Measurement Of Maximum Value Of Dental Radiograph To Predict The Bone Mineral Density

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Abstract— Post-menopausal woman has a high risk to have osteoporosis. The condition of osteoporosis is characterized by the bone mineral density. The gold standard of BMD examination is using DEXA scan, but it has a problem in high cost and limited availability. So the study about the alternative to overcome the problem is necessary. The objective of this study is to measure the maximum value of periapical radiograph and determine its ability to be a predictor for bone mineral density of lumbar spine and hip.

Image processing method was applied to 37 data subject that involved periapical radiograph and DEXA scan. The grayscale image was converted into binary image to observe the connectivity of the pixels. Measurement of maximum value for each radiograph has been done and continued by linear regression method between the maximum value with the BMD of lumbar spine and hip.

The result of this study showed that the maximum value has a weak correlation with the BMD of lumbar spine and hip. The maximum value also cannot be the predictor for BMD of lumbar spine and hip as the significant of F is larger than 0.05 in the linear regression test.

Keywords— BMD, radiograph, periapical, image, maximum value

I. INTRODUCTION

Bone mineral density is an important parameter to indicate the condition of the bone on any site of the body. Bone mineral density generally known as BMD can be used to determine whether the bone is osteoporosis or not. As osteoporosis is a silent disease, that does not give any symptom until it becomes a serious condition. Some of the characteristic of osteoporosis is the decreasing of bone mineral density and alteration of bone architecture so that the bones become fragile and susceptible to fracture which is triggered by light trauma or even without any trauma. Despite its low contribution to morbidity and mortality, osteoporosis has been a social and economic burden worldwide, especially for treatments of osteoporotic fracture [1].

A study conducted by Nutrition Research and Development Center of The Indonesian Ministry of Health collaborated with a private nutrition company in 2005 showed that 2 of 5 Indonesian people has a risk of osteoporosis. This result indicates the necessary of some control program for osteoporosis. The osteoporosis control program by The Indonesian Ministry of Health included the osteoporosis detection and treatment planning. The aim of the program is to acquire the early detection method of osteoporosis for the high-risk community so that the morbidity and mortality caused by osteoporosis can be decreased [2]. The postmenopausal woman has a high risk of osteoporosis due to the decreased of estrogen after menopause. Those who has alterations on the jaw bone (mandible and maxilla) has a possibility of having a risk for osteoporosis or a low bone density [3].

To examine the BMD parameter, it usually uses the Dual Energy X-Ray Absorptiometry (DEXA) as the gold standard by The World Health Organization [4]. The used of DEXA as the gold standard for bone mineral density examination in Indonesia found some difficulties related to its high cost and its limited availability only on some central hospitals [5]. While there is a radiographic technique for dental. Dental radiograph not only shows the internal structure of the teeth but also captures the jaw bones, both of the upper jaw bone (maxilla) and the lower jaw bone (mandible). As a part of the skeletal system, mandible bone condition is affected by systemic bone diseases. Therefore bone alterations of mandible related with systemic bone diseases are visible on dental radiographs. Clinical information supported by radiographic examination can be used as a predictor of hip fracture on a postmenopausal woman [6]. The possibility of a postmenopausal woman to visit the dentist to get dental treatment is higher than their possibility to go to the hospital to get osteoporosis examination...
Therefore the dental radiograph has a high potential as osteoporosis detection instrument.

Osteoporosis manifestation on mandible and maxilla which visible on dental radiograph have been interesting studies in last decade. Some previous studies show that osteoporosis screening can be done by trained dentists using panoramic radiograph [8]. Osteoporotic bone alteration on the mandibular cortical bone is visible on panoramic radiograph, and can easily be seen by a dentist. Whereas the mandible trabecular bone alterations related with osteoporosis also visible on periapical radiographs and panoramic [5], [9]–[11].

As early detection of osteoporosis become the control program by The Indonesian Ministry of Health, the studies about how to detect the osteoporosis earlier are challenging. The prognosis of osteoporosis treatment is better when osteoporosis is detected earlier, while the periapical radiograph is a potential method to be used for that purpose.

