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Original Article

Assessment of the effect of different imaging techniques on planning implant therapy by different clinicians

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Abstract

Aim: To compare the implant size which was determined by different observers using panoramic radiography (PAN) and cone beam computed tomography (CBCT) with inserted implant size.

Material and Methods: 194 PAN and CBCT images which belong to 194 patients who were planned to undergone single-tooth implant therapy were evaluated. 50 anterior regions, 42 premolar regions and 92 molar regions were assessed. These sites were used for planning of dental implant insertion. Images were analyzed by observers with different education and clinic experience backgrounds: one periodontist (observer 1), one oral and maxillofacial radiologist (observer 2), and one general practitioner (observer 3). Panoramic images and cross-sectional CBCT images of each patient were examined; differences in length and width of the implant-to-be from the two imaging systems were analyzed and compared to inserted implant size.

Results: Observer 2 recorded the largest implant width whereas observer 3 recorded narrower implants in PAN. Observer 3 recorded shortest implants than did the other two observers in CBCT and observer 2 recorded narrower implants in CBCT. The CBCT measurements allowed a wider implant in the premolar and molar regions. No significant difference was observed between CBCT and PAN in planning the implant length. The inserted implant size was smaller than the measurements made in CBCT.

Conclusion: The results show that; different observers present different values in determining implant length and width. The inserted implant size and the dimensions measured on CBCT and PAN images were different.

Keywords: CBCT; education; implant planning; implant size; panoramic radiography

INTRODUCTION

The most important step for the success of dental implant depends on a well-developed and detailed presurgical planning. Determining the limits of bone and soft tissue and measurement of the distance to anatomical structures for an ideal implant application is only possible with appropriate radiological techniques (1, 2). Inaccurate evaluation prior to surgery may result in implant failure, damage to nerves, vessels, maxillary sinus perforation, and other complications.

Many radiographic imaging methods such as panoramic, periapical, computed tomography (CT) and cone beam computed tomography (CBCT) can be used in implant planning (3). Panoramic radiography (PAN) is widely used as a standard radiographic examination tool to evaluate the availability of bone height, especially when planning implant surgery (4). The vertical plane measurements taken with panoramic radiograms may show larger and smaller than normal images. Errors occurring in the patient position during the radiography procedure may result in distortions and undesirable magnifications in the image and therefore inaccurate measurements. Also, PAN images don't show the bucco-lingual side of the alveolar bone (5, 6).

CBCT allows dentists to obtain 3-dimensional volumetric data in a single rotation and with a very low radiation dose. It also allows two-dimensional images to be rearranged in planes at coronal, sagittal, oblique and various slopes (7). Many dentists, oral surgeons, and periodontists may access CBCT routinely and use for dental implants procedures (8).

Some clinicians have reported that although there are technical differences between PAN and CBCT, treatment

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outcomes are not affected by these differences (9). Also, the other factors such as the harmony of artistic skill, scientific knowledge, and clinical expertise may affect implant success. Only a few studies have assessed the effect of 2D vs 3D imaging and different profession on dental implant treatment planning (10,11).

This study was conducted to compare the implant size (width and length) planned and placed with digital PANs, and CBCT cross-sectional images by different examiners.

MATERIAL and METHODS

This study was conducted on 194 patients (102 male, 92 females) between January 2017 and January 2019. 194 implants were consecutively placed at the Department of Periodontology in the Bolu Abant Izzet Baysal University. The ethical approval was obtained from the Clinical Researches Ethics Committee of Bolu Abant Izzet Baysal University (number: 2018/270). Patients, who need single-unit implant therapy in the maxillary and mandibular anterior, premolar and molar regions, were enrolled in this study. For each patient, digital PANs and CBCTs were recorded.

The CBCT scans were gained using an I-Cat imaging system (Imaging Sciences International, Hatfield, PA, USA) at 15 mA and 120 kVp, with a voxel size of 0.3 mm and an exposure time of 8.9 sec. Images were investigated using i-CAT vision Q imaging software. Tomography slices of 0.3 mm in cross-sectional views were produced. The measurements were made by using the measurement tool of the software.

