ORIGINAL ARTICLE

Analysis of condylar head density and morphology in osteoporosis and non-osteoporosis patients: an observational descriptive study

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ABSTRACT

Introduction: Osteoporosis is a systemic bone disease characterized by increased bone fragility and susceptibility to fractures, decreased bone mass and changes in the bone's microscopic structure, leading to increased porosity and decreased strength. This study aimed to evaluate the differences in the mandibular bone density and condylar head morphology between osteoporosis and non-osteoporosis patients. **Methods:** The study used an observational descriptive design with a cross-sectional approach. The study population using secondary data consisted of all panoramic radiography photos collected over a six-month period from July to December 2019. A total of 24 radiographs were included, comprising women with osteoporosis (age 40 to 60 years) and without osteoporosis (aged 40 to 50 years). Bone density was measured using a region of interest (ROI) of 3x3mm through histogram analysis, while condyle shape was evaluated visually. The collected data were processed with t-test results. **Results:** This study found that right condyle osteoporosis mean 137.51 ± 17.3, right condyle non osteoporosis 143.65 ± 21,1. Left condyle osteoporosis 133.46 ± 18,6, and left condyle non osteoporosis 143.64 ± 18. The mandibular bone density in condylar region was lower in osteoporosis patients by 6.14 pixels on the right side and 10.48 pixels on the left side. The result of the statistical analysis in all groups were p value > 0,05. However, the t-test results indicated no statistically significant differences between two groups. In terms of morphology, the oval shape was the most common in both groups. The bird beak shape was observed exclusively in the osteoporosis group, while the flat shape was more prevalent in the non-osteoporosis group. **Conclusion:** This study suggests that the mandibular bone density in osteoporosis patients is lower than in the non-osteoporosis group. However, this difference was not statistically significant. Additionally, changes in condylar head morphology did not correlate with osteoporosis status or reflect the observed differences in bone density.

KEYWORDS

Density, non-osteoporosis, osteoporosis, shape of condyle

INTRODUCTION

The international Osteoporosis Foundation (2020) estimates that by 2025, approximately 6,3 million patients per year will experience fractures, with more than half of these cases occurring in Asia. Osteoporosis can lead to various complications, especially fractures. The most common fractures sites in individuals with osteoporosis are the spine, wrist, and pelvis.[1-3]

Osteoporosis is a metabolic bone disease or skeletal disorder characterized by reduced bone strength, leading to an increased risk of fractures.[4] It is an age-related condition that is more prevalent in women aged 40 to 60 years. As the global population ages, the number of individuals with osteoporosis is predicted

to increase. Consequently, further research is needed to understand the changes associated with this disease to develop early detection strategies that can prevent complications and mitigate the severity of osteoporosis.[4]

The condyles, which are part of the mandible, form the only freely movable joint in human body. In patients with osteoporosis, bone resorption is predicted to occur more rapidly, leading to changes in the shape of the condylar head that correspond to a decrease in bone density. Radiographic evaluation of these changes can serve as a potential method for detecting osteoporosis.[5]

Panoramic radiographs are a widely used imaging technique for evaluating the entire dentition and jawbone, often used in routine examinations. Several studies have used dental panoramic radiograph to assess bone quality.[6-8] Examination with panoramic radiographs can evaluate macrostructural bone quality, which refers to the overall architecture and structural integrity of bone, using measurement indices such as the mandibular cortical index (MCI), mandibular cortical thickness (MCT), mental index (MI), and panoramic mandibular index (PMI).[9-11] Additionally, microstructural bone density analysis can be performed by calculating the degree of grayness on the radiograph. This analysis is facilitated by Image-j software, where density values are obtained by assessing the histogram .[12]

