The development of osteoporosis detective analysis method in trabecular condylus of menopause women using panoramic radiograph

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Abstract

Objective: The purpose of this research is to determine the best method to define the bone quality based on trabecular of condylus analysis. Data were obtained from Dental Hospital, Padjadjaran University, Bandung, Indonesia.

Material and Methods: Factors that influence the successful analysis is the choice of Region of Intereset (ROI) and extract feature method. Research were conducted on cross-section of 79 samples which measured in Dual Energy X-ray Absorptiometry (DEXA) as a standard then the panoramic radiograph was taken. Trabecular analysis was conducted in ROI of condylus using panoramic radiograph then cursor was clicked in cortical endorsal following the condylus head shape.

Results: Feature extraction applied 3 analytical methods, they are: Gray Level Co Occurrence Matrix (GLCM), histogram and fraction. Statistical analysis shows t-score DEXA correlates with 3 methods, it was proved that fraction method performed the best correlation in which r-value is 0.377 and GLCM (contrast r = 0.233, correlation = 0.342, energy -0.147, and homogeneity = r = -0.107), and lastly the histogram method (max histogram r = 0.253, range histogram r = 0.06).

Conclusion: Fraction method with ROI of condylus head shape is the best method to determine osteoporosis in post menopause women.

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Introduction

The incidence of osteoporosis in Indonesia increased each year, 1 out of 3 menopause women was suspected with osteoporosis. Osteoporosis analysis is based on trabecular that has 5–8 times as many as cortical metabolism, meanwhile the jaw bone is still controversial. Many factors contribute to the successful analysis which mainly depends on the Region of Interest (ROI) choice, pre-processsing method and feature extraction.[1–4]

Osteoporosis in post-menopause women which is caused by estrogen reduction stimulate pro-inflammatory cytokine (IL-1, IL-6), TGF-β and Receptor Activator of Nuclear Factor Kappa-B Ligand (RANKL) will decrease osteoblast activity and increase osteoclast activity. Osteoclast will exclude proteinase and carbonic anhydrase which cut the collagen, non-collagen and dissolve calcium. This condition causes thinner trabecular and lower the bone density. Systemic bone resorption will decrease the Bone Mineral Density (BMD) in vertebrae, femur and radius as well as in the jaw. It will cause fracture so early detection should be conducted.[5]

Panoramic radiography usage is increasing as the panoramic technology development. Panoramic radiography detects macro and micro structural morphology. Nowadays, radiograph digital technology and panoramic technology have developed and has been performed to determine the bone quality. Since radiograph correlate with bone quality which was found by Azhari et al.[11] various methods that were developed mostly applied to determine the bone quality based on ROI, conducted the depth and the solidity test of margo inferior cortical as the basis to determine bone quality. Bozic et al.[23] and Cakur et al.[7] did not find any significant correlation because the cortical is not as sensitive as the trabecular. Trabecular analysis is mostly conducted in mandible. ROI in mandible are conducted with various methods. Taguchi et al.[6] applied line strength ROI method at molar apical tooth. White[15] analyzed jaw quality in trabecular ROI of bottom incisivus apical and upper molar, there is a decrease in trabecular branch in osteoporotic condition. The ROI in mandible have many weaknesses bacause of local factor such as occlusion and chronic infection which also affects the bone quality.

Condylar head is considered as ROI because as a part of mandible it does not have direct effect to occlusion but accept the highest in stomatognathic system. Condylus is exclude from chronic infection such as gingivitis at mandibular body. Besides, condylus having the most of trabecular about

98.4% have high metabolism. Condylus formation enchondrally is an important growth piont, easier to decrease estrogen same as vertebrae and gold femur of DEXA.[8,9] The ossification process at condylus is faster than that in mandibular histologically because of decreasing estrogen.[9]

Panoramic radiograph using rotation system x-ray penetrate bone mass, muscle and air then become superimposed (bone absorption, muscle and air) resulting on offset image that have to be delete to get the density value close to the real one. Structural radiography micro analysis correlates well with fractal analysis. The purpose of this study is to determine the best method in defining bone quality.

