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Dentistry Section

Comparison of Cone Beam Computed Tomography-Derived Alveolar Bone Density Between Subjects with and without Aggressive Periodontitis

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ABSTRACT

Introduction: Understanding the changes in bone density of patients affected by aggressive periodontitis could be useful in early disease detection and proper treatment planning.

Aim: The aim of this study was to compare alveolar bone density in patients affected with aggressive periodontitis and periodontally healthy individuals using Cone Beam Computed Tomography (CBCT).

Materials and Methods: This cross-sectional study was conducted on 20 patients with a confirmed diagnosis of aggressive periodontitis. Twenty periodontally healthy patients attending the dental clinics for implant placement or extraction of impacted third molars served as controls. Alveolar bone density was measured using CBCT scanning. Comparisons between aggressive periodontitis group and controls for age and alveolar bone density of the anterior and posterior regions were performed using an independent sample t-test. Multivariable linear regression models were also performed.

Results: The differences between groups in regard to age, anterior and posterior alveolar bone density was not statistically significant ($p<0.05$). In the posterior region, the multivariable regression model showed that bone density was not associated with age, gender or the study groups. Whereas, in the anterior region, patient's age was found to be significantly associated with bone density, $p=0.014$.

Conclusion: Alveolar bone density as measured by CBCT in aggressive periodontitis patients was not different from periodontally healthy individuals. Further studies are needed to confirm these findings.

Keywords: Gray scale, Humans, i-CAT, Mandible, Periodontal disease, Retrospective studies

INTRODUCTION

Periodontitis is a major cause of tooth loss and has been suggested as a risk factor for several systemic conditions [1]. Periodontitis is classified into several types of which the aggressive and chronic forms are the two main types. Although both forms have similar pathophysiology, aggressive periodontitis is more destructive in nature with higher progression rate and distinctive clinical characteristics and its aetiology may be different [2]. The rate of destruction in aggressive periodontitis was estimated to be 3-4 times more than the chronic form. Aggressive periodontitis tends to have a familial aggregation and comprised of what was previously known as rapidly progressive and juvenile periodontitis [3].

Aggressive periodontitis patients are likely to loose multiple teeth due to the progression and destructive nature of the disease, which may impact future dental implant rehabilitation. Even though dental implant is not contraindicated in patients affected with aggressive periodontitis, a greater bone loss rate has been reported [4,5]. It is possible that bone density is different in aggressive periodontitis patients. This assumption was based on the reported data that showed an association between periodontitis and osteoporosis where reduced bone density in osteoporotic patients was suggested to create vulnerable sites at which the effect of periodontal pathogens and host immune response is enhanced resulting in rapid progression of periodontal tissue destruction [6]. Furthermore, a recent systematic review showed that osteoporotic subjects had lower dental implant survival rate [7], which could suggest that the quality of recipient bone site might be an important factor.

Studies of early detection of aggressive periodontitis cases would be invaluable in order to provide proper treatment and subsequently prevent the substantial periodontal tissues breakdown associated with delayed discovery. Although much of the information required to diagnose periodontitis can be obtained through clinical examination alone, the information on bone levels and density provided by radiographs has a significant impact on risk assessment, diagnosis as well as treatment outcomes. However, bone density and the precise form of periodontal defects including furcation involvements, hemiseptum and intrabony defects cannot be determined easily from conventional two-dimensional radiographs [8,9]. CBCT could be utilized to overcome these limitations. CBCT can be used to assess the mineral density of craniofacial bone structures and has been utilized to predict osteoporosis [10-14]. CBCT has also been used to assess bone density for dental implant treatment planning and placement [15-17]. Isoda K et al., showed that the quality of evaluated bone using CBCT had a significant correlation with the primary implants stability suggesting that CBCT estimated bone density might predict implant stability [16]. Similarly, Tatli U et al., reported the possibility to use preoperative CBCT to predict the stability of immediately loaded implants [17]. Hasan I et al., reported that CBCT gray values can be used to monitor bone density changes at different periods after insertion of dental implants [15]. However, utilization of gray scale to assess bone density is criticized by some researchers when used as an absolute value [18,19]. Thus, the scanning device and image-acquisition settings and positioning influence the intensity values of CBCT images and should be controlled for in order to reduce CBCT-related variability in mineral density [20].

