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Alveolar Bone Loss Analysis on Dental Digital Radiography Image

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Abstract

Background: Periodontal disease is the second most common tooth and mouth disease in Indonesia. Moreover, radiographic examination is the most useful tool to evaluate alveolar bone loss and diagnose periodontal diseases. This study aimed to analyze radiographically the relationship between alveolar bone loss and age among patients with chronic periodontitis.

Methods: A total of 192 digital periapical images of patients aged 25–40 years were collected. Four regions were selected, including the maxillary and mandibular central incisors and maxillary and mandibular first molars. Alveolar bone loss was measured in the mesial and distal surfaces.

Results: The mean and standard deviation for alveolar bone loss in age categories 1 (age 25–32 years) and 2 (age 33–40 years) were 4.03 ± 1.46 and 5.23 ± 2.5 (mm), respectively. Alveolar bone loss demonstrated a significant relationship with patient's age ($p < 0.001$, Mann–Whitney U test).

Conclusions: The mean and standard deviation of alveolar bone loss reduction in patients with chronic periodontitis was 4.87 ± 0.2 (mm). The alveolar bone loss on the mandibular central incisors' mesial surface is the highest among other regions.

Keywords: alveolar bone loss, chronic periodontitis, dental digital radiography

INTRODUCTION

Periodontitis is a common oral disease with a prevalence of 20%–50% in developed and developing countries.[1] Periodontitis begins with gingivitis, which is an inflammatory condition of gingival tissues caused by bacterial infection associated with dental plaque accumulation. Early stages of periodontitis are characterized by a decrease in the alveolar bone crest of the interproximal area (alveolar bone crest). At this stage, there is a decrease in cortical bone density, cortical bone rounding, and irregular/diffuse boundaries. In the anterior region, there is a blunting of the alveolar crests and slight loss of alveolar crestal bone height. In the posterior region, there is a loss of the usual sharp angle between the lamina dura, and the alveolar peak becomes blunter. Essential features of radiographic examination of periodontal conditions include the amount of bone present, alveolar crest condition, bone loss in the furcation area, width of the periodontal ligament, and local irritation factors. The risk factors of periodontal diseases are the presence of calculus and poor restoration, root length, root morphology, root–crown ratio, poor interproximal contact that can cause food impaction, anatomical alterations, and pathological conditions such as caries, periapical lesions, and root resorption.[2-4]

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Radiographic examinations are essential to determine the diagnosis and prognosis of periodontal diseases and assess the extent of alveolar bone damage and periodontal tissue conditions that affect the prognosis of periodontitis.[5,6] Radiographic projections that can detect periodontal diseases include bitewing and periapical and panoramic projections. Studies in developed and developing countries have found that radiographic projections are often used in panoramic and periapical radiographic examinations.[7,8] Periapical images are more effective than panoramic images in identifying bone damage, especially in small defects.[9] However, in assessing the status of periodontal diseases, intraoral radiography has limitations, including periapical projection. These limitations will provide an incomplete overview of the status of the periodontal tissue. These limitations include intraoral radiography that provides a two-dimensional image and presents a less severe picture than the actual damage. Mild destructive lesions at the beginning of the loss do not cause bone density changes, so periapical radiographs cannot detect them. Furthermore, periapical radiographs do not show a relationship between soft and hard tissues, so they cannot provide information about the depth of the pocket.[10,11] However, the amount of radiation given to the patient is much smaller in radiography than in three-dimensional cone-beam computed tomography (CBCT) radiography. Therefore, intraoral radiography is still the first choice for radiographic examination of periodontitis. In this study, only the mesial and distal sides of the teeth were selected to avoid misinterpretation due to the superimposition of the dental anatomy in the region of interest.

Alveolar bone loss is an indicator of the severity of periodontal diseases. The average value of alveolar bone loss reduction is useful as a reference for predicting the severity of periodontal disease radiographically, which in turn will affect the results of the management of periodontal diseases.[4]

This study aimed to measure the average value of alveolar bone loss from secondary data obtained from periapical images of patients with chronic periodontitis aged 25–40 years. This age range is taken bone density is at its peak and chronic periodontitis often occurs. These results are expected to be an initial reference to the average alveolar bone loss, which provides radiographic information about the mean alveolar bone loss.

METHODS

This analytic descriptive study with a cross-sectional approach was conducted at the dental hospital of the Faculty of Dentistry, Universitas Indonesia, from July to September 2017. This study was approved by the Dental Research Ethics Commission of the Faculty of Dentistry, Universitas Indonesia (Letter No. 05/Ethical Exempted/FKGUI/VI/2017).

