Evaluation of the risk of inferior alveolar nerve injury during an implant procedure: A comparative study between OPG and CBCT

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Background and objectives: Dental implants are considered as one of the major options for replacement of missing teeth and this surgical procedure may be accompanied by trauma to the adjacent vital structure when there is inadequate information of the implant site. The use of OPG as a preliminary diagnostic instead of CBCT may expose the patient to a high risk of trauma to an inferior alveolar canal. To evaluate the possibility of the risk of endangering inferior alveolar nerve during implant placement using OPG or CBCT as a preoperative assessment tool.

Patients and methods: This study is a prospective cross-sectional study carried out in outpatient clinic of the college of dentistry and Denta Plus private center in Erbil city during the period from 1st of January to 31st of August, 2018. A sample of 49 patients was selected according to special criteria: Group I consists of 33 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Orthopantomogram (OPG). Group II; consists of 16 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Cone beam computed tomography (CBCT). The measurement of the distance between a dental implant and inferior alveolar canal were analyzed by CBCT which classified into four levels of parameters (distances) a-Safety zone ≥2 mm, b-Risky zone 1-2 mm, c-Error and high risk >0-1 mm, d-Traumatized ≤0 mm.

Results: the distance between implant and inferior alveolar canal (IAC) for group I (OPG) patients were as following: - in the safety zone for 30.3%, in the risky zone for 15.2%, in error & high risk for 21.2% and traumatized for 33.3%, while this distance for group II (CBCT) patients was in the safety zone for 75%, in the risky zone for 6.3%, in error & high risk for 12.5% and traumatized for 6.3%.

Conclusion: Cone beam computed tomography is the best choice compared to OPG in the pre-implant evaluation and planning for placement as it showed a lower risk of injury to an inferior alveolar canal.

Keywords: Dental implant, cone beam computed tomography, orthopantomogram.

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Introduction

The dental implants now a day represented the common way in replacing missed teeth. The success of a dental implant is depending on restoring both the function and aesthetic of missing teeth that demands thorough pre-implant planning. Evaluating the morphology of bone considered one of the main tasks to determine the quality, quantity, topography and adjacent anatomical structures at the implant site.[1] Assessment of dental implant includes history, physical

examination, and imaging. The orthopantomogram (OPG) can be considered as the most popular imaging technique used for pre-implant radiographic evaluation.[2]

The cone beam computed tomography (CBCT) is an advanced imaging modality replaced high cost, heavy and radiation exposure risk related to conventional computerized tomography (CT) scans. Indeed, the dental implant images of CBCT were more precise than CT scan images. Dental implant evaluation requires multiple cross-sectional images of CBCT, which are currently accessible, easily handled, and low radiation risk, compared to CT. The American Association of oral and maxillofacial radiology supported the use of CBCT in planning for a dental implant.[3]

The shortcoming of OPG comes from its two-dimensional property that gives less information. It is unable to display buccolingual sides of objects in relations to the inferior alveolar canal. The other point is improper sharpness of displaying structures outside the center of rotation of radiology source.[4]

The main advantage of applying CBCT in the dental implant is to provide three-dimensional views that help the examiner to have a better inspection of surrounding hard tissues. It is facilitating the accuracy of views and clarifying the anatomical conflicts.[5]

For the dental implant field, the CBCT is very useful for the preoperative surgical plan, postoperative assessment and for long-term follow up assessment. Pre-operatively, it helps in detecting the morphology and relevant directions, local anatomic and pathological configurations of the residual alveolar ridge. Post-operatively it assists in the better evaluation of complications resulting from the dental implant.[6-8] One of the serious complications of improper dental implant placement is the injury to anatomical structures like inferior alveolar nerve and adjacent teeth or perforation of the maxillary sinus.[9-12]

Proper placing of a dental implant in the jaw bone is achieved by appropriate pre-implant planning including assessment of anatomical structures.[1] In Kurdistan region, most of the implantologists are depending only on (OPG) as an assessment tool which may increase the risk of improper placement and different injuries. The aim of the study was to evaluate the possibility of the risk of endangering inferior alveolar nerve during implant placement using OPG or CBCT as a preoperative assessment tool.

