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Difference of mandibular trabecular bone fractal dimension values on panoramic radiographs of vegetarians and nonvegetarians in Medan City

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ABSTRACT

Background: *Vegetarians are known to be more susceptible to experiencing bone mineral density decreases compared to nonvegetarians. The trabecular bone is sensitive to any changes that disrupt the balance of bone metabolism. On panoramic radiographs, bone density can be evaluated by analyzing the fractal dimensions (FD) of the mandibular trabecular bone.* ***Purpose:*** *This analytical cross-sectional study aimed to assess the mandibular trabecular bone FD values on panoramic radiographs of vegetarians and nonvegetarians in Medan City.* ***Methods:*** *This study used a purposive-sampling technique and obtained 30 digital panoramic radiographs of vegetarians and nonvegetarians in Medan City, aged 20 to 40 years, between January and February 2023, at the radiology installation of Dental and Oral Hospital Universitas Sumatera Utara and Laboratory Clinic Pramita Medan. Fractal analysis was performed using ImageJ 1.54c software with the box-counting method. The data distribution was assessed using the Shapiro–Wilk test. The data were analyzed using an independent samples T-test.* ***Results:*** *The results showed that the FD values of the mandibular trabecular bone were significantly different between the two groups (p = 0.000).* ***Conclusion:*** *The mean FD values on the panoramic radiographs were lower in the vegetarian mandibular trabecular bone than in the nonvegetarian mandibular trabecular bone. Considerations need to be made by dentists when performing treatments related to mandibular trabecular bone surgery in vegetarians.*

Keywords: *fractal analysis; fractal dimension; mandibular trabecular bone; vegetarian; panoramic radiograph*
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INTRODUCTION

The number of vegetarians has increased rapidly in many parts of the world over the past few years. It is estimated that 1–4% of the world's population is vegetarian.[1] Asia has the highest vegetarian demographic, at 19% of its total population. Africa and the Middle East account for 16% of the vegetarian population, the Americas 14%, and Europe 5%.[2] India has the largest vegetarian population, with 448 million (35%) vegetarians.[3] About 5 million (9%) British citizens,[4] 26 million (8%) Americans,[5] and 9.5 million (12%) Germans[6] are vegetarians. The phenomenon of the growing popularity of vegetarian diets has also occurred in Indonesia. About 2 million Indonesians adopted a vegetarian diet, based on data from the Indonesian Vegetarian Society in 2018.[7] Indonesia is the third-fastest-growing vegetarian country globally. About 271 thousand Indonesians became vegetarians between 2016 and 2017.[8]

Health considerations are among the most common reasons people adopt a vegetarian diet.[9] A vegetarian diet reduces the risk of obesity, type 2 diabetes mellitus, hypertension, hypercholesterolemia, and stroke. However, vegetarian diets still have disadvantages. Vegetarians are known to be more susceptible to experiencing bone mineral density (BMD) decreases than nonvegetarians because bone-specific nutrients are found in animal products.[10–14] BMD measures the mineral content found in bones.[15] Nutrients such as calcium, phosphorus, iron, iodine, zinc, protein, vitamin B12, and vitamin D contribute to maintaining bone health.[16,17] One factor that affects BMD is diet. A diet with a low intake of bone nutrients can decrease BMD. Low BMD status can increase the risk of bone fractures.[10]

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Dual-energy X-ray absorptiometry (DXA) is a noninvasive two-dimensional X-ray technique considered the gold standard for diagnosing BMD. However, DXA is expensive and is not widely available in Indonesia.[15,18] Panoramic radiography is the most commonly used technique in dentistry because it is economical, easy to operate, and widely available.[19,20] The utilization of panoramic radiography includes determining the type and size of the dental pulp chamber,[21] confirming the position of wisdom teeth,[22] gender prediction,[23] and detecting jawbone disorders.[19] The trabecular bone is sensitive to any changes that disrupt the balance of bone metabolism.[24] Detecting jawbone disorders can be attempted by assessing trabecular bone density.[19,20] Patients can be referred for further examination by medical specialists if suspicious conditions are found in the mandibular trabecular bone, so that the patient can get a definite diagnosis and appropriate treatment options as soon as possible.[25]

Mandibular trabecular bone density has been assessed on panoramic radiographs in several ways, such as bone relative density,[26] pixel intensity,[27] radiopacity,[28] and fractal analysis.[27,29,30] Fractal analysis is a quantitative technique to determine the complexity and irregularity of a fractal object.[31,32] Fractal analysis assesses objects with porous and branched structures, including trabecular bone. The information from the fractal analysis of numerical data is called the fractal dimension (FD). The FD value describes how completely a structure fills a space. The higher the FD value of the trabecular bone, the more complex, stable, and dense the trabecular bone structure.[32] The most common method for performing fractal analysis of mandibular trabecular bone is box-counting, designed by White and Rudolph in 1999.[29,30]

Box-counting is a numerical method to obtain the FD value of the trabecular bone by utilizing the shape of a box that varies in size. The mandibular trabecular bone structure fills the boxes, and the length of the boxes is adjusted to the smallest detail (pixel) of the mandibular trabecular bone image.[33] The White and Rudolph box-counting method begins by selecting a portion of the mandibular trabecular bone from the analyzed overall panoramic radiograph image. Not all anatomical parts of the panoramic radiographic images are processed and measured – only pixels within the region of interest.[34] ImageJ is the most widely used software in fractal analysis research in dental radiology because it has comprehensive features and is easy to use.[20,31] The image processing steps of the ImageJ software to obtain the FD value of mandibular trabecular bone consist of Gaussian blur filters, subtract background, add, make binary, erode, dilate, skeletonize, invert, and fractal box count.[29]

Although previous studies on vegetarians have been conducted, most studies have only discussed nutrient intake and nutritional status among vegetarians.[35–38] Moreover, studies of the effects of vegetarian diets on bone health generally do not use dental radiographs.[12–14,39] FD analysis research in dentistry using panoramic radiographs has also been conducted.[27,29–31] However, FD analysis research with vegetarians as respondents has yet to be available. To our knowledge, no study has evaluated the differences in the FD values of mandibular trabecular bone in vegetarians and nonvegetarians using panoramic radiographs. Therefore, this study aims to assess the mean FD values of mandibular trabecular bone on panoramic radiographs of vegetarians and nonvegetarians in Medan City and to investigate the difference in mean FD values between the two groups.

