ijlpr 2021; doi 10.22376/ijpbs/lpr.2021.11.3.P68-74

International Journal of Life science and Pharma Research

Research Article

Periodontitis For Better Dental Health

Comparison of Diagnostic Accuracy of Cone Beam Computed Tomography(CBCT) and Digital Radiography Measurements as an Aid in the Placements of Dental Implants: A Retrospective Study

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Abstract: Cone beam computed tomography (CBCT) has gained wide popularity among dentists. This can be attributed to its ability to provide bone morphology, bone dimension details and vital structure locations by producing cross-sectional images along the arches. However, one of the reasons routine usage is hampered is its high cost. It would be a great benefit to the practice of dental implants if there was a more economical alternative. Anatomic landmarks in both the maxilla and the mandible are important to be considered during implant placement, and if overlooked, may lead to failures and complications and this is where Cone beam computed tomography (CBCT) has a slight edge over its other diagnostic counterparts. However, newer digital radiographs have been found to be economical and fairly accurate in line with the highly sophisticated CT scans. Therefore, this study aimed to compare and assess the diagnostic accuracy of CBCT and digital radiography (vistascan) in the placement of implants, which may provide an aid in terms of providing an accurate implant size during the surgical procedure for successful dental implant placement. Data was collected from CBCT and vistascan image measurements made pre-operatively prior to implant placement. The measurements were then compared using certain anatomical landmarks as reference in the maxillary and mandibular arches and additionally, with the actual size of implant placed post-operatively. Statistical analysis using SPSS V22 and paired 't' tests and ANOVA revealed no significant differences in the measurements between both the images. ($P>0.05$). Additionally, both the image measurements were very close to the actual size of the implant placed. Since both imaging techniques were similar in terms of accuracy for implant placement, use of digital radiography (vistascan) may be encouraged as a cost effective option as against CBCT which is expensive for routine assessment.

Keywords: Dental implants, Implant surgical procedure, Diagnostic accuracy, Digital radiography, Cone beam computer scan.

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Recieved On **15 May, 2021**
Revised On **12 July, 2021**
Accepted On **17 July, 2021**
Published On **29 July, 2021**

Funding This research did not receive any specific grant from any funding agencies in the public, commercial or not for profit sectors.

Citation Dr.Shreya Shetty, Dr. Jana Ahmad Alwaznah, Jumana Thaer Abdou, Llojun Khaled Algohani, Renad Hassan Otiaf and Ms Khammarunissa Shaikh. , Comparison of Diagnostic Accuracy of Cone Beam Computed Tomography(CBCT) and Digital Radiography Measurements as an Aid in the Placements of Dental Implants: A Retrospective Study.(2021).Int. J. Life Sci. Pharma Res.11(4), P68-74 http://dx.doi.org/10.22376/ijpbs/lpr.2021.11.3.P68-74

1. INTRODUCTION

Currently, the placements of oral implants are performed as a routine treatment in rehabilitation of partially or fully edentulous jaws. Owing to the significantly high demand and growing popularity and high success rate, dental implants are most often the preferred treatment choice for tooth replacement. However, the challenges involved may complicate the procedure and the treatment outcome. The surgical procedural challenges may be overcome to a considerable extent by a suitable diagnostic technique. Therefore, the need of an accurate diagnostic technique which is also economical, to ensure proper placement of the implants, is the need of the hour. [1] One of the important aspects to be considered during treatment planning of implants is the anatomic landmarks in the area, such as, maxillary sinus posteriorly, the floor of the nose anteriorly in the maxilla and the inferior alveolar nerve in the mandible. The most common cause of complications occurring after implant treatment is due to inaccurate or improper placement of implant, especially violation or lack of consideration of these landmarks. Misaligned or inappropriately placed implants affect their success and predictability. For this reason, careful assessment of crucial anatomic landmarks play an essential role during treatment planning [2] and this is where the advanced imaging techniques, such as digital radiography came into play. Digital imaging techniques are mainly used for pre-implant assessment, evaluating the normal anatomical structures, detecting any pathology in surrounding areas, and estimating the quality and quantity of bone where the implants are supposed to be placed[3]. Depending on the site of implant placement, the anatomical structures in and around them is considered the crucial factor for selecting the implants to be placed and preventing complications. [4] With the presence of a more reliable diagnostic technique such as digital radiography and cone beam computed tomography (CBCT), dental implants have become more integrated in the majority of dental treatments involving missing teeth.[5] A study conducted by Do¨ lekog˘lu et al about the usage of digital radiography and CBCT among Turkish dentists, suggested a number of reasons why dentists prefer the use of digital radiography over other imaging modalities, such as short performance time and the ease to store images. 30% dentists referred patients for CBCT, of which 40% of them were for implant planning. [6] This suggests that the referral for CBCT diagnostic method for implant planning was fairly high and could definitely be avoided if a more economical alternative could be used. If a diagnostic imaging technique is able to fulfill these criteria nearly as much as the CBCT, then it is worth considering. Moreover, there are also reports of an important aspect of the amount of radiation dosage that the patients are subjected to, which also merits consideration.[7]The aim of the study was therefore, to compare the diagnostic accuracy of cone beam computed tomography (CBCT) and digital radiography measurements in the placement of implants and thereby evaluate and analyze their diagnostic accuracy which will aid in the surgical procedure for successful and ideal placement of the dental implant.