Although panoramic radiography has been widely used to assess mandibular bone quality and detect osteoporosis-related changes, limited studies have focused on analyzing condylar head density and morphology in osteoporosis patients, particularly among women in the middle-age and postmenopausal groups. Previous research primarily examined mandibular cortical indices and trabecular patterns; however, the condylar head—being part of the temporomandibular joint that continuously undergoes remodeling—may provide additional diagnostic insight into early bone density alterations associated with osteoporosis.[13-15]

The novelty of this study lies in its radiographic assessment of condylar head density using histogram analysis and its comparison of morphological variations between osteoporosis and non-osteoporosis patients. This dual evaluation provides new data on how systemic bone loss may manifest in mandibular structures visible on panoramic radiographs, supporting the potential role of dental imaging in osteoporosis screening. This study aims to analyze bone density in the condylar region using histogram analysis and to evaluate the morphology of the condylar head in osteoporosis and non-osteoporosis patients. The study is necessary to collect data on bone density and morphological conditions in patients with osteoporosis and without osteoporosis.

METHODS

This study used an observational descriptive design with a cross-sectional approach. This is using secondary data of 48 panoramic radiographs image that consist of 24 osteoporosis patients and 24 non-osteoporosis patients which all population are female from Klinik Izzati Diabetes Cimahi over a six-month period from July to December 2019. The inclusion criteria were panoramic radiograph photo of female patient 40 – 60 years old for osteoporosis groups and 40 – 50 years old for non osteoporosis groups. The exclusion criteria were the result of panoramic photos cannot be interpreted, photo with disease affecting of the mandibular bones, the result photo with mandibular fracture, the resulting photo is distorted the size and shape are not the same as the original object.

The procedure of this study was samples collected and analyze the bone of condyle head region. The bone area analyzed on the left and right condyle head region. The bone density analyze using J image software with histogram analysis and measurement using 3x3 ROI (Region of interest). After analyze left and right the bone of condyle head, we got the value of mean (±SD) right condyle

osteoporosis, left condyle osteoporosis, right condyle non osteoporosis and left condyle non osteoporosis.

The assessment of the morphology condyle was assessed by visually. Observations were made one researcher and two other observers who are radiology-specialist dentists and decisions were made based on mutual agreement.

The data collected were subsequently processed using an independent sample test t – test from the results obtained by osteoporosis and non-osteoporosis patients. All data p value > 0,05 This indicates that the normality test data is homogen. Normality test can be continued for a different test. The data normality test was carried out with the Kolmogorov Smirov the difference test conducted with the Independent Samples test, namely the T Test. Data is said to be different if it has a p value <0.05. (2-tailed)

Figure 1. Analysis area in the condyle area, with a 3x3 mm ROI.[13]

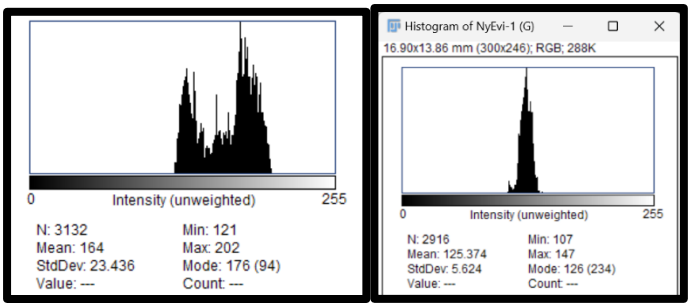

Figure 2. Histogram of the density analysis results in the ROI area of the condilus area with 3x3 mm ROI.[13]

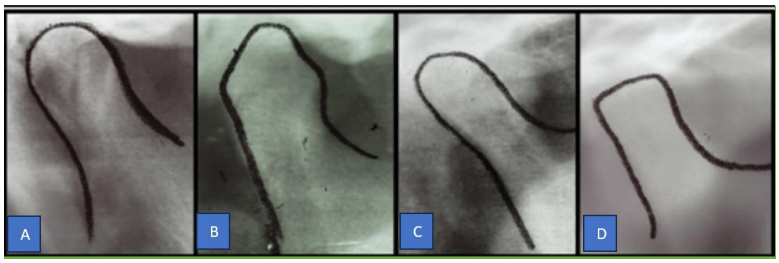

Figure 3. Pathological shape variations of the condyle head observed: a. ovoid, b. *angled*, c. bird beak, d. flat.[14]

RESULTS

The study's results were obtained as follows: A total of 24 radiographs from women with osteoporosis and 24 radiographs form non-osteoporosis patients were analyzed. Bone density was measured using a region of interest (ROI) of 3x3mm through histogram analysis.