Understanding the changes in bone density of periodontitis patients might be useful in its early detection and proper treatment planning. Although estimation of bone density could be useful in the prediction of aggressive periodontitis patients, thus far, CBCT has not been

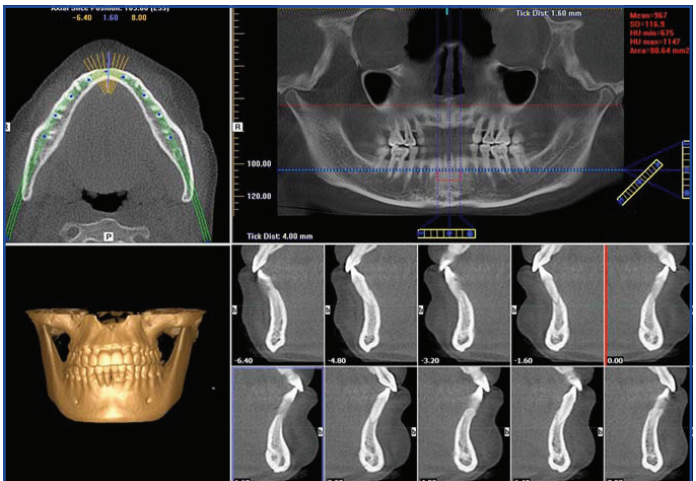
previously utilized to address this issue. Therefore, the purpose of this study was to measure alveolar bone density in aggressive periodontitis patients and compare it with periodontally healthy individuals using CBCT.

MATERIALS AND METHODS

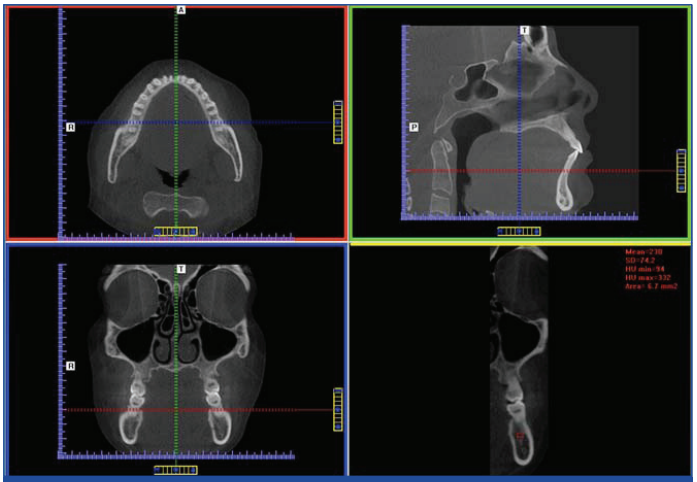
This cross-sectional study was carried out at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia and included 40 individuals using purposive sampling, between the ages of 18 to 40 years. Twenty patients with a confirmed diagnosis of aggressive periodontitis (both localized and generalized) and 20 periodontally healthy patients attending the dental clinics for implant placement or extraction of impacted third molars and required CBCT for their procedure were included in the study. The diagnosis of aggressive periodontitis was made in the postgraduate periodontic clinics based on the case history, clinical and radiographic findings as outlined in 1999 International Workshop for the Classification of Periodontal Diseases and Conditions [21]. The research was conducted in accordance with the principles of the Helsinki Declaration and was approved by the Research Ethics Committee of the Faculty of Dentistry at King Abdulaziz University. An informed consent was obtained from participants prior to their enrollment.

The exclusion criteria included; patients who received medications such as steroids, non-steroidal anti-inflammatory drugs, bisphosphonates or any similar drug that may affect bone density, within the previous six months. Also, patients who received any periodontal treatment in the previous 12 months, patients with known systemic disease according to the Cornell Medical Index [22,23], pregnant females, smokers, osteoporotic patients and patients with any form of periodontitis other than aggressive were excluded.