2. MATERIALS AND METHODS

The present retrospective study was carried out at the dental clinics of Ibn Sina national college for medical studies, Jeddah, KSA during the time period between December 2019 and March 2020 following the approval of the Institutional ethical committee with approval number H -13-13082020. All patients who underwent implant placement were included and the periapical radiographs using vistascan digital imaging and CBCT scans taken preoperatively and during implant placement were evaluated.

2.1 Radiographic examination

The Vistascan system (Durr Dental VistaSoft 2.3 version) was used to obtain the digital periapical radiographs and CBCT scans were procured from the various dental diagnostic centers in the city (CDsee, sirona, etc). Other data relevant to the study was obtained from the patient's medical and dental records. Pre and post-operative radiographs of a total of 50 patients, which included 28 males and 22 females ages ranging from 24 to 60 years, were selected according to the inclusion criteria, i.e., presence of a partially edentulous area whether it was bounded saddle or free end saddle in the maxillary or mandibular area, healthy periodontal tissues and controlled systemic disease, if present. Radiographic images of poor or deficient quality or where the entire root could not be visualized were excluded and thus radiographic images of 43 bounded and 44 free saddle sites were used for the following measurements on both the vistascan image(figure A) and CBCT image(figure B) of each patient by four examiners

1. adjacent tooth length(next to edentulous site)
2. alveolar crest to apex along the adjacent tooth,
3. length of edentulous span, and
4. the vertical distance from alveolar crest using adjacent root as a reference (Proposed implant length) (blue arrow in figure B)
5. Distance from the crest to anatomical landmarks.*

All the measurements were made by each of the four examiners, and an average of the measurements for each image was taken. *In critical areas, important landmarks such as the mandibular canal/mental foramen in lower arch and floor of nose /maxillary sinus in upper arch were considered when measuring images from both Vistascan and CBCT. It should be noted that the figures A and B have been shown as an example of how the measurements have been made, as they were digitally obtained directly from the software. Additionally, measurements 3 and 5 were not included in the statistical analysis as they were not measured in all the cases, and hence, their numbers were too less to be analyzed.

Fig A: PA image using vistascan system showing measurements

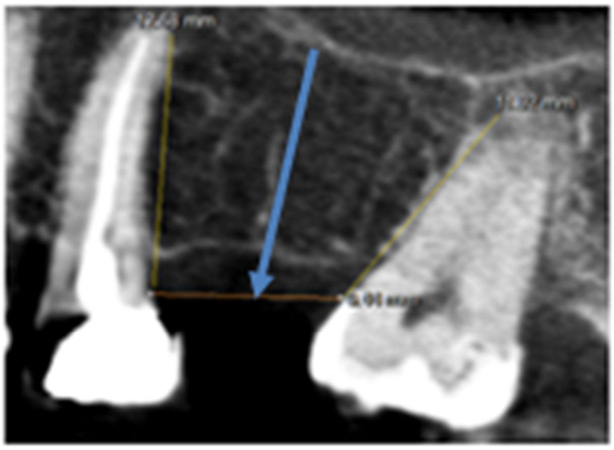

Fig B: CBCT image using sirona system showing measurements

3. STATISTICAL ANALYSIS

The collected data were tabulated and statistically analyzed using SPSSV22 software. Comparison between 2 individual groups of measurements were done by independent "t"tests, where "P" values of less than 0.05 were considered significant. For multiple comparisons, ANOVA followed by post hoc tests was used to compare the measurements between the various groups.