Image processing to extract maximal value of the periapical radiograph and test whether it can be a predictor for bone mineral density of lumbar spine and hip is the objective of this study. By the result of the study, hopefully, it can be a valuable literature about detecting the risk of osteoporosis using dental radiograph, especially for Indonesian woman. The major concept of this study can be seen in Figure 1.

![Figure 1. The concept of the study](image)

II. RESEARCH METHOD

In this study, image processing method to extract the maximal value of the image involved selection of image processing and making a binary image. The maximum value of the image was extracted from the binary image for each radiograph. The maximum value of the image describes how many pixel or point has the maximum value in an image. For this study, this maximum value is related to the connectivity of trabecular bone.

Samples of this study were bone mineral density data and periapical radiographs from 37 postmenopausal woman. To obtain the bone mineral density data, every subject on this study were scanned using DEXA on their hip and lumbar spine. The bone mineral density expressed in bone mass density (BMD), and the result of DEXA scan interpreted by the radiologist refers to the World Health Organization classification for diagnosis of osteoporosis. The periapical radiograph used in this study have passed the quality assurance process by the dentist. High quality and correctly positioned periapical radiographs were included into the study. This study obtained the ethical approval No. 00681/KKEP/FKG-UGM/EC/2016 from the ethics and advocacy unit, Faculty of Dentistry, Gadjah Mada University, Yogyakarta, Indonesia.

The periapical radiograph examination has been done in The Prof Soedomo Dental Hospital, Faculty of Dentistry, Gadjah Mada University, Yogyakarta, Indonesia, using Villa Sistemi Medici Endos ACP CEI dental X-ray (Bologna, Italy) and PSP (photostimulable phosphor plate) image receptor. Periapical radiography exposure was 70 kVp, 8 mA, and 3.2 s. DEXA examination to measure the bone mineral density of the hip and lumbar spine has been done in The Dr. Sardjito General Hospital, Yogyakarta, Indonesia, using Lunar Prodigy Primo DEXA densitometer (GE Lunar Corporation, Madison, WI, USA) with exposure of 42 μGy in 1,27 minutes. Image processing has been done using ImageJ 1.50i software to measure the maximum value of the region of interest (ROI) of periapical radiograph as seen in Figure 2.

![Figure 2. Extraction of image information](image)
grayscale dental periapical radiograph to the binary image of ROI shown in Figure 3.

![Figure 3](image-url)

Figure 3. Dental radiograph (a) the original periapical radiograph, (b) ROI selection, (c) ROI, and (d) binary image of ROI

The measurement of maximum value of the image has been done using ImageJ 1.50i software, a version of Wayne Rasband, National Institutes of Health, USA (http://imagej.nih.gov/ij). ImageJ is in the public domain (https://imagej.nih.gov/ij/download.html) (Accessed on 14 April 2016, Java 1.6.0_20). The linear regression method was applied to determine the correlation and test the maximum value with the bone mineral density of lumbar spine and hip.

### III. RESULT AND DISCUSSION

#### A. Result

Image processing has been done to extract the information of the periapical radiograph of the mandible to get the predictor parameter for bone mineral density of the hip and lumbar spine. Quality assurance were done by the dentist for each radiograph. The ROI selection has been done with the dentist supervision and ROI were approved by the dentist.

The grayscale ROI was converted to binary image finally, measurement of maximum value were done. As there were 37 radiographs and DEXA scanning, so the result of measurement also for all of 37 data. In this study, there were no data that has to be excluded. The statistical analysis were using linear regression method to show the correlation, determination coefficient, and the ability of maximum value to be the predictor for BMD of lumbar spine and hip. Table 1 shows the result of linear regression test for maximum value with the BMD of lumbar spine and hip.

### B. Discussion

Find maxima is the command to measure the maximum value. It indicate how many pixel or point in an image that has the maximum value. This maximum value has reported being able to distinguish the condition of osteoporosis, osteopenia, and normal from the periapical radiograph of mandible [12]. The result of this study was did not suitable with that previous study. It can be caused by the difference of the number of the data involved in the study. The previous study only used three data and they were classified into osteoporosis, osteopenia, and normal by DEXA scanning. While in this study, there were 37 data used. The more the subject can be more complex so that influence the result.

