

Original Research

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

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ABSTRACT

Osteoporosis incidence in Indonesia increase each year, 1 of 3 menopause women suspected have osteoporosis, then earlier detection is needed. Factors that influence the successful analysis is the choice of region of interest (ROI) and extract feature method. 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 Dentistry Hospital, Padjadjaran University Bandung. Research were conducted cross-section to 79 samples which measured in dual energy X-ray absorptiometry (DEXA) as a base standard then taken its panoramic radiograph. Trabecular analysis was conducted in ROI of condylus using panoramic radiograph then cursor was clicked in cortical endoral following the condylus head shape. To reduce the noise, we conducted pre-processing by compensational method, it is a finding of the lowest means of variant number around condylus as a reduce factor then affect the radiograph of condylus become darker. Background sets in zero (0) meanwhile trabecular stay at gray scale. Feature extraction applied 3 analytical methods, they are: gray level co occurrence matrix (GLCM), histogram and fraction. Statistical analysis shows T-score DEXA correlation with 3 methods, proofed that fraction method performed the best correlation which r value is 0.377 and GLCM (contrast $r=0.233$, correlation $=0.342$, energy -0.147 , homogeneity $= r = -0.107$), meanwhile histogram (max histogram $r=0.253$, range histogram $r=0.06$). As a 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 was increased each year, 1 of 3 menopause women suspected osteoporosis. Osteoporosis analysis based on trabecular has 5-8 times as many as cortical metabolism; meanwhile jaw bone is still controversial. Many factors contribute to the successful analysis mainly depends on the region of interest (ROI) choice and pre-processing method and feature extraction.¹⁻⁴

Osteoporosis in post-menopause women which caused by estrogen reduction stimulate cytokine pro-inflammatory (IL-1, IL-6), TGF- β and RANKL will decrease osteoblast activity and increase osteoclast activity. Osteoclast will exclude proitenease and carbonic anhidrase which cut the collagen, non-collagen and dissolve calcium. This condition cause trabecular thinner and lower the bone density. Systemical bone resorbtion will decrease the bone mineral density (BMD) in vertebrae, femur and radius as well as in jaw, it will affected fracture so earlier detection should be conducted.⁵

Panoramic radiography usage is increase as the panoramic technology development and teeth health care need does too. Panoramic radiography detects macro and micro structural morphology. Nowadays, radiograph digital technology and panoramic have developed and has been performed to determine the bone quality. Since radiograph correlate with bone quality which was found by Horner *et al cit* Azhari *et al*⁴, various methods developed. Mandibula mostly applied to determine the bone quality based on various of ROI. Klemetti *et al cit* Azhari *et al*⁴, conduct the depth and the solidity of margo inferior corticle as the basis to determine bone quality. Brooks *et al cit* Bozic⁶ and Drozdowska *et al cit* Cakur *et al*⁷, did not find any significant correlation because cortical is not as sensitive as trabecular. Trabecular analysis mostly conduct in mandible. ROI in mandible have conducted with various methods. Taguchi *et al*⁸, applied line strength ROI method at molar apical tooth. White *et al*⁹, analyze jaw quality in trabecular ROI bottom incisivus apical and upper molar, there is decreasing in trabecular branch in osteoporosis condition. ROI in mandible have many weaknesses because of local factor such as occlusion and chronic infection which also affecting bone quality.

Condylus head as ROI because as a part of mandibular which does not have direct effect to occlusion but accept the highest in stomatognaty system. Condylus exclude from chronic infection such as gingivitis at mandibular body. Besides, condylus have most of trabecular 98.4% then have high metabolism. Condylus formation encondrally is the main growth, easier to decrease estrogen same as vertebrae and gold femur of DEXA^{8,9} Ossification process at condylus is faster than that in mandibular histologically because of estrogen decreasing.⁹

Panoramic radiograph using rotation system x-ray penetrate bone mass, muscle and air then become superimpose (bone absorption, muscle and air) result 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.

MATERIALS AND METHODS

The research population consist of menopause women aged 50-84 at Dental Hospital Faculty of dentistry, Padjadjaran University Bandung who fullfill its inclusion criteria and willing to participate in the research by filling inform consent. No menstrual cycle minimum the last 1 year, osteoporosis medication, suspect diabetes mellitus, calcium metabolism disease, hyper and hypo calsemia, osteomalacia based on the anamnesis result. In this research, we used a computer unit processor intel Pentium dual core 2 Ghz, RAM 4GB, computer screen Samsung, program include toolbox freeware scientific image processing dip. Image to process an image and trabecular and marrow morphology, digital panoramic rontgenography digital (Vatex Korintifceca, 12 mA dan 70 kVp, Screen speed 200), Scanner Dual x ray Absorbsimetry (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 corticle head of condylus region border with condylus neck and end up in condylus neck (Figure1).



Figure 1. Panoramic radiograph and ROI condylus

Cropped image of head condylus then will be standardized its image quality 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 become minus factor of initial picture and makes the last image become darker. To differentiation the marrow area and trabecular area, radiograph background was set to 0, while fore ground as fix trabecular stated in gray scale.