MATERIALS AND METHODS

This cross-sectional study involved 15 vegetarian radiographs and 15 nonvegetarian radiographs. The sample size for this study was determined based on the unpaired numerical comparative analytic formula ($\sigma = 0.11$, $\alpha = 5\%$, $Z\alpha = 1.96$, $Z\beta = 1.28$, $\mu1\text{-}\mu2 = 0.15$).[40]

$$N = \frac{2\sigma^2(Z_\alpha + Z_\beta)^2}{(\mu_1 - \mu_2)^2}$$

The sample size was 12 radiographs for each of the two groups. Anticipating a 10% dropout rate, at least 27 radiographs were needed for the two groups. Therefore, the researcher used 30 radiographs – 15 for each group.

The study was conducted at the Dental and Oral Hospital Universitas Sumatera Utara Radiology Installation and Pramita Clinical Laboratory Medan Radiology Unit from January 2023 to February 2023. The criteria for people who underwent panoramic radiograph imaging in this study were individuals domiciled in Medan City and aged 20 to 40 years, vegetarians who had implemented a vegetarian diet (e.g., lactovegetarian, ovo-vegetarian, lacto-ovo-vegetarian, or vegan) ≥ 6 months, nonvegetarians who had not adopted any vegetarian diet type (e.g., lactovegetarian, ovo-vegetarian, lacto-ovo-vegetarian, or vegan) ≥ 6 months, and individuals not known to suffer from mandibular trauma, not known to suffer developmental disorders related to bone metabolism (e.g., diabetes, hyperparathyroidism, myeloma, or bone metastases), and not known to take medications that affect bone metabolism (e.g., glucocorticoids, anticoagulants, anticonvulsants, immunosuppressants, or chemotherapy).

Before all study procedures began, informed consent was given verbally and formalized in printed form to be completed and signed by the participants. Participants known to meet the criteria were identified through a questionnaire administered by the researcher at the Dental and Oral Hospital Universitas Sumatera Utara Radiology Installation. The questionnaire given to the participants regarding dietary history contained the following questions: (1) What diet do you currently implement? (2) At what age did you become a vegetarian? (3) How long have you been a vegetarian? (4) What foods do you most often consume if you are a vegetarian? (5) What foods do you most often consume if you are a nonvegetarian? (6) How often do you consume meat in one week if you are a nonvegetarian? (7) If you are a nonvegetarian, have you ever been a vegetarian? For how long?

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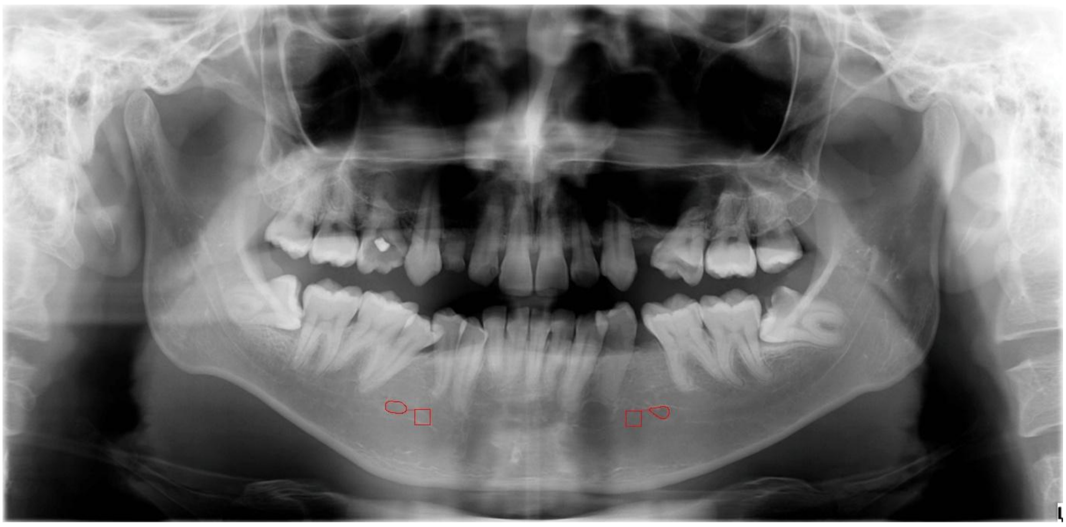

Figure 1. Scheme of the selected regions of interest (ROIs) on the digital panoramic radiographs: ROI 1 in the trabecular bone, 2 mm anterior to the right mental foramen, and ROI 2 in the trabecular bone, 2 mm in front of the left mental foramen.

