Research & Reviews: Journal of Dental Sciences

e-ISSN: 2320-7949
p-ISSN: 2322-0090

Feasibility of CBCT in Evaluating Bone Density of Dental Implant Placement Sites

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Research Article

Received: 09/02/2017
Accepted: 15/02/2017
Published: 22/02/2017

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Keywords: Implant, CBCT, Accuracy, Bone density, Grey scale

ABSTRACT

Aim: To assess density changes of bone after implant placement and to evaluate the feasibility of CBCT for clinical use.

Materials and methods: 40 tapered dental screw implants were placed in 23 patients aged between 18 and 58 years. CBCT was used to measure bone density before and after implant placement. NNT software was used to take bone density recordings using CBCT grayscale values. SPSS software was used to conduct T-test to compare between pre and postoperative density results, as well as CBCT versus CT readings. One-way analysis of variance was also used for Bone density values of the different areas.

Results: A p value of less than (<0.05) for all four jaw areas were recorded owing to a significant increase in the bone density around the implant postoperatively. Multiple comparison showed significant bone density variations between the four areas (p<0.0001), while no significant difference found between CBCT and CT results (P=0.38).

Conclusion: CBCT detected a postoperative increase in bone density after every implant placement suggesting bone compression, which contributes to the implant stability. CBCT bone density measurements were assessed and when compared, they were found consistent to those found in CT. Therefore, it is a reliable alternative for density assessment in routine implant placements.

INTRODUCTION

Dental Implant success rates are highly predictable. Thorough clinical and radiographic assessment of the implant bed is very important to avoid any complications during or after treatment. The initial implant stability is one of the main factors influencing the outcome and prognosis of the treatment.

Unfortunately, 2 dimensional images do not provide a comprehensive evaluation of bone quality [1]. Conventional multi-slice computed tomography (CT) provides three dimensional imaging but it also comes with some drawbacks such as the high cost, long time of procedure and high radiation doses which contraindicates the its use in most dental cases. CBCT on the other hand produces volumetric reconstructions of craniofacial structures similar to (CT); however, it does it with a reduced acquisition times and a lower amount of effective radiation doses [2]. It can aid in the assessment of bone density which is significantly correlated with implant stability parameters. Therefore it is possible to predict the initial stability of an implant using CBCT scans before placing an implant [3-7]. Some previous studies suggested that CBCT is not reliable in assessing bone density and it cannot replace CT scans in doing so [8-15]. The goals of this study were to detect the density changes that occur to alveolar bone at the implant/bone interface, and to correlate the overall density readings to those attained using Conventional CT to assess the reliability of CBCT in doing these measurements for daily clinical use.

MATERIALS AND METHODS

Patients

All implant treatments and radiographic acquisition were performed in the Department of Oral Implantology of Union Hospital

e-ISSN: 2320-7949
p-ISSN: 2322-0090

during September 2013 to April 2014. The current study complies with the moral and ethics standard of Union Hospital, Wuhan.

A total of 23 partially edentulous patients aged between 18 and 58 years old and treated by oral implant rehabilitations were selected. The patients with severe bone deficiency, Systemic diseases affecting bone turnover, patients with pregnancy or lactating, and or had habits that could severely interfere with treatment were excluded from the study. All selected patients had at least two CBCT (preoperative and postoperative) radiographs.

Image Analysis

CBCT radiographs were taken using (NewTom VGi, Italy) with a focal spot of 0.3 mm, with an effective dose of 99 uSv full field of view (FOV) generated images, set at 110 kV, 14-bits grey scale. The CBCT unit was 2.96 mA, with a 3.6 s exposure time. Implants system used for all patients was Nobel Biocare titanium implants. Each patient signed an informed consent letter before any surgical operation. A total of 40 radiographic implant sites were analysed using the NewTom NNT software. 19 of these were maxillary sites and 21 were mandibular. All readings were done under the magnification of 254% for increased visibility and hence more accuracy of measurements.

Using the 3-plane of the NNT viewer, the axial plane was fixed on the edge of the alveolar bone of the suggested implant site, the coronal plane fixed in the middle of the suggested implant site, and the sagittal plane was adjusted to a location approximately midway to the total width of the alveolar bone. This provided a general look at the implant recipient site from the 3 different planes. A sectioning tool in the software was used to outline the entire border of the alveolar bone from the axial view, which formulates an Orthopantogram (OPG) view in where tomographic coronal and sagittal sections can be viewed. Bone density measurements were recorded and then analyzed.