Table 1 Density values of osteoporosis patients and non-osteoporosis

Area ROI	Min	Max	Mean (±SD)
Right Condyle osteoporosis	102.77	166.47	137.51 ± 17.3
Right Condyle non-osteoporosis	108.29	187.11	143.65 ± 21,1
Left Condyle osteoporosis	104.26	196.22	133.46 ± 18,6
Left Condyle non-osteoporosis	105.56	185.66	143.64 ± 18.6

As shown in Table 1, the bone density values in osteoporosis patients were lower than those in non-osteoporosis patients. The difference in density values between the two groups was 6.24 pixels for the right condyle and 10.48 pixels for the left condyle. These results indicate the bone density is higher in non-osteoporosis patients is higher compared to osteoporosis patients.

Table 2 Data normality test in both groups

Area ROI	Statistic	P.value
Right Condyle osteoporosis	0.963	0.504
Right Condyle non-osteoporosis	0.96	0.429
Left Condyle osteoporosis	0.876	0.07
Left Condyle non-osteoporosis	0.97	0.67

The data normality test was carried out with the Kolmogorov Smirov test. Results of the statistical analysis showed in all groups were P value > 0.05. This condition explains that all data obtained are normally distributed.

Table 3. Data Homogeneity Test in both groups

Area ROI		F	P.value
Right Condyle	Equal variances assumed	0.481	0.492
	Equal variances not assumed	0	0
Left Condyle	Equal variances assumed	0.169	0.683
	Equal variances not assumed	0	0

Table 3 shows that in all data groups both Right and Left P value > 0.05. This indicates that the data is homogeneous and can be continued for a different test. The difference test conducted with the Independent Samples test, namely the T Test. Data is said to be different if it has P value. (2 - tailed) < 0,05.

Table 4. Differential test of all test groups

Area ROI		t	P Value (2-tailed)	Std.Error Difference
Right Condyle	Equal variances assumed	-1.103	0.276	± 5.57
	Equal variances not assumed	-1.103	0.276	± 5.57
Left Condyle	Equal variances assumed	-1.918	0.061	± 5.30
	Equal variances not assumed	-1.918	0.061	± 5.30

Based on the results of the t-test (table 4), the results of all groups found no significant differences.This result may be due to the fact that the difference in the values of all groups is very small, although it cannot be proven statistically.

Table 5 Analysis of head shape condyle dextra and sinistra

	Osteoprosis		Non-Osteoporosis	
	Dextra	Sinistra	Dextra	Sinistra
Ovoid	11	8	11	10
Angled	7	9	9	12
Bird beak	5	7	0	0
Flat	1	0	4	2

Based on the observational results, the ovoid shape of the condylar head was the most common in both osteoporosis and non-osteoporosis patient groups. The bird beak shape was observed exclusively in the group of patients with osteoporosis, while the flat shape was more prevalent in the non-osteoporosis patient group.

DISCUSSION

This study showed right condyle osteoporosis mean 137.51 ± 17.3, right condyle non osteoporosis 143.65 ± 21,1. Left condyle osteoporosis 133.46 ± 18,6 and left condyle non osteoporosis 143.64 ± 18.6. The density value of the mandibular bone in the condyle area in osteoporosis patients is lower by 6.14 pixels on the right side and 10.48 pixels on the left side. This study showed that the density value in osteoporosis patients showed lower value compared to the density value of patients without osteoporosis.