All PANs were obtained using the same machine with Soredex (Cranex Novus, Tuusula, Finland) at 10 mA, 70 kVp, for 8 s exposure time. PANs were recorded in high-resolution JPEG format and transferred to Image J v. 1.3 software (National Institutes of Health, Bethesda, MD). The implant lengths and widths were measured using the distance measuring tools of the software.

Examiners and treatment planning

The PAN, and CBCT-cross images of the implant sites were evaluated to select the appropriate implant size by three observers: One periodontist (observer 1), one radiologist (observer 2), and one general practitioner (observer 3) all familiar with implant planning in radiographs. Observers were made evaluations independently.

Observers assessed 4 parameters for each previously indicated location: implant length, implant width, need for augmentation procedure or bone grafting and need for other surgical procedures as nerve lateralization. The decision about the need for bone grafting and/or other surgical procedures was based on the evaluation of the examiners based on bone length and width. The implant sites were specified considering minimal distances between the implant and anatomical structures, 1.5 mm between the adjacent tooth and implant, 3.0 mm between implants, 2 mm safety zone between the implant and neurovascular bundle, and 1 mm between buccal or lingual cortices and the implant (Figure 1). Implant dimensions were limited by anatomical structures such as the maxillary sinus, mandibular canal, and neighboring teeth. At the end of the study, the average of the measurements made by the three observers was evaluated for statistical analysis.

In determining the implant size to be placed, 11 different implant lengths and widths which belongs to different implant manufacturers were selected.

Statistical Analysis

In order to make statistical evaluations, average values were obtained from length and width measurements of three observers and statistical analysis was made according to average values. Differences in the size of the implant to be were analyzed by ANOVA, for all sites and for anterior, premolar and molar sites separately. The pair-wise comparisons between the variables were made by using post hoc Least Significant Difference (LSD) tests. The level of statistical significance was $P < 0.05$.

RESULTS

Distribution of implant sites according to gender were shown in Table 1. Molar teeth ratio was higher for both genders (44.6 % for women and 50 % for men).

Table 1. Distribution of implant sites according to gender in the study population

Gender	Teeth	Frequency (n)	Percent (%)
Women	premolar	26	28.3
	molar	41	44.6
	anterior	25	27.2
	Total	92	100.0
Men	premolar	26	25.5
	molar	51	50.0
	anterior	25	24.5
	Total	102	100.0

n = Number

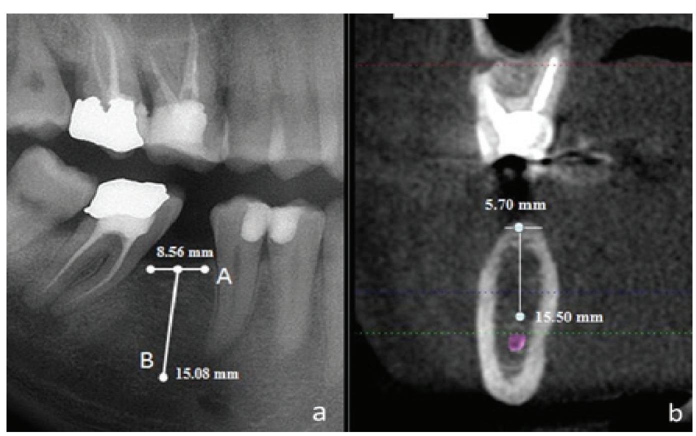

Figure 1. Length and width measurement on PAN (a) and cross-sectional CBCT images (b)

Table 2. Minimum (Min), maximum (Max), Mean, and Standard deviation (SD) values in millimeters for length and width of the implant, recorded by the three observers in each imaging system

	Length				Width			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
PAN measurements								
Observer 1	0.00	18.73	11.77^{A}	3.70	3.36	9.01	5.57^{B}	1.15
Observer 2	0.00	18.81	11.77^{A}	3.75	3.37	9.12	5.63^{C}	1.18
Observer 3	0.30	18.25	11.62^{A}	3.69	3.26	9.09	5.08^{D}	1.12
CBCT measurements								
Observer 1	1.02	20.12	12.42^{E}	3.81	2.51	13.26	6.31^{G}	1.65
Observer 2	1.05	20.00	12.44^{E}	3.72	2.42	13.35	6.30^{G}	1.71
Observer 3	1.03	20.08	12.39^{F}	3.75	2.50	13.20	6.26^{H}	1.68

CBCT: cone beam computed tomography; PAN: panoramic radiographs.
Different superscript letters indicate statistically significance between observers.