In this study, periapical radiographic images were taken from the dental and medical records of patients with mild, moderate, and severe chronic periodontitis in the Dental Hospital of Faculty of Dentistry, Universitas Indonesia. Selected patients were between 25 and 40 years old, whose radiography images were of good quality and the region of interest can be seen and interpreted clearly. This study included 192 samples consisting of 24 dental periapical radiographs of each region. The four regions analyzed were the maxillary and mandibular central incisors and maxillary and mandibular first molars. Radiographic images of the teeth observed were the central incisors and maxillary and mandibular first molars. The incisors and first molars were analyzed because they are prone to bone loss, and maxillary molars have the most apparent periodontitis development.[12-14]

In this study, the distance from the cementoenamel junction (CEJ) to the remaining alveolar bone crest was measured. The inclusion criteria were as follows: patients aged 25–40 years with mild, moderate, and severe chronic periodontitis. The digital periapical intraoral radiographs had good quality. The regions of interest were the I1 and M1 upper teeth and lower teeth that do not experience caries or fillings in the proximal area. The proximal of the teeth were still in contact with the adjacent teeth and could be seen, anatomical landmarks, CEJ and primary bone damage could be clearly seen and interpreted. Tooth surfaces seen are mesial and distal surfaces.

Alveolar bone loss was measured using the Digora Optime for Windows® software (Soredex/Orion Corp., Helsinki, Finland). The first step in measuring the decrease in alveolar bone loss is to determine the CEJ distance between teeth by drawing a line from one tooth to the tooth next to it. Then, the dental axis was determined. In the anterior teeth, measure the line from the highest crown to the apical root. In the posterior teeth, the tooth's axis is determined by drawing a line from the pit to the furcation section (Figure 1). Then, draw a line parallel to the tooth axis from the predetermined CEJ toward the bone damage base.

Alveolar bone loss reduction is measured by calculating the distance between the CEJ to the remaining alveolar bone by two observers. The two observers took two measurements to test the suitability of the alveolar bone loss measurement. A reliability test was carried out through technical error measurement (TEM) using the Dahlberg formula by testing the intra- and interobserver reliability of all data, including alveolar bone loss reduction on periapical radiographs (Table 1). Intraobserver reliability was measured to assess the appropriateness of the observations evaluated by the same observer at different times. Interobserver reliability is measured to determine the reliability of the observational assessment between observers. The Dahlberg formula is obtained by squaring the difference between the first and second measurements and dividing it by twice the number of subjects observed. The square root of the difference in the average square divided by twice the subject can be considered the number of measurement errors, or a Dahlberg error.[15] The tolerance limit of the Dahlberg formula that is still acceptable, or the measurement tolerance, is a TEM of ≤1 mm.[16] To analyze the relationship between alveolar bone loss and age 25–40 years, the average alveolar bone loss on the mesial and distal surfaces was calculated. The age of the patients was divided into two categories with an interval of 8 years: 25–32 years and 33–40 years. After the normality test, the Mann–Whitney U test was chosen to analyze the relationship between the two variables. All statistical analyses were performed using SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA).

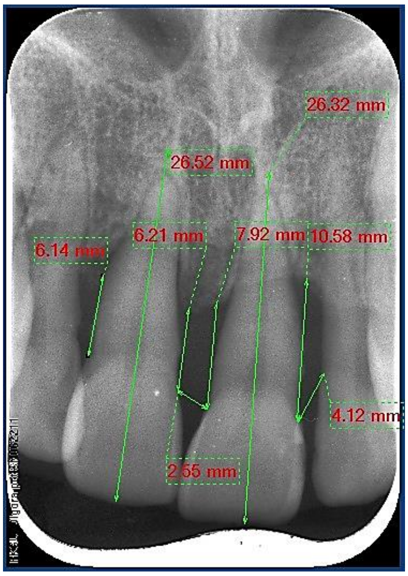

FIGURE 1. Measurement in the anterior and posterior teeth

TABLE 1. Technical error of measurement

Test	Observers	TEM (mm)
Intraobserver reliability	A1 VS A2	0.13
	B1 VS B2	0.41
Interobserver reliability	A1 VS B1	0.51
	A1 VS B2	0.57
	A2 VS B1	0.53
	A2 VS B2	0.45

A = first observer
B = second observer
1 = first observation time
2 = second observation time