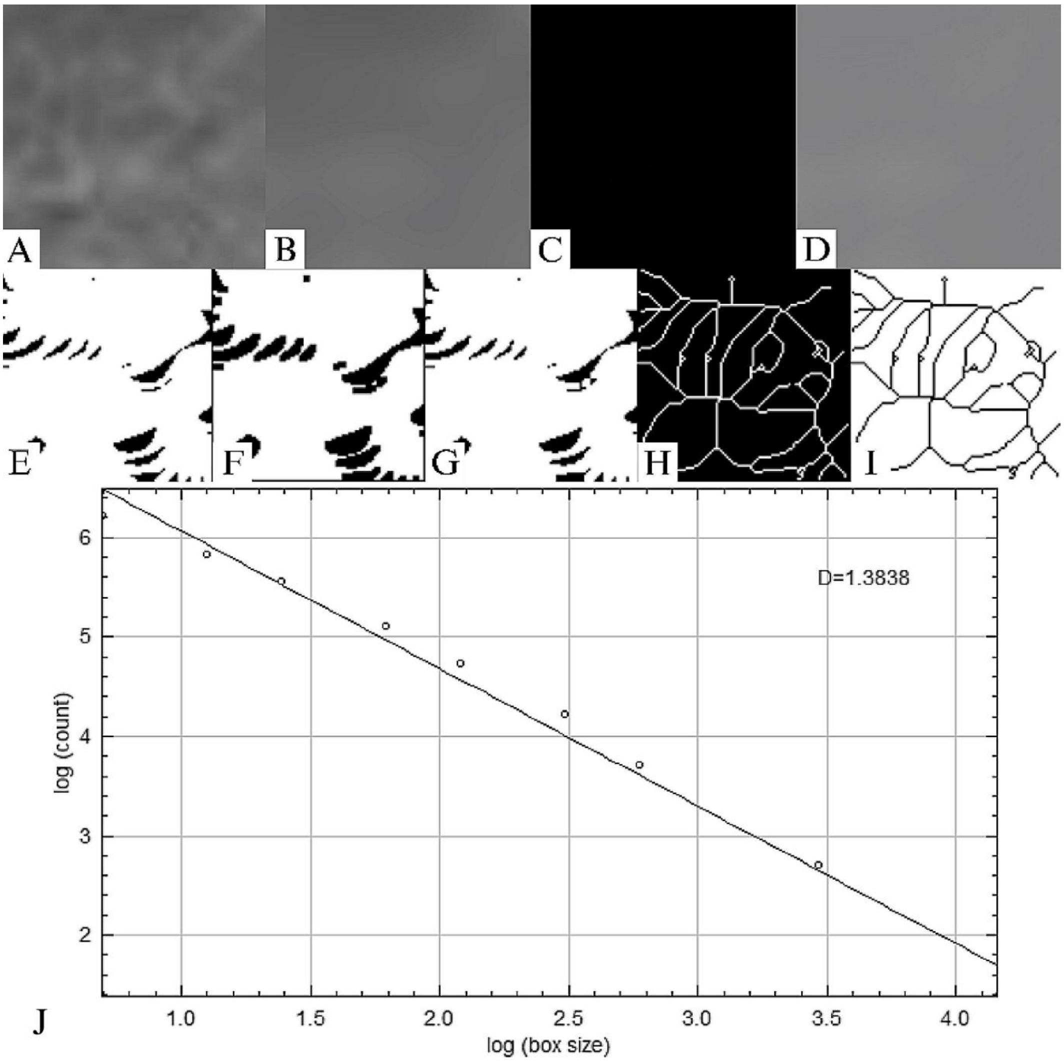

Figure 2. Image processing sequence of the fractal dimensional analysis used in this study. (A) 100 100-pixel square region of interest, (B) Gaussian blur filters, (C) subtract background, (D) add, (E) make binary, (F) erode, (G) dilate, (H) skeletonize, (I) invert, and (J) result plot (personal documentation).

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The sample for the study was determined based on inclusion and exclusion criteria (purposive sampling). The inclusion criteria were panoramic radiographs of good quality and panoramic radiographs that displayed the right and left mental foramina. The exclusion criteria were panoramic radiographs that showed pathological conditions, such as radiolucent lesions or radiopaque lesions on the mandible, especially in the mental foramen area. Three observers evaluated the panoramic radiographs used in this study (DK, CDM, and PW). One of them was an oral radiologist with more than five years of experience. All images (n = 30) were saved in TIFF format, with a matrix size of 7,008 x 3,461 pixels in 300-dpi resolution and 8-bit grayscale. The images were processed using ImageJ version 1.54c software (National Institutes of Health, Bethesda, MD, USA, available at https://imagej.net/ij/download.html) on a Dell Inspiron 3180 x64-based PC 087E (Dell, TX, USA) to obtain the FD values of the mandibular trabecular bone.

Image processing was initiated by manually placing a square-shaped box of a 100 x 100-pixel region of interest (ROI) 2 mm from the mesial edge of the right (ROI1) and left (ROI2) mental foramina. The ROIs were not placed in areas prone to distortion and did not reach any anatomical structures, such as the lamina dura, apical teeth, mental foramen, mandibular canal, and mandibular cortical bone, to avoid the area of overlapping anatomical landmarks (Figure 1). The sequence of image processing steps in performing fractal analysis of the box-counting method consists of Gaussian blur filters, subtracting background, adding, making binary, eroding, dilating, skeletonizing, inverting, and fractal box count (Figure 2).[28] The FD values obtained bilaterally from each radiograph were recorded, calculated, and applied to the statistical analysis. The processing steps were conducted using a methodology from a previous similar study based on the design developed by White and Rudolph.[28] The observers evaluated the images for a second time after two weeks to ensure calibration and to determine the reliability of the jaw measurements. Measurement was performed twice, and the average of the measurements was used as the final result. The reliability of the results in this study was tested using the intraclass correlation coefficient (ICC) to guarantee that the observers held similar views, thus maintaining the validity and consistency of the data collected.

SPSS version 25.0 (IBM SPSS Inc., Chicago, IL, USA) was used for the statistical analysis test. The Shapiro–Wilk test was used to test the normality of the data. The descriptive data of the FD values were presented as the mean and standard deviation. The independent samples T-test was used for data analysis. The analysis results were considered significant when the p-value was <0.05. The study was conducted according to the applicable ethical principles and the World Medical Association Declaration of Helsinki of 1964 and was approved by the Health Research Ethical Committee of Universitas Sumatera Utara (15/KEPK/USU/2023).