Bone Density Recording

Grayscale values were measured for all edentulous area planned for an implant placement operation. All density recordings were done in the buccolingual view of the axial plane using the greyscale bone measuring tool in the NNT software. Eight different recordings were measured for every implant site. First, the recordings were done on the postoperative tomograph with the implant already positioned in the place. This was done to record the exact position of the implant fixture on the 3 different fields of view and to maximize the accuracy of the measurements on the preoperative measurements. The total length of the implant was measured and then divided into four parts in total; the first part is the most coronal 2 mm of the bone representing compact bone, and the rest of the distance was divided into three parts representing the representing the coronal, middle and apical thirds. Measurements were taken from around 1 mm in a parallel manner away from the implant fixture **(Figure 1)**. For every section that was measured, a 2 mm line was drawn and greyscale values were recorded at the 2 ends of this line. To summerize, there was 2 measurements at 4 locations for every implant, adding up to 8 readings per implant. Preoperative tomographs were then analysed in the same way after calculating the location of the implant using the measurement tool. All pre and post-operative locations were re-measured by the same examiner and the average of the two measurements were considered. The mean greyscale values from each 2 points in the same section were calculated and bone densities from both tomographs were compared.

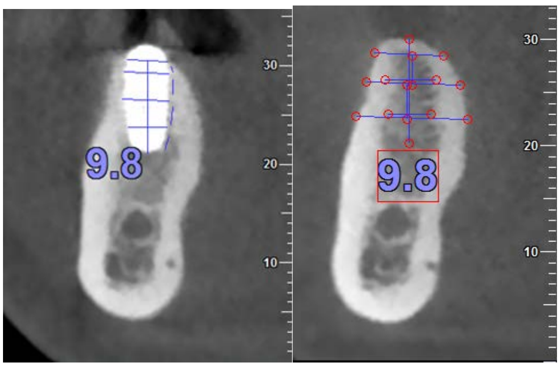

Figure 1. Preoperative vs. postoperative bone density in different areas around the implant site.

Total length of the implant was measured and then divided into 4 parts representing the compact most coronal 2 mm, coronal, middle and apical thirds. Measurements were taken from around 1 mm in a parallel manner away from the implant fixture. Post-operative measurements were taken first then the density was measured at the same location preoperatively.

Statistical Analysis

Volumetric data was obtained by comparing the preoperative and postoperative recordings. Descriptive results were obtained using Microsoft Excel. SPSS software was used to conduct the T-tests and obtain the one way analysis of variance for a multiple comparison between the different jaw densities and one sample test to compare between CTBT and CT results and, to obtain the levels of significance.

e-ISSN: 2320-7949
p-ISSN: 2322-0090

RESULTS

Measurements between the preoperative and the postoperative radiographs of the 4 different areas were averaged. Here, the method of two independent sample t-test was used. The results of two independent sample t-test showed that the postoperative recordings were larger than preoperative ones (P=0.001). Coronal, middle, apical parts had similar results (all p<0.05). The cortical area was found to have the highest density, followed by the coronal, the middle and finally the apical part of the bone surrounding the implant site. There was an overall increase in bone density at the postoperative implant site **(Figure 2)**.

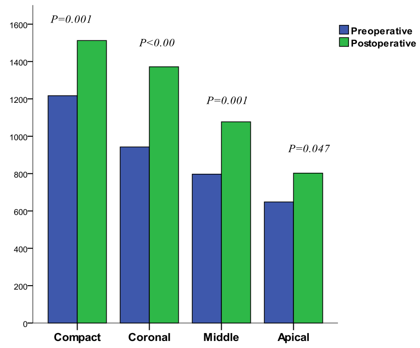

Figure 2. Preoperative vs. postoperative bone density.

Here, the method of two independent sample t-test was used.

The results of two independent sample t test showed that the values of compact had significant difference between preoperative and postoperative, and the values of postoperative was larger than preoperative (P=0.001). Coronal, middle, apical had same results (all p<0.05).

The results of one-way analysis of variance **(Table 1)** showed that the bone density values were different in these four areas (P<0.0001). Multiple comparison showed that Bone density values of Anterior Mandible were larger than others areas (all P<0.05), and bone density values of Posterior Mandible were larger than Posterior Maxilla (P<0.05). The difference of bone density values of Anterior Mandible between CBCT and CT was obtained using One-Sample t-test **(Table 2)**. The bone density values of Anterior Mandible of CBCT (1212) were compared the normal values found in CT scans at the same area (1250 Hounsfield Units) [8]. The result of One-Sample t-test showed that the bone density values of Anterior Mandible was no significant difference between CBCT and CT (P=0.38).

Table 1. One-way analysis of variance for bone density values of the different areas.

