Journal of Research in Medical and Dental Science
2018, Volume 6, Issue 5, Page No: 83-87

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Investigating the Relation between the Presence of Buccal Plate Fenestration and Dehiscence around the Anterior Implants and Alveolar Bone Thickness Using Cone-Beam Computed Tomography

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ABSTRACT

For long-term success of implant treatment, the characteristics of alveolar bone are important to provide proper osteointegration and maintaining bone support of the implant. Buccal bone defects around the implant endanger the stability and success of implant treatment by deranging the biomechanical balance of supporting tissues, and also increasing the probability of deep pockets. This study aims to investigate the relation between the presence of buccal bone fenestration and dehiscence in the anterior implants and thickness of alveolar bone using Cone-beam Computed Tomography (CBCT) images. In 22 patients referring to Maxillofacial Radiology Department of Shahid Beheshti, Dental School, 71 anterior implants were studied. The presence of buccal bone defect was recorded and thickness of alveolar bone in CBCT images was measured in three levels. The relation between CBCT findings were investigated by Kruskal-Wallis and Mann-Whitney statistical analysis. The prevalence of buccal bone dehiscence was 19.7% and the prevalence of buccal bone fenestration was 7%. The mean of alveolar bone thickness was 5.58 ± 1.31 mm at the platform level, at 3 mm apical to platform it was 5.95 ± 1. 57 mm and at 6 mm apical to platform it was 6.99 ± 1.45 mm. A significant relation was observed between the lower thickness of alveolar bone at 3 and 6 mm apical to platform levels and higher prevalence of dehiscence (P=0.00). There was also a similar relation between the thickness of alveolar bone at 6 mm apical to platform and the presence of fenestration (P=0.445). About 27% of anterior implants had surface bone defects and the possibility of these defects was higher in the lower thickness of the alveolar bone.

Key words: Fenestration, Dehiscence, Cone-beam computed tomography

HOW TO CITE THIS ARTICLE: : Mahsima Tayefi Nasrabadi*, Yaser Safi, Zahra Vasegh, Reza Amid, Investigating the relation between the presence of buccal plate fenestration and dehiscence around the anterior implants and alveolar bone thickness using cone-beam computed tomography, J Res Med Dent Sci, 2018, 6 (5):83-87

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Received: 30/07/2018
Accepted: 03/09/2018

INTRODUCTION

Over the past three decades, implant-based dentistry has considerably improved. These improvements have enabled clinicians to achieve some tooth replacement results that were previously unimaginable [1]. When planning implant treatment, the position and required number of implants are determined by the prosthodontist and surgeon. Factors such as the quantity and quality of the host bone, anatomical limitations such as sinus position and mandibular canal, aesthetic needs, and also biomechanical factors are among the effective factors in these decisions when implementing implants. When patients with narrow alveolar ridge are treated with implants, there is a higher risk of surface bone defects around the implant. Lack of bone support on the buccal or lingual side of implant can lead to unfavorable biomechanical conditions [2]. When a tooth is lost, the alveolar bone, especially in the buccal plate, is remodeled. The width of alveolar ridge is decreased to the half in one year, most of which occurs due to buccal plate recession. Despite some advantages, the placement of the implant axis along the desirable crown position is often limited by ridge morphology [3]. In addition, the presence of a labial concavity in the anterior maxilla may produce a small fenestration during implant placement. A small fenestration may not trouble achieving the initial stability, however, more time and cost is needed to correct the defect, and the patient's discomfort increases by lifting the large flap and additional surgical trauma. A large fenestration can cause the loss of initial stability or, over time, by creating deep pockets, endanger the biological health of retaining tissues of the implant [4].

Van et al. reported that the presence of buccal and/or lingual dehiscence around the implant results in a significant increase in stains to the mesial and distal marginal bone of implants, and as a result increasing the risk of overload on supporting bone in these areas and subsequently increasing marginal bone loss, soft tissue recession, or even complete loss of osteointegration [2]. Today, the intraoral periapical images using long cone and parallel technique are standard method for continuous evaluation of dental implants. This technique uses a low radiation dose and has low cost, and is applicable as chairside and has adequate accuracy for follow up implant evaluations. However, periapical images provide two-dimensional images of three-dimensional structures and at the time of evaluating whether fenestration and dehiscence exist are limited, since they only have the capability of evaluating interproximal bone. Cone-beam Computed Tomography (CBCT) provides three-dimensional images of the cortical bone adjacent to the implant, which allows the complete examination of buccal and lingual cortical plates [5]. This study aims to investigate the relation between the presence of fenestration and dehiscence around the anterior implants and thickness of alveolar bone using CBCT images.