RESULTS

The results of the ICC tests were greater than 0.75. This meant that the reliability of the data was excellent (Table 1). The vegetarian group was composed of 73.3% females (n = 11) and 26.7% males (n = 4), with a mean age of 30.9 years (SD 6.57). The nonvegetarian group had 7 females (46.7%) and 8 males (53.3%), with a mean age of 22.2 years (SD 1.97). A total of 53.3% of the participants in this study had been vegetarians since birth (n = 8), 33.3% for more than 10 years (n = 5), and the remaining 13.3% for less than 10 years (n = 2) (Table 2).

The mean FD value of the mandibular trabecular bone with a vegetarian diet differed significantly from that of a nonvegetarian diet. The mean FD value of the mandibular trabecular bone in the vegetarians was 0.253 ± 0.144 lower (intraobserver) and 0.37 ± 0.149 lower (interobserver) than in the nonvegetarians. The intraobserver mean FD values of the mandibular trabecular bone with the vegetarian and nonvegetarian diets were 1.114 ± 0.123 and 1.367 ± 0.074 (p = 0.00), respectively (Table 3). The mean FD values of

Table 1. Results of the intraclass correlation coefficients (ICC) for the average measurements

	n	Intraclass correlation coefficient	F-test with true value 0 (Sig.)
Intraobserver	30	0.825	0.000
Interobserver	30	0.860	0.000

Table 2. Demographic characteristics of the participants in this study, according to diet status

Variable	Nonvegetarians n = 15		Vegetarians n = 15	
	N (%)	Mean (SD)	N (%)	Mean (SD)
Sex				
Male	8 (53.3%)		4 (26.7%)	
Female	7 (46.7%)		11 (73.3%)	
Age, years		22.2 (1.97)		30.9 (6.57)
Duration of being vegetarian, years				
6–10			2 (13.3%)	
11–15			5 (33.3%)	
>15			8 (53.3%)	

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Table 3. Mean fractal dimension (FD) values of the mandibular trabecular bone in the vegetarian and nonvegetarian groups

	FD values	N	Mean	SD*	p-value
Intraobserver	Vegetarians	15	1.114	0.123	0.000**
	Nonvegetarians	15	1.367	0.074	
Interobserver	Vegetarians	15	1.02	0.130	0.000**
	Nonvegetarians	15	1.390	0.072	

*Standard deviation, **significant at α < 0.05.

Table 4. Mean fractal dimension (FD) values based on each mandibular trabecular bone side in the two groups

FD values			N	Mean	SD*	p-value
Intraobserver	Right (ROI1)	Vegetarians	15	1.142	0.130	0.000**
		Nonvegetarians	15	1.385	0.046	
	Left (ROI2)	Vegetarians	15	1.085	0.111	0.000**
		Nonvegetarians	15	1.338	0.118	
Interobserver	Right (ROI1)	Vegetarians	15	1.033	0.144	0.000**
		Nonvegetarians	15	1.400	0.053	
	Left (ROI2)	Vegetarians	15	1.007	0.112	0.000**
		Nonvegetarians	15	1.380	0.086	

*Standard deviation, **significant at α < 0.05.

Table 5. Mean fractal dimension (FD) values of the mandibular trabecular bone from the intraobserver and interobserver calculations

FD values	N	Mean	SD
Vegetarians	60	1.067	0.134
Right	30	1.088	0.146
Left	30	1.046	0.014
Nonvegetarians	60	1.379	0.074
Right	30	1.393	0.035
Left	30	1.365	0.008

the right mandibular trabecular bone were 1.142 ± 0.130 in the vegetarians and 1.385 ± 0.046 in the nonvegetarians (p = 0.00). For the left side, the mean was 1.085 ± 0.111 for the vegetarians and 1.338 ± 0.118 for the nonvegetarians (p = 0.00) (Table 4).

The mean interobserver FD values of the mandibular trabecular bone were 1.02 ± 0.130 for the vegetarians and 1.390 ± 0.072 for the nonvegetarians (p = 0.00) (Table 3). The mean FD values of the right mandibular trabecular bone were 1.033 ± 0.144 in the vegetarians and 1.400 ± 0.053 in the nonvegetarians (p = 0.00). The mean was 1.007 ± 0.112 for the vegetarians and 1.380 ± 0.086 (p = 0.00) for the nonvegetarians for the left side (Table 4).

DISCUSSION

Trabecular bone has a faster and higher metabolism than cortical bone because it has a larger surface area and more cell units.[41] The fast and high metabolism of trabecular bone makes it sensitive to any changes that disrupt the balance of bone metabolism.[24] Trabecular bone is affected by remodeling, which is the process of replacing old bone tissue with new bone tissue through a combination of resorption and bone formation. Bone remodeling takes about six months.[42]

BMD increases steadily from the age of 20 years to a peak at the age of 25–30 years. BMD remains stable at its peak until a person reaches 40 years of age.[43] All bones in the human body, including the mandibular trabecular bone, reach their most stable state and maximum density in the young adult age range (20–40 years).[43] High bone density in young adults is interpreted as a reserve of bone mass for old age. The better the quality of bone density in young adulthood, the less likely the occurrence of osteopenia, osteoporosis, or bone fractures in old age, and vice versa.[44,45] About 60% of the risk of osteoporosis is determined by the level of bone density in young adulthood.[46] The bone resorption process will dominate so that there will be a gradual decrease in density of about 0.5% per year in a person who has passed the period of young adulthood.[47]