	Anterior Mandible	Posterior Mandible	Anterior Maxilla	Posterior Maxilla
Mean	1212.05^{bcd}	923.29^{ad}	761.98^{a}	538.53^{ab}
SD	113.76	215.88	213.63	133.16
F value	26.54			
P	<0.0001			
a, b, c, d mean the results of multiple comparison, represent anterior mandible, posterior mandible, anterior maxilla, posterior maxilla respectively, when it has a, it means this area's bone density values was different from Anterior Mandible, which has statistical significance (P<0.05).				

The results of one-way analysis of variance showed that the bone density values were different in these four areas (P<0.0001). Then the results of multiple comparison showed that Bone density values of Anterior Mandible was larger than others areas (all P<0.05), bone density values of Posterior Mandible was larger than Posterior Maxilla (P<0.05).

Table 2. One-sample t-test used for the difference of bone density values of anterior mandible between CBCT and CT.

	Mean Difference	95% Confidence Interval of the Difference		t-value	P
		Lower	Upper		
Anterior Mandible	-37.95	-133.06	57.15	-0.94	0.38

Whether the bone density values of Anterior Mandible were used CBCT is different from CT, which value is fixed as 1250. The result of One-Sample t test showed that the bone density values of Anterior Mandible was no significant difference between CBCT and CT (P=0.38), it could be say that CBCT to measure the bone density values of Anterior Mandible is the same as CT.

DISCUSSION

It has been proven that the success of any placed implant highly depends on both, the quality and the quantity of the surrounding bone [16]. There is a correlation between high bone density and high rate of implant success, and between high bone density and implant primary stability [17]. Bone density assessment is therefore essential prior to every plan operation and for the success of the treatment [18,19]. However, previous studies had contradicted results on the accuracy and reliability of CBCT in assessing correct bone density. Although most of these studies concluded that CBCT could be considered a diagnostic tool for bone density evaluation, they point that CBCT systems do not display HU correctly and others found overestimated values of HU, and therefore they are less reliable than CT1 [16,20]. This study focused on the evaluation and diagnosis of the bone housing of the implant, so it was essential to know whether CBCT is accurate enough for clinical use or not. Hence, qualitative measurements where done, and it was compared to CT measurements of previous studies using CT scans. What mostly distinguished this study from most previous ones was the number of measurements taken from each site. 4 measurements were taken buccaly from each implant site so a clear and more accurate idea about the changes in bone density along the whole length of the implant.

Postoperative measurements were taken first to record the location of the implant and measure at the same location on the preoperative one. When the statistical analysis was done on the recorded grey scale values it was found that all of the sites showed an increase in density. The sequence was as follows; cortical bone recorded the highest increase, then the coronal part, the middle part and finally the apical part. Patients who had not have a long duration between the pre and postoperative radiographs also showed the same result, suggesting that this increase was not a true increase in bone density but it is rather a “compression” of the alveolar bone by the implant body that was placed, which is correspondent to some of the previous studies. Lee et al. Insertion torque resistance was correlated with objective CT and CBCT measurements of bone density [4]. Georgescu CE concluded that Insertion torque resistance was correlated with objective CT and CBCT measurements of bone density [11]. The difference in the percentage of the increase in density might correlate with the shape of the implant fixture which is widest at the neck or the crest of the alveolar ridge, then tapers gradually until it reaches the narrowest point and the least bone-compressive point at the apex. Therefore it can be suggested that wider implants can compensate for the low quality bone through higher bone compression.

Another bone analysis that was done on this study was to evaluate the reliability of CBCT density analysis. After a location-oriented grouping of the different implant, four groups were made. Following statistical analysis, similar results to Misch’s classification and the Lekholm and Zerb index which classifies bone density radiographically into four types, based on the amount of vertical bone versus trabecular bone. Misch related bone density to the clinical hardness of the bone as subjectively perceived during drilling prior to implant placement [21]. CBCT detected four areas with four zones of different densities, in which grayscale values showed correlation with results obtained from the CT Housfield units. The anterior mandible showed the highest density, followed by the posterior mandible, the anterior maxilla and the posterior maxilla respectively, and the statistical analysis showed correlation between the CBCT and the CT scan values. We can therefore suggest that CBCT can replace multislice CT in dentistry for analyzing mineralized tissue, because it provides adequate image quality associated with a lower exposure dose compared to conventional CT.

CONCLUSION

There was an increase in density measurements postoperatively, which suggests compression of bone around implants after their placement, which is beneficial for the initial implant stability especially in areas of poor bone quality, for instance in the posterior maxilla.

CBCT can accurately detect variations in bone density and values were found relevant to those obtained by the CT scan. Therefore, CBCT is reliable to make pre- & post-operative evaluation of bone quality during dental implant procedures and could be a suitable alternative for conventional CT scans.

CONFLICT OF INTEREST

The author’s does not have any conflict of interest to disclose.

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e-ISSN: 2320-7949
p-ISSN: 2322-0090

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