result in the failure of the patient's care that could even do harm or endangering the patients. In addition, the simple, low dose radiation and relatively cheap way to detect the possibility of osteoporosis that manifested in the jawbone is needed.

On this cross-sectional study, the conventional and modern radiographic examination were then used to evaluate the jawbone quality. Then conventional periapical dental radiographic evaluation is done manually, and the dental digital as well as the digital panoramic were then connected to the value of bone quality using the ultrasound bone densitometry. It is expected that this research could obtain the most correlated bone quality value from the radiographs, to the value assessed by the os calcis ultrasound bone Densitometry. Of the three modalities/tools used in this study, the most X ray modality that could gave the most correlated bone quality value assessed by the os calcis ultrasound bone Densitometry could then be used as the the modality in predicting the possibility occurrence of osteoporosis. In addition to the assessment of the most correlated jawbone value obtained from the three modalities to the bone value assessed by the ultrasound os calcis bone densitometry that considered to be more accurate in detecting osteoporosis, dentists are expected to predict the possibility of osteoporosis based on the use of the X ray equipment available.

Methods

Having passed the ethical clearance process from faculty of Dentistry, Universitas Indonesia, the research was conducted with a cross sectional design. All subjects met the inclusion criteria specified in the population.

Digital panoramic radiographs, digital and conventional periapical radiograph of the research subjects were taken. The parallel technique of the periapical radiograph were taken using the Paralleling Cone Indicator Device (PCID) of the Hanshin XCP, in the dentulous area, between the the first and second mandibular premolars. Evaluation of bone quality is digitally obtained by using the digital radiographic equipment. Radiographic film used was Kodak Insight ® size no, er 2 EP-21 F-speed and parallel techniques used to perform PCID Hanshin® CID-3, using the conventional dental X-ray Belmont® Long Cone with x ray conditions 70 kVp, 15mA, X-ray exposure time to 0.33 seconds for the periapical technique. Furthermore, in the same region the digital periapical radiograph

using Direct Digital Intra Oral Radiography Intra Oral (DDIR) were taken, with digital image receptors Photostimulable system Phosphorous Plate (PSP). Digital system used is Digora® (from Soredex Orion Corporation, Helsinki, Finland).

Evaluation of the bone quality that has been done manually by former researchers,³² carried out on Region of Interest (ROI) between first premolar and second premolar, with the density and pattern of the posterior region trabeculation density criteria as follows:

- Score 1: No visible presence of bone trabeculae.
- Score 2: There was some bone trabeculae that are thin and irregular (trabeculae porous) cortical bone at the top of the alveolar bone seemed very thin or not visible.
- Score 3: Bone trabeculae was evident as in normal alveolar bone (trabeculae solid) at the peak of cortical bone seems very thin alveolar bone disconnected.
- Score 4: Thick bone trabeculae seemed occupying most marrow cavity (bone densed trabeculae) and cortical bone at the top of the alveolar bone appeared thin.
- Score 5: Solid bone without any description of trabeculae (bone trabeculae dense). Bone at the peak of cortical alveolar bone seemed thicker.

Evaluation of the bone quality from panoramic radiograph in the form of the density of cortical mandibular lower cortex in ROI between first and second mandibular premolars. Measurements were done bilaterally on the mandibular cortical bone beneath the foramen mentale. Evaluation of the cortical density on the lower edge of the mandible from panoramic radiographs were conducted using the criteria of Klemetti *et al.*³³ as follows:

- Class 1: homogeneous cortical bone with normal density
- Class 2: mild or moderate porosity of cortical bone (in areas less than 50% of ROI)
- Class 3: severe cortical bone porosity (on the area of more than 50% ROI)

Furthermore, based on diagnostic information obtained, whether in the form of radiographic and radiometric data, the subjects were examined further using the os calcis ultrasound bone densitometer.

Results and Discussion

The number of subjects collected was 100 people with age ranged between 50-70 years. Nine subjects were then excluded due to the consumption of drugs that affect the bone condition. Results of conventional dental radiographs in three people do not have a good quality

evaluation. Total of 88 postmenopausal women involved in the calculation of the research analysis. Characteristics of the number of study subjects between 50 to 70 years with the highest number of subjects are at the age of 57 years (Figure 1).

Conventional dental radiographic evaluation was conducted two times on the Region of Interest (ROI) that has been marked in accordance with the state of dental digital. Based on the table are intra-and inter-observer kappa (Table 1) first reading of observer I and II have the observer s kappa value 0.88 (p < 0.001). The second reading of observer I and II have observer s kappa values 0681 (p > 0.001).