Patients and Methods

This study is a prospective cross-sectional study carried out in the outpatient clinic of the college of dentistry and Denta Plus private center in Erbil city during the period from 1st of January to 31st of August, 2018. A sample of 49 patients was selected and divided into two groups: Group I: consists of 33 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Orthopantomogram (OPG). Group II: consists of 16 patients who had implant in molar and premolar regions, in this group pre-implant assessment done by Cone beam computed tomography (CBCT).

Inclusion criteria include patients aged 18 years or older with mandibular premolar and molar implant who were assessed preoperatively by CBCT and OPG. Exclusion criteria include patients with a history of surgical intervention (trauma, fracture, cystic lesion, lateralization of inferior alveolar nerve, mental nerve).

Ethical approval was obtained from the Ethical Committee of the College of Dentistry and written informed consent was taken from selected patients.

The data was collected by the researcher from recorded preoperative CBCT and OPG. The measurement of distances between the dental implant and inferior alveolar canal were analyzed by CBCT by two specialist radiologists. The measurements performed using coronal and sagittal views of CBCT images and the mean of both measurements were taken in this study for all parameters.

Measurement of the distance of dental implant to the inferior alveolar canal: The NNT software for linear measurements was used to evaluate the distance between the implant and inferior alveolar canal in both sagittal and coronal views and by measuring the closest points between the implant and inferior alveolar canal. The

distance of implant to inferior alveolar canal classified into four levels of parameters depending on anatomic limitation to implant placement[13]: a-Safety zones ≥2 mm, b-Risky zone 1-2 mm, c-Error and high risk >0-1 mm, d-Traumatized ≤0 mm (either with contact, inside or cross the canal) (Figures 1 and 2).

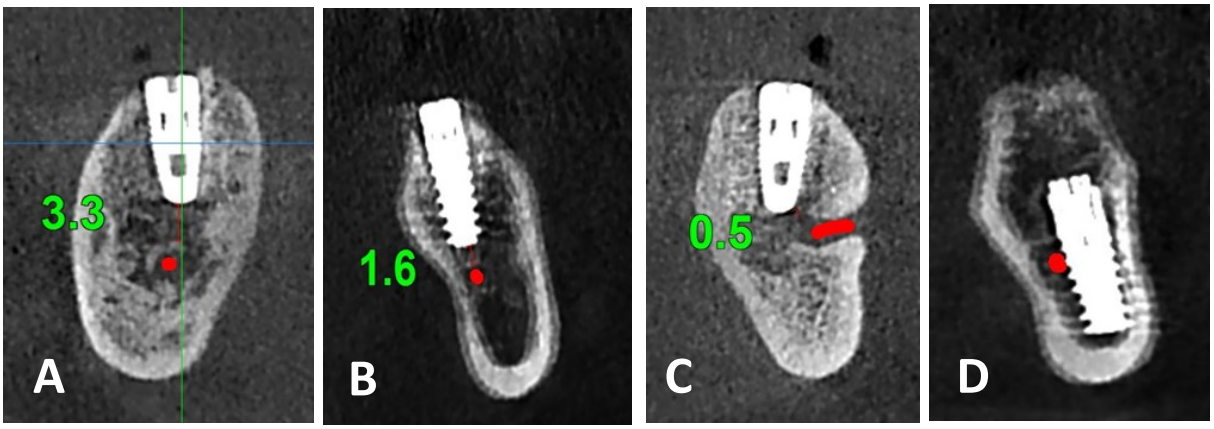

Figure 1: Distance of implants to the inferior alveolar canal (IAC) in the cross-sectional coronal view, A-Safety zones ≥2 mm, B-Risky zone 1-2 mm, C-Error and high risk >0-1 mm, D-Traumatized ≤0 mm.