Figure 1   Panoramic radiograph and ROI condylus

Figure 2   A. Image intensity before compensation, B. Image intensity after compensation

Material and Methods

The research population consist of menopause women aged 50–84 at Dental Hospital Faculty of Dentistry Padjadjaran University, Bandung who fullfill the inclusion criteria willingnes to participate in the research by filling in form of consent. No menstrual cycle for the last 1 year, osteoporosis medication, suspected diabetes mellitus, calcium metabolism disease, hyper and hypo calcemia and osteomalacia based on the anamnesis result. In this research, we used a computer unit processor intel pentium dual core 2 Ghz, RAM 4 GB, computer screen samsung, program include toolbox freeware scientific image processing dip. To process the image of trabecular and marrow morphology, digital panoramic roentgenography (vatex korintificea, 12 mA and 70 kVp, Screen speed 200), scanner Dual X-ray Absorptiometry (DXA) (lunar corporation, madison, wisconsin, USA).

This research analyzes the microstructure of bone using ROI following condylus head. To determine ROI, click in endosteal part using mouse cursor following the condylus head shape. The interception of down part following cortical head of condylus region border with condylus neck and end up in condylus neck figure1.

The image quality of cropped image of condylus head will then be standardized by removing superimpose using compensational method. Compensation was conducted by determining the mean of the lowest variant around condylus that is the area in the lowest grade density, almost 0. The lowest variant were calculated and became minus factor of initial picture and made the last image become darker. To differentiation the marrow area and trabecular area, radiograph background was set to 0, while foreground as fix trabecular stated in gray scale.

Figure 2 perform ROI of condylus mandible and histogram of right and left part before conducting image quality improvement figure 2a, shows ROI of condylus mandible and histogram of right and left part after conducting image quality improvement and its performance is darker figure 2b. Then followed by conducting the threshold.

Performed condylus mandible image and histogram of right and left part before image quality
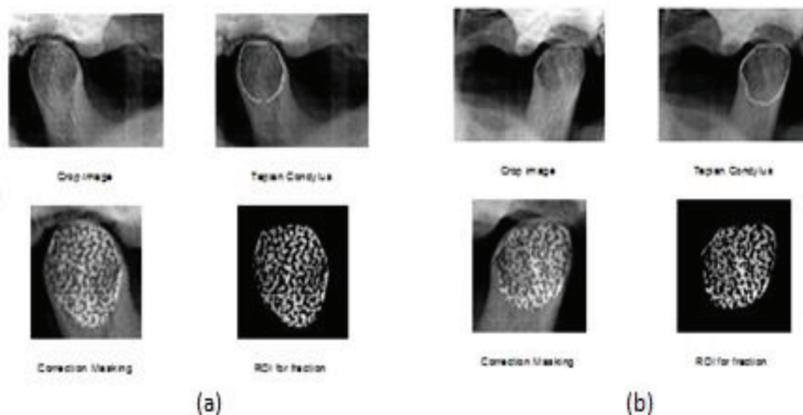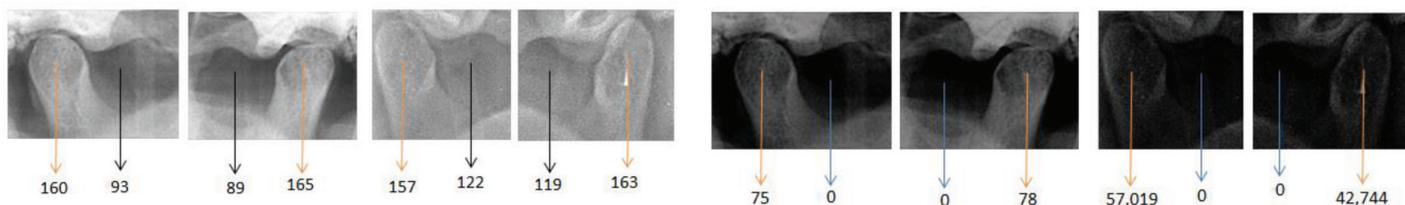

Figure 3   After threshold and background is 0, right (a), left (b); meanwhile trabecular is degraded

Table 1   Research subject characteristics

Description	Group		
	Normal (n = 39)	**Osteopenia (n = 15)**	**Osteoporosis (n = 25)**
Age (SD)	59.1 (5.6)	67.0 (8.7)	65.6 (7.6)
Height (SD)	157.1 (4.1)	153.9 (5.1)	151.4 (5.0)
Weight (SD)	61.8 (9.6)	56.4 (6.8)	52.2 (9.8)
Body Mass Index (kg/m²) (SD)	25.0 (4.0)	23.8 (2.5)	22.8 (4.3)