Kappa values with the second lowest first reading by the observer is one that is 0.645 (p < 0.001). The kappa value with the second highest first reading by observer 2, namely 0.912 (p < 0.001), with an average of all readings kappa value of 0.7815.

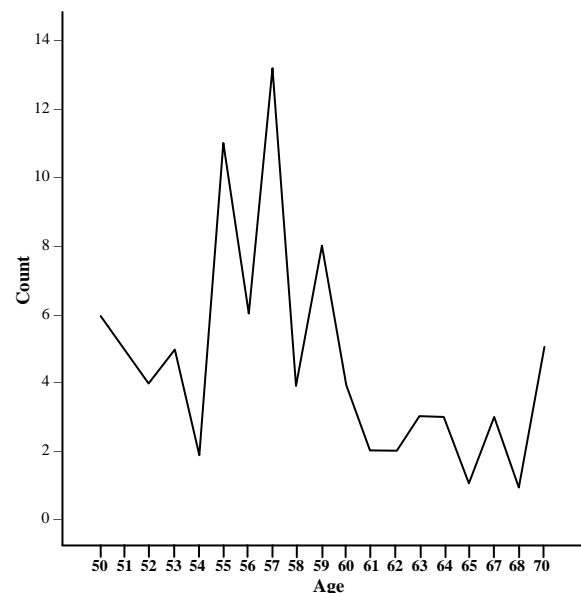


Figure 1. Characteristics of Subjects' Distribution

Table 1. Kappa Value of Intra and Inter Observer Agreement of Two Observers

	Observer	Kappa Value	p Value
1	1a vs 1b	0.880	0.000
2	1a vs 2a	0.645	0.000
3	1a vs 2b	0.847	0.000
4	1b vs 2a	0.716	0.000
5	1b vs 2b	0.912	0.000
6	2a vs 2b	0.681	0.000
	average	0.7815	

- 1a = observer 1 first reading
- 1b = observer 1 second reading
- 2a = observer 2 first reading
- 2b = observer 2 second reading

Table 2. Correlation Between Evaluated Factors

		Stiffness index	Dental Dig	Mandibular Inf Cortex	Scoring
Stiffness index	Pearson Correlation	1	0.17	-0.382 (**)	0.246 (*)
	sig. (2-tailed)	.	0.114	0	0.021
	N	88	88	88	88
Den Dig	Pearson Correlation	0.17	1	-0.265 (*)	0.705 (**)
	sig. (2-tailed)	0.114	.	0.013	0
	N	88	88	88	88
Mandibular Inf Cortex	Pearson Correlation	-0.382 (**)	-0.265 (*)	1	-0.365 (**)
	sig. (2-tailed)	0	0.013	.	0
	N	88	88	88	88
Scoring	Pearson Correlation	0.246 (*)	0.705 (**)	-0.365 (**)	1
	sig. (2-tailed)	0.021	0	0	.
	N	88	88	88	88

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The value of the results obtained from ultrasound Bone Densitometry of the os calcis were correlated to the dental radiometric digital, digital panoramic and conventional dental. Table of correlation between SI (stiffness index) with a digital dental, digital panoramic and conventional dental row are 0.170, $p = 0.11$ ($p > 0.05$), -0.382 , $p < 0.001$ ($p < 0.05$) and 0.246 , $p = 0.021$ ($p < 0.05$) respectively.

Value significant relationship was found between the SI with only a digital panoramic and conventional dental. The highest correlation was found between the values of SI with mandibular Inferior Cortex on digital panoramic (-0.382 , Pearson Correlation Tests).

Various studies have been attempted to detect the possibility of osteoporosis through the jaw bone quality assessment.^{20,21,33} In this research, the evaluation of density as one of the mandibular bone quality parameters of some radiographic projection that is relatively widely used in Indonesia were conducted to evaluate 88 research subjects. Early detection of osteoporosis can be done with the assessment or evaluation of mandibular bone quality, both at the lower edge of mandibular cortical bone of the panoramic radiograph, as well as in the cancellous bone from dental radiographs. Changes in cortical bone is affected by reduced osteoblast as happened to female patients with osteoporosis due to old age, whereas bone cancellous/trabeculation changes were triggered by the increase in osteoclasts as post menopause osteoporosis occurs in women due to loss or decrease of the estrogen level.³⁴

Characteristics of 88 postmenopausal female subjects could be seen in Table 1. The number of the largest and smallest frequency of the subjects contained in the age group 50-56 years and 65-69 years, were 39 (44.3%) and 13 (14.7%). One cause of the difficulty of finding

subjects with 65-69 years age group who are willing to participate in this research is a relatively long distance between the location of the subjects in Bekasi checkpoints in the West with FKG UI Salemba, in Central Jakarta.