Patients were scanned using i-CAT Next Generation CBCT unit (Imaging Sciences International, LLC, Hatfield, PA, USA). All the selected images were acquired with the same machine and scan settings. Scans were taken with 0.4 mm voxel resolution, 16 cm field of view diameter and 13 cm field of view height with 8.9 seconds scan time. Scans were processed and interpreted using i-CAT vision software. A calibrated Oral and Maxillofacial Radiologist interpreted all images. By using the software density measurement tool (gray scale value), alveolar bone density was recorded on selected locations and slices. The measurements of the anterior area of the mandible were taken apical to the anterior teeth on the reconstructed panoramic view. The slice thickness for the reconstructed panoramic view was adjusted to 3 mm for all images. This was undertaken to limit bone density measurement to the trabecular bone. The measured area size was adjusted to be equal in all cases and it was 80.6 mm^2 as shown in [Table/Fig-1]. In



[Table/Fig-1]: The measurements of the anterior area of the mandible were taken apical to the anterior teeth on the reconstructed panoramic view and the slice thickness for the reconstructed panoramic view was adjusted to 3 mm and adjusting the measured area size to be equal to 80.6 mm^2.



[Table/Fig-2]: The measurements at the apical area between mandibular first and second molars were performed on the multi planar view and a cross sectional slice was generated perpendicular to mandibular buccal surface.

the posterior area of the mandible, measurements were performed on the multi planar view at the apical area between mandibular first and second molars bilaterally. Cross-sectional slice on each side was generated perpendicular to mandibular buccal surface. Slice thickness and measured area size were standardized in all cases [Table/Fig-2].

STATISTICAL ANALYSIS

Data analysis was carried out using the Statistical Package for Social Science (SPSS for Windows, version 20, IBM Corp, Armonk, NY, USA). The data are presented as mean ± Standard Deviation (SD). Normality was tested using the Kolmogorov–Smirnov, and thus parametric tests were performed. Independent sample t-tests were used to compare aggressive periodontitis with controls for age and bone density of the anterior and posterior regions. Multivariable linear regression models were also performed and statistical significance was set at p<0.05.

RESULTS

A total of 40 individuals were included in this study, 20 diagnosed with aggressive periodontitis and 20 periodontally healthy controls. The total sample consisted of 24 females and 16 males with no difference in gender distribution between groups, p = 0.55.

The results of the bivariate analysis are shown in [Table/Fig-3]. The mean age of the total study sample was 30.1 (±6.1) years with no significant difference between groups, mean age of aggressive periodontitis was 32 (±4.6) years and 29.4 (±6.5) years for the control group, p= 0.43. The mean bone density for the total sample in the anterior region was 882.4 (±238.2) and 259.1 (± 96.1) in the posterior region. In aggressive periodontitis, the mean bone density

	Total sample	Aggressive Periodontitis Means ± Standard Deviation	Control Means ± Standard Deviation	p-value
Age	30.1 (6.1)	32 (4.6)	29.4 (6.5)	0.43
Bone density:				
Anterior region	882.4 (238.2)	822.1 (225.7)	955.5 (240.2)	0.12
Posterior region	259.1 (96.1)	284.2 (92.5)	230.7 (95.2)	0.12

[Table/Fig-3]: Descriptive and bivariate statistics of the study sample.

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value
	B	Std. Error	Beta		
Age	21.5	7.6	0.63	2.81	0.01
Gender	53.3	99.6	0.12	0.54	0.60
Group	-105.3	100.5	-0.23	-1.05	0.31

[Table/Fig-4]: The multivariable linear regression model of the anterior bone density.

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value
	B	Std. Error	Beta		
Age	6.4	3.9	0.38	1.60	0.13
Gender	-24.4	52.3	-0.11	-0.47	0.65
Group	49.7	52.7	0.22	0.94	0.36

[Table/Fig-5]: The multivariable linear regression model of the posterior bone density.

in the anterior region was 822.1 (±225.7) and was 955.5 (±240.2) for the control group with no statistically significant difference, p = 0.12. In the posterior region the mean bone density for the aggressive periodontitis and the control groups were 284.2 (±92.5) and 230.7 (±95.2), respectively with no significant difference between them, p = 0.12.

The results of the multivariable regression models are shown in [Table/Fig-4,5]. In the anterior region, no significant association was found between bone density and groups. However, patient's age was significantly associated with bone density. A one-year increase in age was found to be associated with 21.5 unit increase in bone density independent of gender and group. In the posterior region, bone density was not associated with study groups, age or gender.