4. RESULTS

The collected data were divided into 2 groups-(TABLE 1)
Group 1: Bounded edentulous span (bounded saddle) (n=43)
Group 2: Free edentulous span (free end saddle) (n=44).
The following measurements with vistascan and CBCT images of the implant sites in both the groups were made: From the alveolar crest to the root apex of adjacent tooth (used as reference); proposed implant length and actual implant length placed. The mean values of the measurements from alveolar crest to the root apex of adjacent tooth were 12.7419 + 02.51323(group 1) and 13.448+2.15199(group 2) respectively. With regard to vertical distance from alveolar crest using adjacent root as reference (proposed implant length), the mean values were 12.2267+2.45028(group1) and 12.9102+2.11975(group2) respectively. The mean values of the implant size placed were 11.0233+1.33610(group 1) and 11.0000+1.32945(group 2) respectively. Independent 't' tests to test the equality of means in the groups revealed no significant difference between the groups($p>0.05$) when comparing the above measurements(Table 2). ANOVA tests revealed significant results when comparisons were made between and within groups ($P<0.05$) for the alveolar crest to root apex measurements and proposed implant length measurements. ($P<0.05$)(TABLE 3). Group 1&2 were further sub grouped based on the placement of 1or 2 implants being placed in the edentulous span. Hence, post-hoc Tukey HSD analysis included 4 groups – subgroup 1A &B(referred to as 1&2 in table 4), and subgroup 2A&B(referred to as 3&4 in table 4). The comparison relevant to our study was meant to be between subgroup 1&3 and subgroup 2&4 and the tests showed no significance between the said groups($p>0.05$)(table 4).

Table1: Group Statistics

Combined measurements		N	Mean	Std. Deviation	Std. Error Mean
Alveolar crest to apex- along the root	1.00	43	12.7419	2.51323	.38326
	2.00	44	13.4480	2.15199	.32442
Vertical distance from alveolar crest using adjacent root as reference – (proposed implant length)*	1.00	43	12.2267	2.45028	.37366
	2.00	44	12.9102	2.11975	.31956
Implant size placed	1.00	43	11.0233	1.33610	.20375
	2.00	44	11.0000	1.32945	.20042

Table 2:Independent Samples Test

Independent Samples Test

		Equality of Variances		t-test for Equality of Means					Interval of the	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Alveolar crest to apex- along the root	Equal variances assumed	.783	.379	-1.409	85	.163	-.70609	.50124	-1.70269	.29050
	Equal variances not assumed			-1.406	82.420	.163	-.70609	.50214	-1.70493	.29274
Vertical distance from alveolar crest using adjacent root as reference – (proposed implant length)*	Equal variances assumed	1.247	.267	-1.392	85	.167	-.68348	.49085	-1.65943	.29247
	Equal variances not assumed			-1.390	82.696	.168	-.68348	.49168	-1.66146	.29449
Implant size placed	Equal variances assumed	.000	.996	.081	85	.935	.02326	.28579	-.54497	.59148
	Equal variances not assumed			.081	84.932	.935	.02326	.28580	-.54501	.59152

Table 3: Anova

		Sum of Squares	df	Mean Square	F	Sig.
Alveolar crest to apex- along the root	Between Groups	48.911	3	16.304	3.174	.028
	Within Groups	426.351	83	5.137		
	Total	475.262	86			
Vertical distance from alveolar crest using adjacent root as reference – (proposed implant length)*	Between Groups	49.206	3	16.402	3.350	.023
	Within Groups	406.328	83	4.896		
	Total	455.535	86			
Implant size placed	Between Groups	.418	3	.139	.077	.972
	Within Groups	150.570	83	1.814		
	Total	150.989	86			

Table 4: Post Hoc test - Multiple comparisons Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Alveolar crest to apex- along the root	1.00	2.00	1.64931	.71505	.105	-.2255	3.5241
		3.00	-.46587	.61131	.871	-2.0687	1.1369
		4.00	.56118	.71505	.861	-1.3136	2.4359
	2.00	1.00	-1.64931	.71505	.105	-3.5241	.2255