This is in line with research conducted by Azhari in her study stated that the difference in the width of the mandibular cortex of the right and left jaws can be caused by a pattern of one-sided mastication. The low width of the mandibular cortex is also accompanied by tooth loss, although tooth loss has many causes, however, some studies state that people who experience bone resorption or with osteoporosis experience tooth loss. Osteoporosis is a systemic degenerative disease that occurs in bone, characterized by a reduced bone mass and disrupted microarchitecture of bone tissue.[15,16,17] Bone density, defined as the amount of bone mass measured per units of area (mm2) or volume (mm3).[18-19]

Bone density in the mandible can be assessed by evaluating trabecular pattern of.6 Trabecular play an important role in radiographic imaging , and their loss leads to reduced bone density, which is quantified in pixel units on radiograph.[20,21] The primary factors contributing to osteoporosis include age-related bone tissue resorption and gonadal hormone deficiency.15,18 In women, the mechanism of bone loss is primarily associated the aging process and estrogen deficiency following menopause.[22,23]

The result of the study in table 5 about analysis of head morphology condyle dextra and sinistra showed that rounded shapes are the most found morphology variation followed by angled and bird beak both in osteoporosis and non osteoporosis group. The flate shapes are found little both in osteoporosis and non osteoporosis. Based on the result of this condyle head variations observation, it was obtained the result that the condyle head morphology is varied in each group. Mathew et al32 stated that condyle shape variation can occur because the adaptive or degenerative changes in TMJ occur for a long time and continuously. TMJ especially the condyle will continue to receive functional loads during life.

The result of the study described above have similiarity with the result of the study Singh et al.[24] Which in his research observed condyle shape variations of 350 subjects. His research found the most condyle shape variation is rounded as much as 57%, then followed by pointed 29%, angled 10%, and the least is flattened 4%. Sahithi et al., also explained that the most widely appeared condyle shape variations are rounded as much as (39.25%), but there is a difference from the second most angled form variation of (35.5).

The study also observed condyle morphology variation on both side of the right and left pastient's jaw. From the results obtained as many as 48 patients have different shapes on the right and left sides of the condyle. This is in a statement by Song et al[25] which says that in the same individual there may be a difference in the condyle shape between the left and right sides. Based on the research of Singh et al., also found the conformity of results regarding the condyle form that is not always the same on both sides, which is as much as 18.6%, while the same shape on both sides remains more at 81.4%

The temporomandibular joint (TMJ) connects the skull and mandible and is a complex joint responsible for the opening,closing, and other movements of the jaw. The TMJ is an organ that plays an important role in the stomatognathic system and is the only joint in the head.[14,26] The shape of the condylar head is one of the parameters that can be analyzed through radiographic imaging.

The appearance of the condylar head is highly variable and influenced by numerous factors, including inflammatory processes and bone remodeling.[14,27] Generally, the condylar head can be classified into five shapes: flattened, pointed, angled, round, and crooked finger.[24,25] Variations in condylar head shape are influenced by various factors and are also related to TMJ function.[28] Pathological changes in condylar head include osteophytes, bird beak deformation, sclerosis, flattening, and erosion.[14,26,] These changes can result from remodeling, inflammation, and trauma.[36,37 29]

Factors that also affect the density of bone is estrogen hormone deficiency it causes changes in the condylar head shape in both osteoporosis and non-osteoporosis groups. However, based on the results of the study, it appears that there is no specific shape resulted from osteoporosis, as both groups show the same tendency of damage. Pathological shape variations of the condylar head include ovoid, angled, birdbeak, and flat. This suggest that the inflammation and remodeling occurring in the condylar head is more influenced by physiological conditions of the TMJ, which is constantly moving. This is in line with research by Sonal V and Dhea Lisa, which states that changes in the shape of the condylar head are influenced by multiple factors, including TMJ physiology and TMD conditions (joint inflammation).[29]