DISCUSSION

This study used the CBCT to measure the alveolar bone density in aggressive periodontitis patients and healthy controls. The results of the present study showed no difference between the two groups. It was not possible to compare the results of this study to others as no previous studies have examined alveolar bone density in patients affected with aggressive periodontitis. Numerous studies on chronic periodontitis are available in relation to osteoporosis or low bone mineral density; but their results were inconclusive. Some investigators showed that the prevalence of chronic periodontitis is higher in osteoporotic subjects [24-26]. In a recent study, treatment of osteoporosis by bisphosphonate therapy as an adjunct to non-surgical periodontal treatment resulted in significant improvement in periodontal condition [27]. Also, a recent systematic review found a positive relationship between osteoporosis and periodontal disease [28]. In contrast, others found no association between periodontitis and osteoporosis or low bone mineral density [29-31].

CBCT is an excellent tool for viewing anatomy in three dimensions. Its application in clinical dental practice provides a number of merits when compared to conventional CT and it has become commonly used for oral and maxillofacial imaging, providing great three-dimensional resolution, gray density range and contrast, and good pixel/noise ratio [32].

Several investigators demonstrated a significant correlation between CBCT and CT when measuring bone density [33-35]. Still, the use of gray scale value of CBCT to assess bone density was not recommended by some investigators when used as an absolute value [18,19]. A study showed that CBCT was not beneficial when CBCT values are taken as absolute values for the assessment of bone density of jaws and established that although CBCT has a low radiation dose, however it does not provide precise estimation of bone density [18]. This was attributed to the fact that CBCT lacks the ability to provide Hounsfield Unit (HU) measurements [36-38]. However, several investigators have argued that CBCT gray-scale values could be similar to HU [33,39-45]. Valiyaparambil JV et al., evaluated the correlation between dental CBCT gray scale values and HU and if CBCT gray values correlate with clinical bone quality subjectively assessed during dental implant placement [34]. Their results showed that the dimensional accuracy of CBCT was comparable with CT although the gray density values of the CBCT images (voxel value) were not absolute.

In the present study voxel values of standardized CBCT images were compared between the aggressive periodontitis group and their control, which eliminated the need for having absolute values [34]. Moreover, Campos MJ et al., in a study to assess the degree of mineral density of the apical third of the roots of maxillary central incisors and of the periapical bone [46], through CBCT images, comparing orthodontically treated and untreated subjects, they stated that mineral density determination is the best indicator for the quality of mineralized tissues, and CBCT has been proposed as a low radiation dose method for achieving such a purpose.

Periodontitis is a multifactorial disease that develops as an interaction between bacteria and the host response. The genetic predisposition in cases of aggressive periodontitis in particular is recognized as an important factor. Even though the prevalence of aggressive periodontitis is low, the destructive nature of this disease makes its early detection and proper understanding of the soft and hard tissue conditions to plan their comprehensive treatment is vital [3]. The successful treatment of aggressive periodontitis relies on early diagnosis and treatment targeted against the causative micro-organisms to provide optimum environment, free of infection to aid healing. The detection of aggressive periodontitis is complex and involves a great amount of skill. A corner stone of periodontal examination is periodontal probing of six sites per tooth, which is laborious and time consuming. This is the classical screening and monitoring method that has to be repeated periodically and thus far, no alternative screening tools with proven utility are available [47].

Conventional radiographs are valuable adjunct to clinical examination as it provides essential information regarding the extent and pattern of alveolar bone status. The use of these radiographs greatly aids the diagnosis of periodontal disease, as they can be useful in assessing the effect of treatment as well as disease progress and prognosis. However, conventional radiographs have major limitations such as they provide two-dimensional views of three-dimensional structures and underestimate alveolar bone destruction [9]. These limitations can be overcome by CBCT which provide greater information, but thus far CBCT is not considered a routine imaging modality. The CBCT radiation dose is equivalent to conventional full mouth series and about 3 to 7 times panoramic radiograph dose [9,48,49].

LIMITATION

One limitation to the current study was its small sample size due to the stringent inclusion criteria; thus, studies with larger sample size are recommended. Furthermore, future studies to compare the assessment of bone density using CBCT, CT-Scanning and Dual-Energy X-Ray Absorptiometry (DXA) in aggressive and other forms of periodontitis are suggested.

CONCLUSION

Within the limitations of the study, the results showed no difference in alveolar bone density between aggressive periodontitis patients and periodontally healthy controls.

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