		3.00	-2.11518*	.71028	.020	-3.9774	-.2529
		4.00	-1.08813	.80131	.529	-3.1890	1.0128
	3.00	1.00	.46587	.61131	.871	-1.1369	2.0687
		2.00	2.11518*	.71028	.020	.2529	3.9774
		4.00	1.02705	.71028	.475	-.8352	2.8893
	4.00	1.00	-.56118	.71505	.861	-2.4359	1.3136
		2.00	1.08813	.80131	.529	-1.0128	3.1890
		3.00	-1.02705	.71028	.475	-2.8893	.8352
Vertical distance from alveolar crest using adjacent root as reference – (proposed implant length)*	1.00	2.00	1.90394*	.69806	.038	.0737	3.7341
		3.00	-.15981	.59679	.993	-1.7245	1.4049
		4.00	.34831	.69806	.959	-1.4819	2.1785
	2.00	1.00	-1.90394*	.69806	.038	-3.7341	-.0737
		3.00	-2.06375*	.69340	.020	-3.8818	-.2457
		4.00	-1.55563	.78227	.201	-3.6066	.4954
	3.00	1.00	.15981	.59679	.993	-1.4049	1.7245
		2.00	2.06375*	.69340	.020	.2457	3.8818
		4.00	.50812	.69340	.884	-1.3099	2.3261
	4.00	1.00	-.34831	.69806	.959	-2.1785	1.4819
		2.00	1.55563	.78227	.201	-.4954	3.6066
		3.00	-.50812	.69340	.884	-2.3261	1.3099
Implant size placed	1.00	2.00	.03704	.42494	1.000	-1.0771	1.1512
		3.00	-.03439	.36329	1.000	-.9869	.9181
		4.00	.16204	.42494	.981	-.9521	1.2762
	2.00	1.00	-.03704	.42494	1.000	-1.1512	1.0771
		3.00	-.07143	.42210	.998	-1.1781	1.0353
		4.00	.12500	.47620	.994	-1.1235	1.3735
	3.00	1.00	.03439	.36329	1.000	-.9181	.9869
		2.00	.07143	.42210	.998	-1.0353	1.1781
		4.00	.19643	.42210	.966	-.9103	1.3031
	4.00	1.00	-.16204	.42494	.981	-1.2762	.9521
		2.00	-.12500	.47620	.994	-1.3735	1.1235
		3.00	-.19643	.42210	.966	-1.3031	.9103

** The mean difference is significant at the 0.05 level.*

5. DISCUSSION

The search for a suitable diagnostic method prior to implant placement which is economical, ensures accurate placement and consequently affects the long term success of implant therapy; is still elusive. Digital radiography has come a long way in dentistry and the newer variants show a lot of promise in terms of diagnostic accuracy and reliability. Cone beam tomography (CBCT) has been a sure shot and a reliable guide prior to implant placement for a while now but the only drawback is its high cost and lack of affordability for a wide group of patients. The most important aspect prior to selection of suitable implant is the available bone height and width which consequently translates to selection of the right implant size. Although CBCT is the most foolproof way to achieve this, vistascan (digital radiography system) has shown promising results so far, as evidenced with endodontic procedures. [8-14] However, there is limited evidence available with regard to viability and feasibility of digital radiography(vistascan) in dental implantology.[1,2] The present study therefore attempted to explore the idea of possibly using digital radiographs(vistascan) instead of the sophisticated CBCT as a more economic option to assess the implant site and proceed to select the appropriate implant size by comparing the measurements made by both the imaging techniques and analyzing their accuracy. Like the CBCT, vistascan also uses software to make measurements on the radiographic image which enables the clinician to get the required information prior to or during the procedure. In order to confirm this, the study analyzed retrospectively obtained data from patients who already had implants placed in the past year. Measurements using fixed landmarks which were used as reference points were made in both the vistascan images and CBCT images and comparisons of these measurements were found to be statistically not significant thereby indicating that in terms of accuracy both the images were nearly the same as also evidenced by some researchers.[15] When the measurements were assessed to compare with the actual size of the implant placed, it was again observed that both the images were nearly accurate in predicting the amount of available space for implant placement. Although the statistical tests revealed otherwise, as they compare the means; when the individual site measurements were compared, the CBCT images were much more accurate in predicting the correct size of implant to be used than their digital counterparts, especially in terms of the width of the implant. This was naturally expected since the CBCT provided images and subsequently, measurements in 3-dimensions as against the digital 2-dimensional radiographs. However this drawback of the vistascan can be overcome by combining the radiography technique with intraoral clinical bone mapping.[16] This option can be considered if CBCT may not be possible under certain circumstances. Another significant advantage of digital radiographs is the reduced radiation dosage when compared to the CBCT. Although CBCT is considered a low dose radiological method[17], the effective dose of CBCT is several to hundreds of times higher compared with conventional dental radiography[18]. Literature has shown that there is evidence of harmful effects of radiation from CBCT among pediatric patients[19]; similar effects cannot be ruled out in adults and therefore their indiscriminate use should be avoided. Our study revealed that the CBCT measurements came closer in terms of selection of actual implant size, which is fairly consistent with the data found in literature, [14,15,20,21]. However, comparisons of the measurements by the 2 images were not statistically significant thereby suggesting that in terms of accuracy for implant selection, measurements obtained by both techniques were nearly the same.