FD analysis of the jawbone on dental radiographs is a reliable diagnostic tool for osteoporosis screening and can be a reference BMD test.[48] Based on a prior study, a decrease in BMD values corresponds to a decrease in fractal dimension.[49–51] The results of the FD values in this study were evaluated to ascertain their reliability. The present study revealed excellent reliability for both intra- and inter-observer measurements, indicating that the selection of ROI 1 and ROI 2 to obtain the FD values was carried out accurately (Table 1). The reliability of the study results was ensured by the utilization of standardized and calibrated tools. The measurement of FD values on extraoral radiographs using ImageJ with a similar methodology has also been performed in previous studies.[29,30]

This study showed that the mean FD value of the mandibular trabecular bone with a vegetarian diet differed significantly from a nonvegetarian diet. In Table 3, the mean FD value of the mandibular trabecular bone in the vegetarians was 18–26% lower than in the nonvegetarians. Lower mean bone density in vegetarians was found by Menzel et al.,[12] Syagata,[13] and Nugroho et al.,[39] although

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they used different methods in their studies. Menzel et al.[12] showed that the mean values of the heel bone density were 111.8 ± 10.7 dB/MHz in vegetarians and 118.0 ± 10.8 dB/MHz in nonvegetarians.[12] Similar results were found by Syagata.[13] A study by Nugroho et al.[39] with 31 vegetarians showed that 24 had osteopenia and seven had osteoporosis. To the best of our knowledge, no study has examined the FD value in vegetarians in any part of the bone using any radiographic techniques. Not a single study about FD values involving vegetarians as study subjects has been conducted.

In Tables 3 and 4, the study results indicated a significant difference between the mean FD values of the mandibular trabecular bone in the vegetarians and the nonvegetarians. In this study, diet was assumed to cause a significant difference in the mean FD value of the mandibular trabecular bone. A diet with a low intake of bone nutrients can lead to a decrease in BMD.[10] Nutrients such as calcium, phosphorus, iron, iodine, zinc, protein, vitamin B12, and vitamin D are essential in maintaining bone health.[16,17] According to previous studies, individuals who adopt a vegetarian diet have a low intake of bone nutrients. These nutrients include calcium, vitamin D, iodine, selenium, zinc, iron, protein, and vitamin B12.[36,37,52] A greater and more adequate variety of bone nutrients can be found in animal products,[10] including cow's milk,[53] chicken, beef, fish, eggs, and derived products, such as cheese and yogurt.[37,38]

Sutiari et al.[36] showed significantly lower intakes of vitamin D, B12, and calcium among vegetarians. Fallon et al.[37] revealed that vegetarians are significantly deficient in vitamin D, vitamin B3, vitamin B12, iodine, and selenium. Vegetarians also have significant deficiencies in riboflavin, folate, and vitamin B9. According to Fallon et al.,[37] these deficiencies occur because meat and dairy products are excluded from the daily diet. Based on a study by Menzel et al.,[12] zinc intake among vegetarians is significantly lower than among nonvegetarians. Zinc promotes osteoblast cell differentiation, proliferation, and remineralisation.[12] Another reason for the low intake of bone nutrients by vegetarians is the high content of antinutrients in plant foods, including nuts, seeds, and green vegetables. Antinutrients can inhibit the absorption of zinc, iron, calcium, and magnesium. As a result, bone nutrients from plant-based foods are more difficult to absorb and cannot be optimally utilized by the body.[38,54,55]

Liu et al.[56] affirmed that animal protein derived from white meat, such as chicken, fish, and seafood, can significantly reduce and prevent bone loss. Similar results were not found for plant protein. Animal protein is superior to plant protein, as the body absorbs it more easily.[56] In a study by Fitriani et al.[35] with 21 vegetarian respondents, 12 had inadequate protein intake (54.5%), and 15 had insufficient iron intake (68.2%). Fitriani et al.[35] suggested that the inadequate iron intake was because the respondents' only sources of iron were tofu and tempeh. Plant iron, including iron in tofu and tempeh, is non-heme iron that is difficult to absorb. The body can absorb only 1–15% of non-heme iron, in contrast to 15-40% of heme iron (animal iron).[35,38] Animal foods also contain 20–30% more iron than plant foods.[33] Iron-rich foods include egg yolks, liver, poultry, red meat, and shellfish.[57]

Most vegetarian respondents in this study chose vegetables, tofu, tempeh, and potatoes as their daily diet. In contrast, the daily diet of the nonvegetarian respondents was dominated by animal products, including chicken, eggs, beef, and cow's milk. The dietary intake of the nonvegetarian respondents was more diverse, as they also consumed plant-based foods, such as vegetables, tempeh, and tofu. Religious factors were behind the adoption of a vegetarian diet since childhood, based on the questionnaire data. Animal-based foods, such as eggs, fish, and meat, were characterized as foods of darkness that would bring bad karma because they were obtained by harming living beings. There is no standard for the FD value of healthy mandibular trabecular bone. However, in the studies of Pacheco-Pereira et al.[29] and Coşgunarslan et al.[30] using similar methods, the FD values of the mandibular trabecular bone in healthy patients were significantly higher than in patients with disease. The mean FD values of the mandibular trabecular bone in those studies were similar to the mean FD values in this study.[29,30]

In this study, the mean FD value of the left and right mandibular trabecular bone with a vegetarian diet was similar to a previous study using similar methods (Table 4).[29] Pacheco-Pereira et al.[29] showed that the mean FD values of the left and right mandibular trabecular bone in 45 healthy patients were 1.206 ± 1.112 and 1.253 ± 0.075, respectively. Pacheco-Pereira et al.[29] discovered that the mean FD values of the healthy patients were significantly higher than those of the patients with diseases that affected bone structures. A similar result was found by Coşgunarslan et al.,[30] who showed that the mean FD value of the mandibular trabecular bone of 106 healthy patients not taking medications was 1.25 ± 0.1.