Table 2   Comparison of density analysis in three research groups

Variable	Group			p-value
	Normal (n = 39)	**Osteopenia (n = 15)**	**Osteoporosis (n = 25)**	
Contrast	0.66	0.66	0.559	0.02
(SD)	(0.15)	(0.39)	(0.13)	
Correlation	0.97	0.97	0.973	0.15
(SD)	(0.00)	(0.01)	(0.01)	
Energy	0.80	0.83	0.812	0.16
(SD)	(0.04)	(0.05)	(0.04)	
Homogeneity	0.92	0.93	0.932	0.18
(SD)	(0.01)	(0.02)	(0.01)	
Fraction	0.11	0.10	0.098	0.03
(SD)	(0.03)	(0.02)	(0.03)	
Max histogram	0.31	0.26	0.241	0.08
(SD)	(0.09)	(0.10)	(0.12)	
Range histogram	0.31	0.32	0.318	
(SD)	(0.07)	(0.06)	(0.06)	

Note: p-value was calculated by Kruskal–Wallis test (p < 0.05).

Table 3   Correlation between t-score and seven trabecular structures analysis features

T-score correlation with	Correlation coefficient (r_s)	p-value
Contrast	0.233	0.040
Correlation	0.342	0.020
Energy	-0.147	0.198
Homogeneity	-0.107	0.353
Fraction	0.377	0.014
Max. histogram	0.253	0.025
Range histogram	-0.060	0.603

Note: r_s = Correlation coefficient of rank Spearman.

improvement was conducted and its performance was darker than the image. Afterwards, features were extracted using 3 methods (GLCM, Histogram and Fraction).

Gray Level Co-occurrence Matrix (GLCM) method

It is one kind of textural analysis method with a statistical approach. The method applied greyish level of relationship among pixel in an image. Features like "contrast", "energy", "correlation" and "homogeneity" were chosen because the recent research proved that those parameters are efficient to differentiate the textural pattern.[10] Those features are, contrast, perform spread size (moment inertia) of image matrix elements. Contrast measure the number of local variety in an image. Energy, known as uniformity or angular second moment. Energy measures the similarities of the texture in a couple of repeated pixel. Correlation, is linear dependent measurement of greyish level in an image, where μ_x and σ_x are average score and standard deviation of column element at matrix P (i, j), μ_y, σ_y are the mean and standard deviation of line element at matrix P (i, j). Homogeneity, known as inverse difference moment. This feature perform the homogeneity of an image and reach its maximum score when all elements in images are similar.[10]

Histogram Normalization Method

Histogram is a simple method. The Probability Density Function (PDF) shows the comparison of grey level in an image. If each pixel has its area then it can be calculated with histogram normalization, thus.

A is image area and H (v) is the number of incidence that occurred in each intense quantity level.

Fraction method

Fraction is a comparison between the number of density level of grey level of trabecular and trabecular grey area.

Results

The characteristics from post-menopause women who come to Dental Hospital, Padjadjaran University, Bandung in this research were age, body height, body weight and body mass index as show at table 1.

Table 1 showed that the characteristics of osteoporosis and osteopenia groups were higher than normal menopause group.

The comparison between groups (normal, osteopenia, and osteoporosis) of all variables show that osteoporosis group has the lowest density.

From the relationship between t-score and measurement of density variables based on multiple regret analysis show that fraction is the best variable than other.

Discussion

The ROI condylus head was the choice based on the anatomy and panoramic technic. Anatomically, condylus head has trabecular structure which is

Table 4 Relationship between t-score and measurements of density based on multiple regret analysis

Variable	Coef B	SE (B)	t-count	p-value
I. Initial model:				
Contrast	-0.471	1.322	0.356	0.723
Correlation	18.060	28.091	0.643	0.522
Energy	10.252	20.580	0.498	0.620
Homogeneity	-32.525	53.850	0.604	0.548
Fraction	13.578	13.466	1.007	0.317
Max histogram	-0.114	3.084	0.037	0.971
Range histogram	-5.332	3.627	1.470	0.146
II. Last model:				
Fraction				

Note: r (multiple) = 0.544; p < 0.001

98.4% and the homogeny structure has the biggest load in stomatognathic system and a few local factor such as chronic infection and mechanical load directly.