The result of this study Estrogen plays a critical role in maintaining bone mass.[31] Estrogen deficiency leads to increased apoptosis and differentiation of osteoblasts through various mechanisms. Estrogen enhances osteoblast viability and prevents apoptosis via estrogen receptor (ER-) and Wingless-type-1 (Wnt)/β-catenin signaling pathways, both of which promote osteoblast proliferation and differentiation. Inhibition of estrogen receptor (ER-) expression suppresses osteoblast differentiation.[28] In the physiological process of bone remodeling, IL-17 activation is associated with estrogen deficiency and contributes to the development of osteoporosis. IL-17 increases the secretion of RANKL, TNF-α, and IL-1, which are inflammatory cytokines that promote bone resorption.[32] Postmenopausal women with osteoporosis have higher serum concentrations of IL-17 and RANKL.[33]

Under normal conditions, estrogen induces apoptosis of dendritic cells and memory cells. Estrogen deficiency prolongs the lifespan of dendritic cell, triggering an inflammatory response characterized by increased levels of IL-7 and IL-15 which activates memory T cells to produce TNF-α and IL-17.[26] Most participants in the osteoporosis group had entered menopause and were diagnosed with osteoporosis through dual-energy X-ray absorptiometry (DXA) examination. This confirms that these individuals are at a physiological stage where osteoporosis is likely to occur, consistent with the decline in estrogen levels.[34] In contrast, participants in the non-osteoporosis group were aged 40 to 50 years, an age range in which menopause is less likely to occur, as menopause typically begins around age 50 or olde.

However, the absence of definitive diagnostic evidence, such as DXA examination, in the osteoporosis group, this cannot be confirmed.[35] The process of bone formation accelerates during puberty, peaks between the ages of 20 and 35 years, and gradually decreases with aging. The decrease in bone mass starts around the age of 30, and this reduction will continue throughout the aging process. As a result, bone density in older individuals is lower than in younger individuals.[20,21] These findings align with research by Kenkre, which highlights the role of estrogen in bone remodeling and osteoblast proliferation. Similarly, studied by Audina and Azhari explain the impact of menopause process and estrogen deficiency that cause a decrease in bone density.[36,37]

There are several limitations in this study, including the limited number of studied that discuss condylar head variations. In addition, panoramic radiograph images may introduce biases that can make the observation of condylar shape ambiguous. Visual observatio of condylar head without the use of tools is susceptible to subjectivity, as individual perception when interpreting condylar shapes may vary. To minimize bias, we used two observers. The results may be due to the fact that the differences in values across all groups are very small, although this could not statistically.

CONCLUSION

The density value of the mandibular bone in the condyle area in osteoporosis patients is lower by 6.14 pixels on the right side and 10.48 pixels on the left side. based on table 1. This study showed that the density value in osteoporosis patients showed lower value compared to the density value of patients without osteoporosis. However, this difference was not statistically significant and changes in condylar head morphology do not reflect the influence of osteoporosis in correlation with the bone density value. There are variation in the form of the condyle. This study suggests that the density condylar head in osteoporosis patients is lower than in the non-osteoporosis group. The implication of this study to Early detection of cases of osteoporosis is indispensable for effective prevention and treatment.

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Informed Consent Statement: Written informed consent was obtained from all study participants prior to their inclusion in the research. The purpose and procedures of the study were explained in detail to the participants, and they were given the opportunity to ask questions and clarify any doubts they may have had. Participants were informed that their participation was voluntary and that they could withdraw from the study at any time without any consequences.
Data Availability Statement: The data that support the findings of this study are available upon request from the corresponding author. Restrictions apply to the availability of these data, which were used under license for this study and are not publicly available. However, data are available from the authors upon reasonable request and with the permission of the data provider.
Conflicts of Interest: The authors declare no conflicts of interest related to this study

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