The FD values of the mandibular trabecular bone of the vegetarians in this study were observed to be lower than those recorded from a previous study's control group comprising healthy patients. Based on these findings, dentists should be careful when performing surgical procedures involving bone structures, such as tooth extraction,[58] implant surgery,[59] bone grafting,[59] and gingivectomy,[60] in vegetarians. Preoperative assessment of the mandibular trabecular bone in vegetarians is necessary. Furthermore, supplementary measures are required to enhance bone nutrition to elevate the FD values of the mandibular trabecular bone in vegetarians. Vegetarians must take bone supplements, such as calcium, zinc, vitamin D, and vitamin B12, under a clinician's control. Moreover, consumption levels and dietary processing must be optimized to meet bone nutrient requirements. These measures can be a way for vegetarians to balance the bone metabolic process so that a decrease in bone density can be avoided.[61]

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Other factors affecting BMD are age, sex, race, systemic diseases, traumatic history, genetics, and lifestyle. These include diet, physical activity, alcohol intake, and smoking.[10,15] One limitation of this study was that the FD values were only assessed based on dietary factors and using small sample sizes. Even though the study did not aim to investigate the BMD status of the vegetarian and nonvegetarian samples, they were carefully selected to reduce the confounding factors related to lowering BMD (e.g., systemic diseases, traumatic history, obesity, and smoking). Another limitation of the study was that it did not conduct blood biochemistry tests on each participant. Future research should involve larger sample sizes, blood biochemistry tests, and BMD examination techniques to reveal the correlation between the FD value of vegetarian mandibular trabecular bone on panoramic radiographs and BMD status.

In conclusion, the mean FD values on panoramic radiographs are lower in vegetarian mandibular trabecular bone than in nonvegetarian mandibular trabecular bone. Considerations need to be made by dentists when performing treatments related to mandibular trabecular bone surgery in vegetarians.

REFERENCES

1. Wozniak H, Larpin C, de Mestral C, Guessous I, Reny J-L, Stringhini S. Vegetarian, pescatarian and flexitarian diets: sociodemographic determinants and association with cardiovascular risk factors in a Swiss urban population. Br J Nutr. 2020; 124(8): 844–52.
2. Hargreaves SM, Nakano EY, Zandonadi RP. Brazilian Vegetarian Population-Influence of Type of Diet, Motivation and Sociodemographic Variables on Quality of Life Measured by Specific Tool (VEGQOL). Nutrients. 2020; 12(5): 1406.
3. Pattar S, Shetty P, Shetty GB. Impact of vegetarian versus non-vegetarian diet on health outcomes in male individuals: A comparative study. Adv Integr Med. 2023; 10(1): 1–7.
4. Nakamura H, Kawashima T, Yamasaki L, Lwin KS, Eguchi A, Hayabuchi H, Tanoe Y, Tanaka S, Yoneoka D, Ghaznavi C, Uneyama H, Shibuya K, Nomura S. Reducing salt intake with umami: A secondary analysis of data in the UK National Diet and Nutrition Survey. Food Sci Nutr. 2023; 11(2): 872–82.
5. Salehin S, Rasmussen P, Mai S, Mushtaq M, Agarwal M, Hasan SM, Salehin S, Raja M, Gilani S, Khalife WI. Plant Based Diet and Its Effect on Cardiovascular Disease. Int J Environ Res Public Health. 2023; 20(4): 3337.
6. Voll A, Jost L, Jansen P. Heartfulness in Vegans, Vegetarians, and Omnivores. Int J Environ Res Public Health. 2023; 20(6): 4943.
7. Arwanto V, Buschle-Diller G, Mukti YP, Dewi ADR, Mumpuni C, Purwanto MGM, Sukweenadhi J. The state of plant-based food development and its prospects in the Indonesia market. Heliyon. 2022; 8(10): e11062.
8. Euromonitor International. Top 10 Global consumer trends 2019. 2019. Available from: https://go.euromonitor.com/white-paper-EC-2019-Top-10-Global-Consumer-Trends.html. Accessed 2023 Mar 29
9. Hopwood CJ, Bleidorn W, Schwaba T, Chen S. Health, environmental, and animal rights motives for vegetarian eating. Capraro V, editor. PLoS One. 2020; 15(4): e0230609.