Table 3. Minimum (Min), maximum (Max), Mean, and Standard deviation (SD) values in millimeters for length and width of the implant recorded in CBCT images, panoramic radiographs (PAN), and inserted implant size

		Length				Width			
Teeth Group	Modality	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
	CBCT	1.00	20.00	12.43^{A}	3.90	2.42	13.20	$6.29^{D,E}$	1.69
All Teeth	PAN	0.00	18.81	11.77^{B}	3.75	3.36	9.12	$5.70^{D,F}$	1.16
	Inserted ımplant size	6.00	14.00	$9.91^{A,B}$	1.39	3.00	5.50	$3.93^{E,F}$	0.50
	CBCT	8.00	20.00	14.00^{G}	2.86	3.13	7.85	5.32^{I}	1.10
Anterior Teeth	PAN	9.01	18.79	13.34^{H}	2.64	3.38	7.13	4.93^{J}	0.84
	Inserted ımplant size	8.00	14.00	$10.04^{G,H}$	1.36	3.00	4.30	$3.59^{I,J}$	0.32
	CBCT	5.51	18.65	13.45^{K}	3.22	2.42	8.90	$5.95^{M,N}$	1.47
Premolar Teeth	PAN	5.09	18.50	12.57^{L}	3.07	3.36	7.06	$5.08^{M,O}$	0.90
	Inserted ımplant size	8.00	12.00	$10.30^{K,L}$	1.33	3.00	4.80	$3.87^{N,O}$	0.40
	CBCT	1.00	19.24	11.01^{P}	4.25	3.71	13.20	$7.02^{R,S}$	1.75
Molar Teeth	PAN	0.00	18.47	10.46	4.08	3.86	9.01	$6.19^{R,T}$	1.11
	Inserted ımplant size	6.00	12.00	9.63^{P}	1.38	3.00	5.50	$4.14^{S,T}$	0.52

ANOVA model, followed by Least Significant Difference (LSD) post-hoc tests: A-O $P < 0.001$. P $P= 0.024$
$^{R, S, T}$ $P < 0.001$. The mean difference is significant at the 0.05 level

The measurements determined for the implant length in PAN did not differ for the three observers (Table 2). However, in measurements to determine implant width, observer 2 recorded the largest implant width. Observer 3 recorded narrower implants than the other observers in PAN.

In CBCT, observer 3 recorded shortest implants and observer 2 recorded narrower implants. However, in both PAN and CBCT, differences in implant length and width between the observers were, on average less than one millimeter Considering the average of all teeth, CBCT measurements allowed a wider implant. The same was true in the premolar and molar regions. In the anterior region, no statistically significant difference was observed between CBCT and panoramic measurements, but higher mean values were obtained with CBCT measurements (Table 3). No significant difference was observed between CBCT and PAN in planning the implant length.

When inserted implant sizes were compared with CBCT measurements, it was seen that inserted implant size was smaller than the measurements made in CBCT.

The frequency of the cases according to the need for bone grafting or augmentation procedure and for other surgical procedures was shown in Table 4. It was seen that the need for surgical procedures was more in the molar region.