RESULTS

The frequency of the sample was distributed equally in each category. In this study, measurements were carried out twice by two observers. In this study, the Dahlberg formula tested the reliability of measurements to get the TEM value. These results indicate that the value is still within the tolerance range of measurement, i.e., ≤1 mm.[15, 16]

As shown in Table 2, 7.98 mm is the highest average decrease in mesial surface alveolar bone loss, which is found in the mandibular central incisors. By contrast, 6.85 mm is the highest mean value of the highest distal alveolar bone loss reduction, which is found in the lower central incisors. The maxillary first molar has a lower mean mesial surface alveolar bone loss with an average of 3.73 mm. Moreover, the smallest mean distal surface alveolar bone loss on the lower first molar was 3.08 mm.

Table 3 shows that the average decrease in the alveolar bone loss on the mesial surface is higher than the average decrease in the alveolar bone loss on the distal surface. The mesial surface has an average value of 5.14 ± 0.31 mm. By contrast, the distal surface has an average value of 4.6 ± 0.26 mm.

Table 4 shows that most periodontitis cases in RSKGM FKG UI are mild, reaching more than half, affecting 98 bone surfaces, or 51% of the total radiograph samples, while moderate periodontitis was found in 40 bone surfaces, or 21% of the total radiograph samples. Severe periodontitis was found in 54 bone surfaces, or 28% of the total radiograph samples.

Table 5 shows the relationship between alveolar bone loss and patient's age (p = 0.044, Mann–Whitney U test). Radiography images were categorized into two according to the age of the patients: age 25–32 years as category 1 and age 33 – 40 years as category 2. The mean and standard deviation for the alveolar bone loss in categories 1 and 2 were 4.03 ± 1.46 mm and 5.23 ± 2.5 mm, respectively. A significant relationship was found between alveolar bone loss and patient's age (p = 0.044, Mann–Whitney U test). With increasing age, the severity of periodontitis also increased.

TABLE 2. Mean values, standard deviations, and minimum and maximum distances according to the teeth

Teeth	Mean ± SD (mm)	Minimum (mm)	Maximum (mm)
Maxillary central incisor			
Mesial	5.13 ± 0.58	2.31	12.94
Distal	3.82 ± 0.40	2.23	10.58
Maxillary first molar			
Mesial	3.73 ± 0.37	2.02	8.35
Distal	4.66 ± 0.55	2.03	15.46
Mandibular central incisor			
Mesial	7.98 ± 0.60	2.08	13.00
Distal	6.85 ± 0.48	2.20	11.33
Mandibular first molar			
Mesial	3.74 ± 0.43	2.14	12.67
Distal	3.08 ± 0.17	2.12	5.48

TABLE 3. Mean values, standard deviations, and minimum and maximum distances according to the surfaces of all teeth examined

Variable	Mean ± SD (mm)	Minimum (mm)	Maximum (mm)
Mesial surface of all teeth	5.14 ± 0.31	2.02	13.00
Distal surface of all teeth	4.60 ± 0.26	2.03	15.46

TABLE 4. Distribution of periodontitis based on the severity of all teeth examined

	Total surface (%)
Mild	98 (51%)
Moderate	40 (21%)
Severe	54 28%)

TABLE 5. Comparison between alveolar bone loss and patient's age category

	Mean ± SD (mm)	*p*
Category I (25–32 years old)	4.03±1.46	0.044*
Category II (33–40 years old)	5.28±2.50	

*Mann–Whitney U test

DISCUSSION

This study found that patients with an 8-year age difference had a significant bone loss of more than 1 mm (Table 5). The strength of this study is related to its use of digital radiography to obtain data. Compared with conventional radiography, digital radiography makes it easier to measure alveolar bone loss because it can zoom in and enhance images. The TEM values between observers are within the tolerance range of measurement. This is possibly due to the use of digital radiography, which is accompanied by the observer's experience in interpreting radiography images. The age range 25–40 years was used to avoid physiological aging because the bone density is at its peak at this age. This condition is caused by the rapid bone formation during puberty, where the bones become more prominent, longer, thicker, and denser. At age 40, the bone formation rate will progressively reduce, resulting in physiological bone loss.[17] A study found no significant difference in bone loss reduction in women <5 and >5 years of menopause and reported a significant relationship between periodontitis and age.[18] Another study of periodontitis involving 1,064 randomized participants (aged 18–95 years, 617 female, 447 male) showed that the risk of periodontitis significantly increased with age (odds ratio = 1.05, 95% confidence interval 1.04–1.06).[19] The results of this study indicate that periodontitis can become more severe with increasing age and can occur at any age. This reinforces the importance of maintaining oral health to prevent periodontitis that worsens with advancing age.[20,21]