5.1 *Limitations*

Some of the limitations of our study included lack of consideration of the variability of vertical and horizontal magnification factors as well the positioning of periapical radiographs and the lack of standardization of the different CBCT imaging software, as the patients were referred to various diagnostic centers across the city. Additionally, the amount of radiation dosage exposure in both the techniques could not be compared.

6. CONCLUSION

With implant therapy becoming hugely popular, it is not always affordable for a clinician to acquire a CBCT scan under many circumstances, and with the need for implant placement being more demanding, it may be suggested to opt for a more economic option of digital radiography especially in developing countries or in a population comprising of lower socioeconomic strata, as our study shows not much difference in their measurements when predicting implant size. Therefore, based on the preliminary results of our pilot study, digital radiographs such as vistascan may be recommended as an alternative to CBCT for implant screening.

7. AUTHOR CONTRIBUTION STATEMENT

Dr Shreya Shetty, the corresponding author conceptualized the study, outlined the study design, conducted the literature review and approved the final draft of the manuscript. Dr Jana Alwazna, Dr Llojun Algohani, Dr Renad Otaif and Dr Jumana Abdou were mainly responsible for the data collection, interpretation and preparation of the initial draft of the manuscript. Ms. Khammarunissa Shaikh performed the statistical analysis for the study and contributed to the results of the study. All the authors read and approved the final version of the manuscript.

8. CONFLICT OF INTEREST

Conflict of interest declared none.