10. Iguacel I, Miguel-Berges ML, Gómez-Bruton A, Moreno LA, Julián C. Veganism, vegetarianism, bone mineral density, and fracture risk: a systematic review and meta-analysis. Nutr Rev. 2019; 77(1): 1–18.
11. Desmond MA, Sobiecki JG, Jaworski M, Płudowski P, Antoniewicz J, Shirley MK, Eaton S, Książyk J, Cortina-Borja M, De Stavola B, Fewtrell M, Wells JCK. Growth, body composition, and cardiovascular and nutritional risk of 5- to 10-y-old children consuming vegetarian, vegan, or omnivore diets. Am J Clin Nutr. 2021; 113(6): 1565–77.
12. Menzel J, Abraham K, Stangl GI, Ueland PM, Obeid R, Schulze MB, Herter-Aeberli I, Schwerdtle T, Weikert C. Vegan Diet and Bone Health-Results from the Cross-Sectional RBVD Study. Nutrients. 2021; 13(2): 685.
13. Syagata AS. Kepadatan tulang pada vegetarian vegan dan non vegan. Diponegoro, Semarang; 2011. p. 1–34.
14. Chuang T-L, Koo M, Chuang M-H, Lin C-H, Huang C-H, Wang Y-F. Changes in Bone Mineral Density and Trabecular Bone Score over Time between Vegetarian and Non-Vegetarian Middle-Aged and Older Women: A Three-Year Retrospective Medical Record Review. Int J Environ Res Public Health. 2022; 19(4): 2445.
15. Kranioti EF, Bonicelli A, García-Donas JG. Bone-mineral density: clinical significance, methods of quantification and forensic applications. Res Reports Forensic Med Sci. 2019; 9: 9–21.
16. Falchetti A, Cavati G, Valenti R, Mingiano C, Cosso R, Gennari L, Chiodini I, Merlotti D. The effects of vegetarian diets on bone health: A literature review. Front Endocrinol (Lausanne). 2022; 13: 899375.
17. Ciosek Ż, Kot K, Kosik-Bogacka D, anocha-Arendarczyk N, Rotter I. The Effects of Calcium, Magnesium, Phosphorus, Fluoride, and Lead on Bone Tissue. Biomolecules. 2021; 11(4): 506.
18. Astuti ER, Arifin AZ, Indraswari R, Putra RH, Ramadhani NF, Pramatika B. Computer-Aided System of the Mandibular Cortical Bone Porosity Assessment on Digital Panoramic Radiographs. Eur J Dent. 2023; 17(2): 464–71.
19. Lita YA, Azhari A, Firman RN, Epsilawati L, Pramanik F. Aspek radiografis dan biologis tulang dalam penilaian kualitas tulang pada osteoporosis. J Radiol Dentomaksilofasial Indones. 2019; 3(2): 47–9.
20. Rachmawati N, Firman RN, Epsilawati L, Damayanti MA. Analysis of the panoramic radiographic density of the mandibular bone in the elderly due to increased cortisol levels. J Radiol Dentomaksilofasial Indones. 2022; 6(2): 55.
21. Kartika D, Batubara FY. Analysis of Pulp Chamber Size on Mandibular Second Molar using Biometric Methods on Panoramic Radiograph in Mongoloid Malayan Race Female Population Malayan Race Female Population. 2020; (Icosteerr 2018): 676–8.
22. Bingül MB, Oğuz F, Evren A. Analysis of mandibular third molar impaction classification with different skeletal malocclusions. Dent J. 2023; 56(4): 213–9.
23. Astuti ER, Iskandar HB, Nasutianto H, Pramatika B, Saputra D, Putra RH. Radiomorphometric of the jaw for gender prediction: A digital panoramic study. Acta Med Philipp. 2022; 56(3): 113–21.
24. Xu W, Ni C, Wang Y, Zheng G, Zhang J, Xu Y. Age-related trabecular bone loss is associated with a decline in serum Galectin-1 level. BMC Musculoskelet Disord. 2021; 22(1): 1–13.
25. Carmo JZB, Medeiros SF de. Mandibular Inferior Cortex Erosion on Dental Panoramic Radiograph as a Sign of Low Bone Mineral Density in Postmenopausal Women. Rev Bras Ginecol Obstet. 2017; 39(12): 663–9.
26. Hanafiah OA, Hanafiah DS, Syaflida R. The Effect of Topical Application of 3% Binahong. J Int Dent Med Res. 2021; 14(2): 736–41.
27. Oliveira ML, Pedrosa EFNC, Cruz AD, Haiter-Neto F, Paula FJA, Watanabe PCA. Relationship between bone mineral density and trabecular bone pattern in postmenopausal osteoporotic Brazilian women. Clin Oral Investig. 2013; 17(8): 1847–53.
28. White SC, Rudolph DJ. Alterations of the trabecular pattern of the jaws in patients with osteoporosis. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology 1999; 88(5): 628-35.
29. Pacheco-Pereira C, Silvestre-Barbosa Y, Almeida FT, Geha H, Leite AF, Guerra ENS. Trabecular and cortical mandibular bone investigation in familial adenomatous polyposis patients. Sci Rep. 2021; 11(1): 9143.