Table 4. Frequency of need for bone grafting and/or other surgical procedures was based on the evaluation of the examiners

Region	Augmentation procedure (Sinus lifting or vertical augmentation)	Need for surgical procedures (Horizontal Augmentation)
Anterior (n=50)	0 (0%)	3 (6%)
Premolar (n=52)	4 (7.7%)	0 (0%)
Molar (n=92)	21 (22.8%)	6 (6.5%)

n = Number

DISCUSSION

Appropriate treatment planning is a main step of implant therapy to select an implant with the proper size, and location. Some studies have suggested that CBCT should not be preferred as a imaging technique if the essential information can be obtained through routine radiographic methods, however, the clinician cannot assess the complexity of the bone dimensions because the data are presented in a 2D format that superimposes the different structures by PAN view (12). The inferior alveolar canal is not surrounded by the compact cortical bone in all patients therefore, in some cases, the mandibular canal may not be displayed clearly on PAN views (1).

The purpose of this study was to investigate whether different clinicians with different educational backgrounds and type of image examination PAN or CBCT could affect determining the size of the implant and the possible need for bone grafting. In the present study, the measurements determined for the implant length in PAN did not differ for the three observers. Thus no significant difference was observed between CBCT and PAN in planning the implant length. However, shorter implant length was recorded when mean measurements were evaluated in PAN. Similarly, in a study of Correa et al., implants measured in cross-sectional CBCT images were shorter and narrower than implants measured on a panoramic image or CBCT-based panoramic view (11). Also in our study, placed implants were shorter than the implants measured on a PAN view or CBCT view. This can be related to bone density, difficulty during surgical application (inadequate mouth opening e.g.) and preference and experience of clinicians.

Also, the buccolingual width and angulation of the available bone are the most important criteria for proper implant selection and success of implant therapy (13). According to our results, CBCT measurements allowed a wider implant in the premolar and molar regions, but in the anterior region, no statistically significant difference was observed between CBCT and PAN measurements. In the study of Correa et al. showed differences in length in the molar region and in width in the premolar region; however, the differences were small and toward a determined implant size was significantly shorter in CBCT-based panoramic images than in digital PAN images. Conversely, Guerrero et al. showed that CBCT had little effect on the presurgical planning of implant width and the changes between the increase and the decrease in the length and the width were equally distributed. The observers did highly repeatable presurgical planning under the two different diagnostic technique, suggested that tomograms did not provide additional information by regarding implant width (7). However, in comparing CBCT and PAN measurements, the implant widths were different and CBCT measurements provided for a wider implant planning in our study.

Dau et al. compared implant planning of observers with different levels of professional training (general dentists, oral surgeons and maxillofacial surgeons) using PAN and CBCT', and found statistically significant differences between observers (14). Similarly, when the other previous studies were considered, it was seen that, the results of the studies differed according to observer experience and education level (15, 16). In the present study, three observers with different educational levels were made the measurements. The length measurements obtained by observers in PAN were similar. The mandibular canal and the mental foramen were left with 2 mm safety margin when determining the length in PAN, and the upper limit of the maxillary sinus was taken as the reference in the maxilla posterior. The reference points were fixed. This should be the reason why similar measurements were obtained by observers. However, the width measurements in PAN differed between the three observers. This may be due to the reference of different points when measuring. 3rd observer (general practitioner) noted a narrower implant in PAN. In CBCT measurements, the length and width values recorded by observer 1 and observer 2 were similar, but observer 3 obtained shorter and narrower implant measurements. This may be due to the fact that Observer 1 and 2 are more knowledgeable and experienced in CBCT interpretation and evaluation of anatomical structures in CBCT.

Both PAN and CBCT can be reliably used to determine the preoperative implant length. But in a posterior area, because of anatomical structures such as neurovascular bundle and maxillary sinus, PAN-based preoperative planning of implants should be done more carefully to select longer implant lengths. In addition, CBCT can allow observers to plan implant therapy with enhanced subjective image quality and greater surgical confidence.

CONCLUSION

It is important to emphasize the limitations of this study in which patient selection was performed retrospectively. In the study, the cases were heterogeneous, only single tooth-implant planning cases were considered. Both the planning and the implant sizes to be selected may differ more in case of difficult implant cases, that is, when there is more tooth deficiency, in PAN and CBCT evaluation. However, CBCT can give more different results in cases with a larger toothless region.

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