MATERIALS AND METHOD

Among patients referring to the Maxillofacial Radiology Department of Shahid Beheshti Dental School for CBCT images which were prescribed for other diagnostic purposes, patients with successful dental implants in the aesthetic area under functional loading for at least 6 months which were placed in the prescribed imaging field were selected non-randomly. The scan of patients was captured by NEWTOME VGI (QR.Verona-Italy) with a 150 or 200 mm voxel size and a KVp of 110. Volume Reconstruction was performed by NNT software. All CBCT measurements were performed by one observer. Using NNT software version 5.5, the obtained volumetric data were reconstructed based on the longitudinal axis of each implant. Samples with high levels of metal artifacts which were distorting the images and making the measurements difficult were excluded. Measurements were performed in cross sectional images with a thickness and interval of 0.5 mm (perpendicular to the alveolar bone arch) at the middle section of each implant. The presence or absence of fenestration and dehiscence was determined for each implant (Figure 1A and Figure 1B).

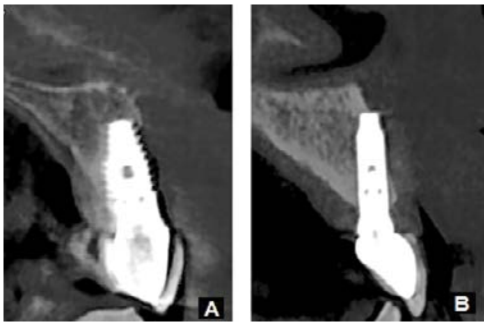

Figure 1: A) Implant with buccal dehiscence B) Implant with buccal fenestration

The thickness of alveolar bone was measured in three levels: 1) at platform level 2) 3 mm apical to platform and 3) 6 mm apical to platform (Figure 2).

Table 1: Mean and standard deviation of the alveolar bone thickness in CBCT images in three levels

	Image level	Number of cases without data	Number of cases with data	Lowest (mm)	Highest (mm)	Mean (mm)	Standard Deviation	P value
Thickness of the Alveolar Bone	At platform level	55	16	3.4	8.2	5.58	1.31	0
	3 mm apical to platform	8	63	2.6	9.7	5.95	1.57	
	6 mm apical to platform	0	71	3.5	9.7	6.99	1.45	

P value obtained from Kruskal Wallis test

Table 2: Mean and standard deviation of the alveolar bone thickness in CBCT images in three levels based on presence of fenestration and dehiscence

Level			Number	Mean (mm)	Standard Deviation	P value
At platform level	Fenestration	No	15	5.5	1.32	0.32
		Yes	1	6.8	-	
	Dehiscence	No	13	5.68	1.38	0.54
		Yes	3	5.13	1.05	
At 3 mm apical to platform	Fenestration	No	58	6.01	1.61	0.21
		yes	5	5.28	0.95	
	Dehiscence	No	49	6.5	1.19	0
		yes	14	4.04	1.24	
At 6 mm apical to platform	Fenestration	No	66	7.08	1.44	0.045
		Yes	5	5.88	1.06	
	Dehiscence	No	57	7.33	1.28	0
		Yes	14	5.62	1.31	

P value obtained from Mann-Whitney test

Figure 2: Measurement of alveolar bone thickness in three levels

In order to distinguish the cases with buccal bone defects from the cases of periimplantitis induced alveolar bone resorption, which there was no bone all around the implant, if there was no alveolar bone at measuring level, it was recorded as "without data". For differentiating the horizontal bone loss and cases with non-level buccal and lingual bone plate resorption, the thickness of alveolar bone was measured between present avleolar bone plate at intended level and a line connecting buccal and lingual crests. The obtained data were analyzed by SPSS version 21 (SPSS Inc., Chicago, IL, USA Version). In order to assess the agreement between the measured factors by one observer (intra-examiner error), the relevant factors in 10 samples were measured twice with a two-week interval, and Min, Max, and the average intra-class correlation coefficient indicators was calculated in each parameter. The relation between CBCT findings were investigated by Kruskal-Wallis and Mann-Whitney statistical analysis. Informed consent to participate in the study was taken from all patients and this study was approved by IR.SBMU.RIDS.REC.1395.344 at the Ethics Committee of Shahid Beheshti University of Medical Sciences.

RESULTS

The obtained correlation coefficient in all repeated measurements for assessing intra-observer error was above 0.9. A total number of 22 patients were studied. The data related to 15 women and 7 men with an average age of 61.22 ± 15.48 years (minimum 16 and maximum 85 years) were evaluated. In these patients, 71 areas with anterior implants under functional loading were investigated. According to the findings of this study, the prevalence of dehiscence was 19.7% (14 cases) and 80.3% of the samples (57 cases) did not have dehiscence. The prevalence of fenestration was 7% (5 cases) and 93% of the samples (66 cases) did not have fenestration (Figure 1). The average thickness of the alveolar bone at the platform level was 5.58 ± 1.31 mm, at 3 mm apical to platform was 5.95 ± 1.57 mm and at 6 mm apical to platform was 6.99 ± 1.45 mm (Table 1 and Table 2).