DOI: 10.20473/j.djmkg.v58.i4.p347–354

30. Coşgunarslan A, Aşantoğrol F, Soydan Çabuk D, Canger EM. The effect of selective serotonin reuptake inhibitors on the human mandible. Oral Radiol. 2021; 37(1): 20–8.
31. Kato CN, Barra SG, Tavares NP, Amaral TM, Brasileiro CB, Mesquita RA, Abreu LG. Use of fractal analysis in dental images: a systematic review. Dentomaxillofac Radiol. 2020; 49(2): 20180457.
32. Ersan N, Özel B. Fractal dimension analysis of different mandibular regions in familial Mediterranean fever patients: A cross-sectional retrospective study. PLoS One. 2023; 18(6): e0288170.
33. Rahmad A, Azwar A, Zulfian Z. Analisis Kawasan Terbangun di Kota Pontianak Berdasarkan Dimensi Fraktal. Prism Fis. 2023; 10(3): 360.
34. Bankhead P. Analyzing fluorescence microscopy images with ImageJ. ImageJ. 2014; (May): 1–195.
35. Fitriani F, Marlina Y, Roziana R, Rahmadini D. Gambaran Asupan Protein, Zat Besi Dan Kadar Hemoglobin Pada Remaja Putri Vegetarian Vegan Di Indonesia Vegetarian Society (Ivs). J Ris Gizi. 2021; 9(1): 11–5.
36. Sutiari NK, Khomsan A, Riyadi H, Anwar F, Kurniati DPY, Astuti W. Status kesehatan dan asupan mikronutrien vegetarian dan nonvegetarian di Bali. J Gizi Klin Indones. 2021; 17(4): 157.
37. Fallon N, Dillon SA. Low Intakes of Iodine and Selenium Amongst Vegan and Vegetarian Women Highlight a Potential Nutritional Vulnerability. Front Nutr. 2020; 7: 72.
38. Neufingerl N, Eilander A. Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review. Nutrients. 2021; 14(1): 29.
39. Nugroho ISP, Muniroh L. Hubungan konsumsi pangan sumber kalsium dan aktivitas fisik dengan kepadatan tulang lacto ovo vegetarian di Yayasan Buddha Tzu Chi Surabaya. Media Gizi Indones. 2018; 12(1): 64.
40. Bolarinwa OA. Sample size estimation for health and social science researchers: The principles and considerations for different study designs. Niger Postgrad Med J. 2020; 27(2): 67–75.
41. Kivell TL. A review of trabecular bone functional adaptation: what have we learned from trabecular analyses in extant hominoids and what can we apply to fossils? J Anat. 2016; 228(4): 569–94.
42. Kenkre JS, Bassett J. The bone remodelling cycle. Ann Clin Biochem. 2018; 55(3): 308–27.
43. Zhu X, Zheng H. Factors influencing peak bone mass gain. Front Med. 2021; 15(1): 53–69.
44. Osterhoff G, Morgan EF, Shefelbine SJ, Karim L, McNamara LM, Augat P. Bone mechanical properties and changes with osteoporosis. Injury. 2016; 47 Suppl 2(Suppl 2): S11-20.
45. McVeigh JA, Howie EK, Zhu K, Walsh JP, Straker L. Organized Sport Participation From Childhood to Adolescence Is Associated With Bone Mass in Young Adults From the Raine Study. J Bone Miner Res. 2019; 34(1): 67–74.
46. Molino G, Montalbano G, Pontremoli C, Fiorilli S, Vitale-Brovarone C. Imaging Techniques for the Assessment of the Bone Osteoporosis-Induced Variations with Particular Focus on Micro-CT Potential. Appl Sci. 2020; 10(24): 8939.
47. Barnsley J, Buckland G, Chan PE, Ong A, Ramos AS, Baxter M, Laskou F, Dennison EM, Cooper C, Patel HP. Pathophysiology and treatment of osteoporosis: challenges for clinical practice in older people. Aging Clin Exp Res. 2021; 33(4): 759–73.
48. Cavalcante D de S, Silva PG de B, Carvalho FSR, Quidute ARP, Kurita LM, Cid AMPL, Ribeiro TR, Gurgel ML, Kurita BM, Costa FWG. Is jaw fractal dimension a reliable biomarker for osteoporosis screening? A systematic review and meta-analysis of diagnostic test accuracy studies. Dentomaxillofac Radiol. 2022; 51(4): 20210365.
49. Hayek E, Aoun G, Geha H, Nasseh I. Image-based Bone Density Classification Using Fractal Dimensions and Histological Analysis of Implant Recipient Site. Acta Inform Med. 2020; 28(4): 272–7.
50. Carvalho BF, de Castro JGK, de Melo NS, de Souza Figueiredo PT, Moreira-Mesquita CR, de Paula AP, Sindeaux R, Leite AF. Fractal dimension analysis on CBCT scans for detecting low bone mineral density in postmenopausal women. Imaging Sci Dent. 2022; 52(1): 53–60.
51. Sindeaux R, Figueiredo PT de S, de Melo NS, Guimarães ATB, Lazarte L, Pereira FB, de Paula AP, Leite AF. Fractal dimension and mandibular cortical width in normal and osteoporotic men and women. Maturitas. 2014; 77(2): 142–8.
52. Klein L, Dawczynski C, Schwarz M, Maares M, Kipp K, Haase H, Kipp AP. Selenium, Zinc, and Copper Status of Vegetarians and Vegans in Comparison to Omnivores in the Nutritional Evaluation (NuEva) Study. Nutrients. 2023; 15(16): 1–20.
53. Walther B, Guggisberg D, Badertscher R, Egger L, Portmann R, Dubois S, Haldimann M, Kopf-Bolanz K, Rhyn P, Zoller O, Veraguth R, Rezzi S. Comparison of nutritional composition between plant-based drinks and cow's milk. Front Nutr. 2022; 9: 988707.
54. Singh J, Arora SK. Antinutritional factors in plant based foods. Int J Agric Sci. 2023; 19(1): 366–75.
55. Thakur A, Sharma V, Thakur A, Vishal Sharma C. An overview of anti-nutritional factors in food. Int J Chem Stud. 2019; 7(1): 2472–9.
56. Liu Z-M, Huang Q, Long H-H, Li S-Y, Wu Y, Zhang S-J, Tang X-Y, Chen Y-M. Increased Dietary Intakes of Total Protein, Animal Protein and White Meat Protein Were Associated with Reduced Bone Loss-A Prospective Analysis Based on Guangzhou Health and Nutrition Cohort, South China. Nutrients. 2023; 15(6): 1432.
57. Akalu Y, Yeshaw Y, Tesema GA, Demissie GD, Molla MD, Muche A, Diress M, Tiruneh SA. Iron-rich food consumption and associated factors among children aged 6-23 months in sub-Saharan Africa: A multilevel analysis of Demographic and Health Surveys. PLoS One. 2021; 16(6): e0253221.
58. Putrino A, Marinelli E, Agrillo A, Zaami S. New Perspectives in Third Molar Auto-Transplantation: Literature Review and a Case Report of Clinical, Financial and Forensic Implications. Medicina (Kaunas). 2024; 60(3): 473.
59. Nguyen TTH, Eo MY, Kuk TS, Myoung H, Kim SM. Rehabilitation of atrophic jaw using iliac onlay bone graft combined with dental implants. Int J Implant Dent. 2019; 5(1): 11.
60. Huang X, Zhu W, Zhang X, Fu Y. Modified gingivoplasty for hereditary gingival fibromatosis: two case reports. BMC Oral Health. 2022; 22(1): 1–9.
61. Agnoli C, Baroni L, Bertini I, Ciappellano S, Fabbri A, Papa M, Pellegrini N, Sbarbati R, Scarino ML, Siani V, Sieri S. Position paper on vegetarian diets from the working group of the Italian Society of Human Nutrition. Nutr Metab Cardiovasc Dis. 2017; 27(12): 1037–52.

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