<table>
<thead>
<tr>
<th>Value</th>
<th>BMD lumbar spine</th>
<th>BMD hip</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>0.049</td>
<td>0.132</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.002</td>
<td>0.017</td>
</tr>
<tr>
<td>F</td>
<td>0.086</td>
<td>0.617</td>
</tr>
<tr>
<td>Sig F</td>
<td>0.772</td>
<td>0.438</td>
</tr>
<tr>
<td>A</td>
<td>0.352</td>
<td>0.894</td>
</tr>
<tr>
<td>B</td>
<td>0.912</td>
<td>0.746</td>
</tr>
</tbody>
</table>

The maximum value can be measured only on a binary image. This is why the ROI was converted from gray scale image to binary image. This method also has been used in the previous study for the dental image [13]. The image was converted into a binary image in order to determine whether a pixel belongs to an object and do not belong to the other object. The binary image also better in showing the connectivity of some pixels. The well connected pixels will form a closed area. The more the close area result in the higher the density of the image. Therefore the more the maximum value was detected, the higher the BMD [12]. Basically, this study agrees with that previous study. It can be seen from the Table 1, which show the positive correlation between the maximum value with the BMD of lumbar spine and hip.

The correlation coefficient between the maximum value with the BMD of lumbar spine and hip was 0.049 and 0.132 respectively. And from the R square, it can be inferred that the BMD of lumbar spine is influenced by the maximum value only 0.2 % and 99.8% by the other parameter. While the BMD of hip is influenced by the maximum value only 1.7% and 98.3% by the other parameter. It shows that the determination coefficient of maximum value to the BMD of lumbar spine and hip were too weak.

Although the maximum value of the image has an influence to the BMD of lumbar spine and hip, but by the value of sig F, it can be inferred that the maximum value cannot be the predictor for BMD of the lumbar spine and hip (sig F > 0.05). This insignificant result can be caused by the difference of ROI size. It should be the same size for all ROI for the study.
The result of the study should be saved in a database, in order to create an automated system or computer-aided system, information of dental radiograph need to be extracted and saved in a database [13]. The condition of low bone mineral density may induce perforation on the trabecular bone of mandible that can be characterized by the increase of small areas in the radiograph. The result of this study is suitable for previous studies [10], [11], [14]. The previous study showed that periapical radiograph potential to be used as osteoporosis predictor using the parameter of length and the amount of strut on a particular region of the periapical radiograph. Terminus is the end of trabecular strut, and the node is a node of two or more terminus of one strut. The amount of terminus node of the strut was lower for the osteoporotic bone compared with the normal bone. The study indicates that on the osteoporotic bone, the trabecular bone was more disconnected where only few terminus have adequate connection each other [15].

The result of this study adds the number of references about detecting the risk of osteoporosis using dental radiograph, especially for Indonesian Woman. Although the parameter proposed in this study was not suitable to be the predictor of bone mineral density neither of lumbar spine nor hip, but it is important that the potential of using dental radiograph to detect the risk of osteoporosis is high. Physician and dentist must be considered that osteoporosis is a systemic skeletal disease so that studies to obtain the predictor for osteoporosis using radiograph on another site besides hip and lumbar spine have a probability to be developed. This probability is valuable in fact that DEXA equipment needs high cost and its availability is limited in particular public health services. For that reason, a computer aided system will be necessary. This agrees with the previous study that the development of information technology has an impact on the development of various aspects of human life, especially in health [16].

This study was done only on the anterior region of mandible. It will be possible to do this method for the posterior region of mandible. As we know that the condition of the trabecular bone can be different between anterior and posterior region. It is an opportunity to use another measurement parameter for the dental radiograph in order to get the suitable predictor for the osteoporosis condition of lumbar spine and hip.

**IV. CONCLUSION**

The maximum value of the periapical radiograph did not suitable to be the predictor of bone mineral density of neither lumbar spine nor hip. It is necessary to find another parameter that can be developed to establish a computer-aided system for osteoporosis screening by the dentist using dental radiograph.

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