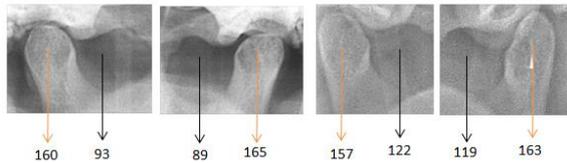


Figure 2a. Image intensity before compensation

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



Figure 2b. Image intensity after compensation

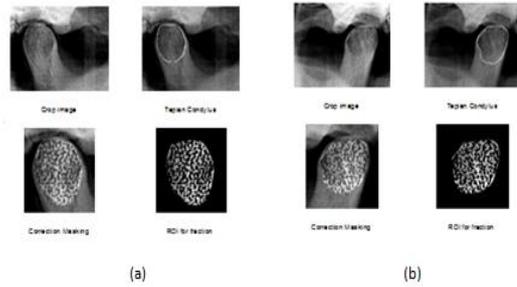


Figure 3. After threshold and background is 0, right (a), left (b); meanwhile trabecular is degraded

Perform condylus mandible image and histogram of right and left part before conducted image quality improvement and its performance is 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. Its method applied greyish level of relationship among pixel in an image. “contrast”, “energy”, “correlation”, and “homogeneity” features were chosen because at the recent research prove 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 couple 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 dan 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. 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

$$p(v) = \frac{1}{A}H(v)$$

A is image area and H(v) is the number of incidence 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. Research subject characteristics.

Description	Group		
	Normal (n=39)	Osteopeni (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/m ²) (SD)	25.0(4.0)	23.8(2.5)	22.8(4.3)

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

Table 2. Comparison of density analysis in three research groups.

Variable	Group			p value
	Normal (n=39)	Osteopeni (n=15)	Osteoporosis (n=25)	
Contrast (SD)	0.66 (0.15)	0.66 (0.39)	0.559 (0.13)	0.02
Correlation (SD)	0.97 (0.00)	0.97 (0.01)	0.973 (0.01)	0.15
Energy (SD)	0.80 (0.04)	0.83 (0.05)	0.812 (0.04)	0.16
Homogeneity (SD)	0.92 (0.01)	0.93 (0.02)	0.932 (0.01)	0.18
Fraction (SD)	0.11 (0.03)	0.10 (0.02)	0.098 (0.03)	0.03
Max histogram (SD)	0.31 (0.09)	0.26 (0.10)	0.241 (0.12)	0.08
Range histogram (SD)	0.31 (0.07)	0.32 (0.06)	0.318 (0.06)	0.96

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

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

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.

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	15.559	5.505	2.826	0.006

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

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

ROI condylus head was choice based on the anatomy and panoramic technic. Anatomically, condylus head has trabecular structure which is 98.4%, homogeny structure, has the biggest load in stomatognaty 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 overiectomy (OVX) as an osteoporosis method, performed different trabecular pattern at condylus and mandibular body. In addition, ROI shape is also related, the study on animal perform mostly trabecular modification occur in subchondral head of condylus and mandibular body.²² Besides that, 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 minimum distortion compare to premolar and canine regio. Macro study in condylus region distorse in macro analysis 4.76% in gold standard CBCT.^{2,6} Micro structural analysis study using cow ribs as a jaw model which located in curved jaw model in condylus regio. Porosity micro analysis using fractal method by gold standard micro-CT result in the differentiation of mean porosity 4.6%.^{5,8} Premolar and canine regions have distortion 10.3%, radiograph classified as good if distortions level is less than 10%.^{5,8}

The study to develop the method was performed by using 24 samples applied GLCM method in 4 features (homogeneity, energy, contrast and correlation) result in satisfaction. Preprocessing using ROI in condylus central by ROI 50x50 pixel.^{2,9} This study continue to 79 samples using White & Rudolf modification which consist of 4 features (trabecular number, marrow number, trabecular area, marrow area), to study the microstructural changing 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 doesn't 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 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 compensations did not applied in the previous research, assumed that it is the greatest contribution factor in analysis. The previous study applied filter Gaussian which used to reduced noise, not superimpose.^{1,17,19}

Textural analyzed of statistical approach, the most known approach is gray level co-occurrence matrix (GLCM) which applied 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 analysis ($r > 0.4$) (Table 3).

If T score (Lumbar spine) is 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 regressed analysis was conducted, we proof that fraction feature is the best compare to the other features (Table 4).

Statistical analysis results show correlation of T-score DEXA, using 3 methods, proven that fraction method has the best correlation with r value is 0.544, $p=0.001$ and sensitivity is 82.5 and specificity is 41.03. Based on the recent research on trabecular conducted by White¹⁵ there is a correlation between BMD lumbar spine and trabecular ROI pattern at apical incisive bottom and apical molar one up right. Watanabe *et al*¹⁶ proof that differentiations of trabecular pattern in woman and man. The differentiation in trabecular followed simultaneously by cortical bone.

CONCLUSION

Fractal method is the best method compare to GLCM method and histogram method to analyze trabecular structure of condylus head analysis based on trabecular. In this research, osteopeni and osteoporosis are hardly compared, it must be conducted further research using trabecular analysis method specifically conducted particular technic of temporo mandibular joint (TMJ).

SUGGESTION

In this research, osteopeni and osteoporosis are hardly compared, it must be conducted further research using trabecular analysis method specifically conducted particular technic of *temporo mandibular joint* (TMJ).

CONFLICT OF INTEREST

The authors report no conflict of interest.

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