9. REFERENCES

1. Qassadi W, Alshehri T, Alshehri A. Review on dental implantology. Egypt J Hosp Med. 2018;71(1):2217-25. doi: 10.12816/0045293.
2. Yilmaz B, Ozcelik BT, Sarantopoulos DM, McGlumphy E. Importance of CT scans in diagnosing symptoms from misplaced implants. Implant Dent. 2012;21(2):108-11. doi: 10.1097/ID.0b013e31824bff1f, PMID 22391861.
3. Loubele M, Van Assche N, Carpentier K, Maes F, Jacobs R, van Steenberghe D, Suetens P. Comparative localized linear accuracy of small-field cone-beam CT and multislice CT for alveolar bone measurements. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105(4):512-8. doi: 10.1016/j.tripleo.2007.05.004, PMID 17900939.
4. Coppenrath E, Draenert F, Lechel U, Veit R, Meindl T, Reiser M, Mueller-Lisse U. Cross-sectional imaging in dent maxillofacial diagnostics: Dose comparison of dental MSCT and NewTom 9000 DVT. RöFo. 2008;180(5):396-401. doi: 10.1055/s-2008-1027142, PMID 18543414.
5. Pye AD, Lockhart DE, Dawson MP, Murray CA, Smith AJ. A review of dental implants and infection. J Hosp Infect. 2009;72(2):104-10. doi: 10.1016/j.jhin.2009.02.010, PMID 19329223.
6. Dölekoğlu S, Fişekçioğlu E, İlgüy M, İlgüy D. The usage of digital radiography and cone beam computed tomography among Turkish dentists. Dento Maxillo Facial Rad. 2011;40(6):379-84. doi: 10.1259/dmfr/27837552, PMID 21831978.
7. Chau AC, Fung K. Comparison of radiation dose for implant imaging using conventional spiral tomography, computed tomography, and cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(4):559-65. doi: 10.1016/j.tripleo.2008.11.009, PMID 19168378.
8. Ramis-Alario A, Tarazona-Alvarez B, Cervera-Ballester J, Soto-Peñaloza D, Peñarrocha-Diago M, Peñarrocha-Oltra D, Peñarrocha-Diago MA. Comparison of diagnostic accuracy between periapical and panoramic radiographs and cone beam computed tomography in measuring the periapical area of teeth scheduled for periapical surgery. A cross-sectional study. J Clin Exp Dent. 2019;11(8):e732-8. doi: 10.4317/jced.55986, PMID 31598202.
9. Weber MT, Stratz N, Fleiner J, Schulze D, Hannig C. Possibilities and limits of imaging endodontic structures with CBCT. Swiss Dent J. 2015;125(3):293-311. PMID 26168687.
10. Vizzotto MB, Silveira PF, Arús NA, Montagner F, Gomes BP, da Silveira HECBCT for the assessment of second mesiobuccal (MB2) canals in maxillary molar teeth: effect of voxel size and presence of root filling. Int Endod J. 2013;46(9):870-6. doi: 10.1111/iej.12075, PMID 23442087.
11. Patel S, Wilson R, Dawood A, Foschi F, Mannocci F. The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography - Part 2: a 1-year post-treatment follow-up. Int Endod J. 2012;45(8):711-23. doi: 10.1111/j.1365-2591.2012.02076.x, PMID 22775142.
12. Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. J Endod. 2007;33(1):1-6. doi: 10.1016/j.joen.2006.08.013, PMID 17185117.
13. Jorge ÉG, Tanomaru-Filho M, Guerreiro-Tanomaru JM, Reis JM, Spin-Neto R, Gonçalves M. Periapical repair following endodontic surgery: two- and three-dimensional imaging evaluation methods. Braz Dent J.

2015;26(1):69-74. doi: 10.1590/0103-6440201300252, PMID 25672388.

14. Abella F, Patel S, Durán-Sindreu F, Mercadé M, Bueno R, Roig M. An evaluation of the periapical status of teeth with necrotic pulps using periapical radiography and cone-beam computed tomography. Int Endod J. 2014;47(4):387-96. doi: 10.1111/iej.12159, PMID 23889592.
15. Bornstein MM, Bingisser AC, Reichart PA, Sendi P, Bosshardt DD, von Arx T. Comparison between Radiographic (2-dimensional and 3-dimensional) and Histologic Findings of Periapical Lesions Treated with Apical Surgery. J Endod. 2015;41(6):804-11. doi: 10.1016/j.joen.2015.01.015, PMID 25863407.
16. Sunil, Mishra, Pankaj. P. Hazari & Mahajan, harsh & Mishra. 2019. A Review of Various Techniques and Studies for Bone Mapping in Oral Implant Placement;9:73-83.
17. Ludlow JB, Timothy R, Walker C, Hunter R, Benavides E, Samuelson DB, Scheske MJ. Effective dose of dental CBCT-a meta-analysis of published data and additional data for nine CBCT units. Dento Maxillo Fac Radiol. 2015;44(1). doi: 10.1259/dmfr.20140197, PMID 20140197. (PMC Free article). Google Scholar.
18. Farman AG. ALARA still applies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100(4):395-7. doi: 10.1016/j.tripleo.2005.05.055, PMID 16182157, Google Scholar.
19. American Academy of Oral and Maxillofacial Radiology. Clinical recommendations regarding use of cone beam computed tomography in orthodontics. [corrected]. Position statement by the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;116(2):238-57. doi: 10.1016/j.oooo.2013.06.002, PMID 23849378, Google Scholar.
20. Sogur E, Baksi BG, Gröndahl HG, Lomcali G, Sen BH. Detectability of chemically induced periapical lesions by limited cone beam computed tomography, intra-oral digital and conventional film radiography. Dento Maxillo Facial Radiol. 2009;38(7):458-64. doi: 10.1259/dmfr/15206149, PMID 19767516.
21. Liang YH, Jiang L, Gao XJ, Shemesh H, Wesselink PR, Wu MK. Detection and measurement of artificial periapical lesions by cone- beam computed tomography. Int Endod J. 2014;47(4):332-8. doi: 10.1111/iej.12148, PMID 23815501.