The study was conducted in accordance with the rules of radiographic studies. The Kappa value showing the average agreement of inter-and intra-observer was up to 0.7815. Correlation analysis between the possibility of osteoporosis in leg bone (stiffness value index/SI) with a digital panoramic radiograph evaluation and conventional dental radiographs showed a significant correlation, while the correlation with the SI value evaluation of digital dental radiograph showed no significant results (Table 1). The statistical test of Pearson correlation between digital panoramic radiograph and conventional dental radiographs of the SI, shows that the value of a digital panoramic radiograph Pearson correlation was higher (-0.382 , $p < 0.001$) compared with the conventional dental radiograph (0.246 , $p = 0.021$). The results are consistent with Taguchi *et al.*³³ who concluded that the measurement of bone density in mandibular cortical bone by Klemetti *et al.* method has the highest specificity and good sensitivity and is more easily done visually.³³ Compared with periapical dental radiograph, panoramic radiograph radiographic image distortion produced is greater. Langlais *et al.*, however, states that the value of the minimum distortion on panoramic radiograph is in an area that lies between the rotation center of the beam with the film area and posterior maxillary posterior mandible.³⁵

The existing difference in significance between bone density assessment using digital dental radiographs against the value of SI, can caused the density values derived from digital dental radiograph of radiometric measurement, which is an analytical representation of the number of pixels in the quantitative value of 0-256 gray scale and displayed on the monitor screen

computer.³⁶ Meanwhile, the bone densitometry measuring instruments used in this study, the leg bone ultrasound densitometry, were measuring the bone mineral density estimates contained in the os calcis. Correlation value of digital panoramic radiograph of the highest SI values among the three radiographic modalities used in this study, indicates that the evaluation of the density of cortical bone can be more accurate than the evaluation of bone density at the cancellous bone which in addition depends on the density relative to the bone marrow cavity, also influenced by the pattern or structure contained in the trabeculation on ROI (Region of Interest).

Conventional dental radiograph radiograph is the most widely used in the field of dentistry, with a lower radiation dose and relatively inexpensive compared with panoramic radiographs. From these results, although the conventional dental radiograph has a Pearson correlation value that is lower than the panoramic, the correlation of conventional dental radiographs of the SI values still provides significant results. This is in accordance with the results of research done by Linda *et al.*²⁶ who has done the jawbone density evaluation from conventional dental radiographs in comparison to lumbar bone value used as the gold standard examination, that the alveolar bone trabeculation could be used to detect osteoporosis.

From the results of this study it can be said that by using panoramic radiographs or conventional dental radiographs a dentist could done the early detection by predicting the possibility of osteoporosis through the evaluation of jaw bone quality changes. By doing this, the suspected patient/s could then be referred or recommended to obtain a more accurate further examination to diagnose osteoporosis. The weakness of this study is the gold standard used is the ultrasound os calcis bone densitometry that has lower accuracy values in diagnosing osteoporosis compared with the DEXA (Dual Energy X-ray Absorptiometry). The use of this tool as the gold standard were based on considerationcons that this tool is easy to carry, does not cause radiation to the subject of research, relatively easy to use, and cost effective.

Conclusion

It could be said that the purpose of this study was to obtain a possible means of early detection of osteoporosis by radiographic examination, which is simple, and affordable by public, as well as cost-effective. Research conducted by using three radiographic modalities that each compared to the value of the os calcis SI densitometry, and gives the result that the panoramic radiograph and conventional dental can be used in patients with high risk for the possibility of early detection of osteoporosis. Thus we can conclude that if the dentist were care enough to evaluate the bone quality in patients at high risk for osteoporosis, the dentist could give contribution

in preventing further occurrence of osteoporosis, which in turn can reduce mortality and morbidity of osteoporosis disease in Indonesia. Furthermore, ongoing research is required (longitudinal) using a series of panoramic radiograph and dental radiograph series to be able to observe changes in cortical bone and jaw bone trabeculation.

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