According to Kruskal Wallis test, there was a significant difference in thickness of the alveolar bone at three levels (P=0.00). The investigation of alveolar bone thickness based on fenestration and dehiscence at three levels showed that at platform level 1 case had fenestration and 3 cases had Dehiscence. As the thickness of the alveolar bone in the samples with Fenestration was 6.8 mm, in the samples with Dehiscence was 5.13 ± 1.05 mm. At the 3 mm apical to platform, 5 cases had Fenestration and 14 cases had Dehiscence. As the thickness of the alveolar bone in samples with Fenestration was 5.28 ± 0.95 mm, and in samples with Dehiscence it was 4.04 ± 1.24 mm. At 6 mm apical to platform, 5 cases had Fenestration and 14 cases had Dehiscence. As the thickness of the alveolar bone in the samples with Fenestration was 5.88 ± 1.06 mm, in the samples with dehiscence, it was 5.62 ± 1.31 mm. The investigation of the mean and standard deviation of radiographic alveolar bone thickness based on Fenestration and Dehiscence in three levels indicated that the low thickness of the alveolar bone at 3 and 6 mm apical to platform levels was significantly associated with the presence of Dehiscence (P=0.00). There was also a similar relation between the thickness of alveolar bone at the 6 mm apical to platform and the presence of Fenestration (P=0.445).

DISCUSSION

Cone-beam Computed Tomography is a volumetric acquisition which provides accurate and reliable submillimeter resolution images which is able to detect peri-implant defects. However in the presence of metallic objects in imaging field such as amalgam or titanium implants, two types of CBCT introduced artifacts including beam hardening and streaking artifact may decrease image quality. Kamburoglu et al. concluded that CBCT images with <0.3 mm voxel size have the highest diagnostic value in identifying the simulated defects of the marginal buccal alveolar bone around the implant [6]. In this study, CBCT images with 0.2 mm or less voxel size were used to assess the surface bone defects of buccal implants.

The quality and quantity of the supporting bone of implant plays a significant role in distribution and tolerance of the forces which osteointegrated implants involved in [7]. The low thickness of the buccal bone surface can be the reason for bone recession around the implant which is difficult to repair after placement of the implant [8]. The results of the study by Qahash et al. indicated that there is a significant relationship between the thickness of the buccal bone plate and the amount of bone recession and to maintain the alveolar bone surface, the minimum thickness of the buccal bone surface should be 2 mm [9]. Okumura et al. studied the effect of cortical tissue thickness on the distribution of stress in a simplified model and indicated that increasing the bone thickness reduces stress [10]. The presence of surface bone defects around the implant increases the stress on the bone supporting the implant by reducing the effective contact surface between the implant and the bone. Chan et al. reported an approximately 20%

prevalence of fenestration at the buccal implant level [4]. In their study, the placement of virtual implants on CBCT images along the axis of contralateral tooth crown was used to investigate the prevalence of fenestration. The obtained results of this study indicated that the lower thickness of the alveolar bone at the 3 mm and 6 mm apical to platform levels was significantly relevant with the presence of dehiscence. There was also a similar relation between the thickness of alveolar bone at the 6 mm apical to platform and the presence of fenestration. The results of this study indicated that lower alveolar bone thickness is associated with an increased prevalence of buccal surface defects of the anterior implants. Clinical experiences have indicated that implant placement in an optimal position is not always possible. The ridge morphology, beauty needs, and anatomical limitations including adjacency to nasal cavity, maxillary sinus and inferior alveolar canal, are the determinant factors in determining the position and angle of implant placement [11]. Diameter and shape of implant and direction of applying force affects the distribution of stresses on the implant [12]. Himmolva et al. reported that increased dimensions of implant have significant effect on reducing stresses focused on the support bone in the implant cervix area, and the effect of increased diameter of the implant compared to the increased length of implant has a more pronounced effect on the reduction of these stresses [13]. On the other hand, the alveolar bone recession caused by the wound healing process after tooth extraction, dentures–induced wears, bone injuries as well as anatomical variations such as bone depressions associated with canine fossa, can lead to limitations in choosing implant size or force the surgeon to place the implant in a position that requires angular abutments [14]. Nowzari et al. stated that the prevalence of thin facial alveolar bone (thickness less than 2 mm) may be associated with the risk of dehiscence, fenestration, and soft tissue recession after immediate implant placement. The dimensions of the buccal bone plate is the main factor affecting the recession of this plate after tooth extraction, and buccal alveolar bone recession is a key determinant in implant success [15]. The limitation in bone dimensions along with the higher diameter of chosen implants can increase the risk of surface bone defects and subsequent gingival recession.

CONCLUSION

The prevalence of dehiscence at the buccal surface of the anterior implants is 2.8 more than the prevalence of fenestration and in cases with these defects, thickness of the alveolar bone is lower significantly.

CLINICAL IMPORTANCE

In the case of inadequate thickness of the alveolar bone, especially in anterior area, where the position of the prosthesis due to its cosmetic importance is a determining factor in choosing the implant position, and also due to the probability of bone recession, considering the necessity of bone augmentation when providing treatment plan is recommended.

CONFLICT OF INTEREST

All authors declare that there is no conflict of interest.

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