In addition, condylus formation is more sensitive enchodrally than mandibular formation, which is through intramembranous. Trabecula study using micro-CT on monkey's mandibular that has been ovariectomized (OVX) as an osteoporosis method, performed different trabecular pattern at condylus and mandibular body. In addition, The ROI shape is also related, the study on animal perform mostly trabecular modification that occurs in subchondral head of condylus and mandibular body.[22] Besides that, the ROI shapes influence as well. The study on animal suggest that trabecular changing occur mostly in head condylus of subchondral part because of the reduction of trabecular interconnectivity and forming a marrow room which is bigger than that in central part of condylus head, meanwhile this study applied ROI following the condylus head shape.[5,6]

Factorial panoramic of radiographical technic has the most minumun distrosion compare to premolar and canine region. Macro study in condylus region distort in macro analisist 4.76% in gold standart CBCT.[2,6] Micro structural analisist study using cow ribs as a jaw model which is located in curved jaw model in condylus region. Porosity micro analysis using fractial method by gold standard micro-CT resulted in the differentiation of mean porosity 4.6%.[5,8] Premolar and canine regions have distorted 10.3%, radiograph classified as good if distortions level is less than 10%.[5,8]

The study to develop the method was performed using 24 samples by applying GLCM method in 4 features (homogeneity, energy, contrast and correlation) resulted in satisfaction. Preprocessing was done using ROI in condylus central by

ROI 50x50 pixel.[2,9] This study was continued to 79 samples using White & Rudolf modification which consist of 4 features (trabecular number, marrow number, trabecular area and marrow area), to study the microstructural changes in condylus central using ROI 50x50 pixel. It shows that the best correlation is performed in trabecular wide feature compare to trabecular number, but it does not correlate significantly to BMD vertebrae 61. This study continues changing pre-processing, that is eliminating noise and superimpose through compensation.

Compensation principle is based in DEXA analysis principle, compensation was applied by determine the lowest mean variety around condylus head, its results is a minus factor of radiograph, thus noise and superimpose are caused by soft tissues, the air can be reduced. Compensation results make radiograph darker, so it perform almost real trabecular density. After that, we perform threshold to reduce noise then make the background to 0 meanwhile trabecular stays in gray scale. This compensation was not applied in the previous research and was assumed that it is the greatest contributing factor in analysis. The previous study applied filter gaussian which used to reduce noise, not superimpose.[1,17,19]

Textural analysis of statistical approach, the most known approach is gray level co-accurrence matrix (GLCM) which applies statistical calculation based on grey level distribution of the relation among pixel in an image. Correlation test results in 7 features of the same ROI, all features perform high correlation. This states that 7 features applied are applicable as parameter of trabecular analysist (r>0.4) table 3.

The t-score (Lumbal spine) correlated with 7 features (head condylus of trabecular). Results shows that generally the correlation is weak, based on Guilford (r<0.4). Among those 7 features, the best correlation is with contrast, correlation, and fraction. After multiple regression analysist was conducted, we proved that fraction feature is the best compare to the other features table 4.

Statistical analysist results show correlation of t-score DEXA, using 3 methods, it was proven that fraction method has the best correlation with r-value is 0.544, p=0.001 and sensitivity is 82.5 and specivity is 41.03. Based on the recent research on trabecular conducted by White[15] there is a correlation between BMD lumbal spine and trabecular ROI pattern at apical incisive bottom and apical molar one up right. Watanabe et al.[16] proved that there are differentiations of trabecular pattern in woman and man. The differentiation in trabecular followed simultaneously by cortical bone.

Conclusion

Fractial method is the best method compare to GLCM method and histogram method to analyze trabecular structure of condylus head analysist based on trabecular. In this research, osteopeni and osteporosis are hardly compared, further researh must be conducted using trabecular analysis method and also conduct specific technic like Temporo Mandibular Joint (TMJ).

In this research, osteopeni and osteporosis are hardly compared, further researh must be conducted using trabecular analysist method specifically to conduct particular technic of TMJ.

Conflict of Interest

The authors report no conflict of interest.

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