Table 2 shows a wide variation in the average alveolar bone loss reduction among the maxillary central incisors, maxillary first molar, mandibular central incisors, and mandibular first molars. The highest average alveolar bone loss is found in the mandibular central incisors at 7.41 mm (standard deviation, 0.39 mm), followed by the maxillary central incisor at 4.47 mm (standard deviation, 0.36 mm), maxillary first molar, and finally mandibular first molar. Previous studies have shown similar results, i.e., among molars, canines, premolars, and incisors, the most severe alveolar bone loss is found in the incisors. This is caused by high deposition of calculus usually found in the lower incisor teeth and maxillary molar[22]. These studies also prove that lower incisor and upper molar teeth have the most plaque accumulation and are at risk for more progressive periodontal disease. The anatomy of the alveolar crest in the mandibular incisors also increased the risk of alveolar bone loss. The anatomy of the alveolar crest is very narrow, making bone damage easier. Concerning root anatomy, which is a predisposition factor for periodontal disease, the mandibular incisors have deeper root concavities than other teeth. Although no significant correlation was found between alveolar bone loss reduction and root concavity, such kind of root anatomy should not be ignored. It can interfere with periodontal instrument access, such as when cleaning subgingival calculus.[23] Alveolar bone loss in the maxillary molars can easily occur because of furcation, i.e., the presence of periodontitis will increase the risk of bone loss.[24] Many studies have reported that periodontitis is most severe in the maxillary molars.[23] However, their findings were not obtained by measuring the highest alveolar bone loss reduction, but by looking at the teeth that are most often lost in adulthood.

Table 3 shows that the mesial surface has an average decrease in alveolar bone height higher than that in the distal surface, where the mesial surface has an average decrease of 5.14 mm (standard deviation, 0.31 mm) and the distal surface has an average decrease of 4.6 mm (standard deviation, 0.26 mm). A previous study also presented the same results.[25] A study on the periodontal disease progression found that, during the study period, bone loss mostly occurred on the mesial surface of the first molar teeth.[25] Unlike the mesial surface, Fukuda *et al*. reported alveolar bone loss on the distal surface. In their study, average alveolar bone loss was found in the lower jaw canine and maxillary first molar. The distal surface of the lower canine was deeper and concave, which caused the differences in results.[22] On the distal surface, the mandibular first molar has smaller and shorter anatomy. These factors can facilitate the retention of plaque and make it difficult to clean because of the difficulty of accessing and passing instruments on its surface.[26] The results of the present study are consistent with those of Fukuda *et al*.[22] and Desai *et al*.[27]: that is, the average alveolar bone loss reduction in the distal surface of the maxillary first molar was higher than that in the mesial surface. In the present study, the average alveolar bone loss reduction in the distal surface of the maxillary first molar was 4.66 mm, while that of the mesial surface was 3.73 mm.

As shown in Table 4, most of the patients in the Dental Hospital Faculty of Dentistry, Universitas Indonesia, experienced mild periodontitis. Mild periodontitis occurred in more than half of the patients (approximately

51%). This is consistent with the results of previous studies conducted on adults and older people in the United States. In that study, two-thirds of the patients (approximately 53.1%, or 56.2 million population) experienced mild periodontitis, while the remaining population had moderate and severe periodontitis.[28] From these data, most of US patients experienced mild periodontitis. This is consistent with the result of the present study. Similarly, Susanto *et al*. revealed that patients with periodontitis in Indonesia experienced a mild course.[29]

This study is limited by the use of radiographic examination itself. Radiographs can overlook approximately 1.4 mm from the actual size in the case of interproximal bone loss and provide a less severe picture than the actual damage[30]; so, the results obtained in this study may differ from the original bone loss reduction measured using surgical techniques. Further studies are needed in the clinical setting. Studies measuring all surfaces of the teeth in the oral cavity by using 3D CBCT radiography are also warranted.

CONCLUSIONS

The mean and standard deviation of alveolar bone loss reduction in patients with chronic periodontitis was 4.87 ± 0.2 mm. In this study, the alveolar bone loss reduction in the mesial surface of the mandibular central incisors was the highest when compared with the mesial and distal surfaces of other teeth.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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