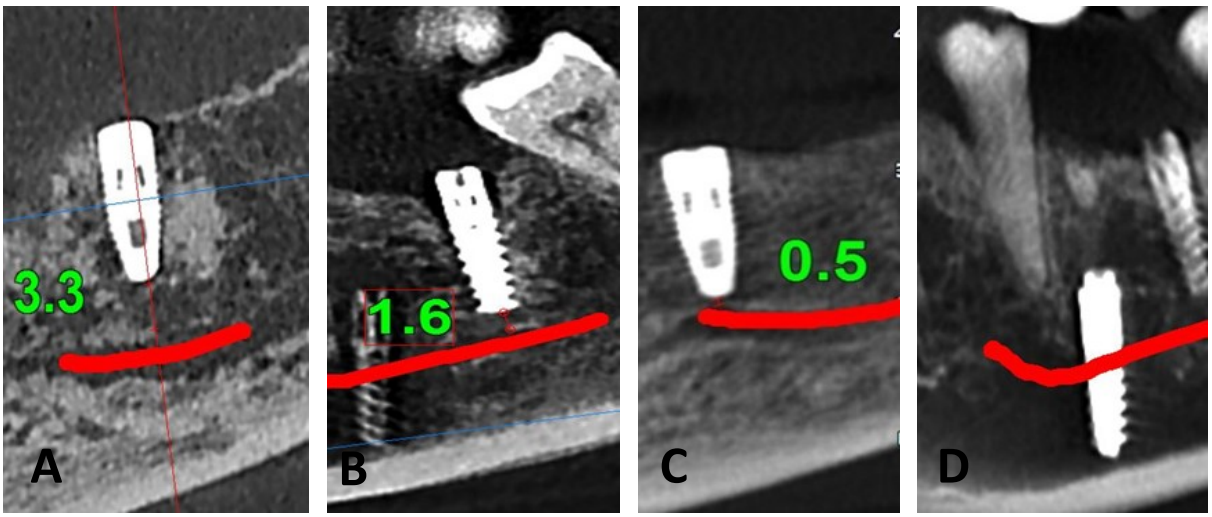

Figure 2: Distance of implants to the inferior alveolar canal (IAC) in the cross-sectional sagittal view, A-Safety zones ≥2 mm, B-Risky zone 1-2 mm, C-Error and high risk >0-1 mm, D-Traumatized ≤0 mm.

The measurement of the distance between the implant and the inferior alveolar canal was done according to the following views:

Coronal view: the measurement done by measuring the shortest distance of implants to the inferior alveolar canal (IAC) in the cross-sectional coronal view (CSCV) in mm and this measurement was done by finding the shortest distance between the implant and IAC from different measurements from different points (buccal, center, lingual) and choosing the shortest distance (Figure 3A). This reading illustrates the position and relation of the dental implants (DI) to the vital tissues in the vertical and buccolingual dimensions and any possibilities of injury.

Sagittal view: the measurement done by measuring the shortest distance of implants to the inferior alveolar canal (IAC) in the cross-sectional sagittal view (CSSV) in mm and this measurement was done by finding the shortest distance between the implant and IAC from different measurements from different points (mesial, center, distal) and choosing the shortest distance (Figure 3B). This reading illustrates the position and relation of the dental implants (DI) to the vital tissues in the vertical dimension and any possibilities of injury.

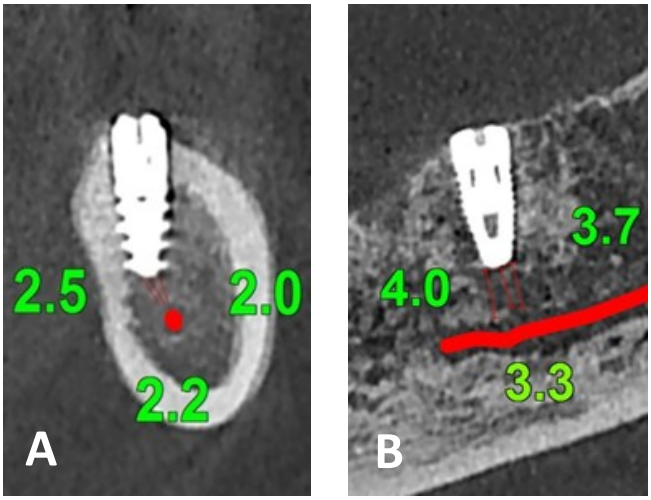

Figure 3: measurement the distance of the implant to the inferior alveolar canal in different points and choosing the shortest distance. (A) Cross sectional coronal view, and (B) Cross sectional sagittal view.

CBCT device: Cone Beam CT Newtom, model: Giano FOV: 8 * 11 cm Made in Italy (Software NNT 9.0 version). Workstation (DELL: core I 7, ram 16, hard 2 Terabyte Made in the USA. Dicom Printer: Codex and Car stream Made in USA and X-ray viewer also Made in the USA in addition to anti-noise program and Voxial size 0.3.

Statistical analysis was carried out with SPSS software version 22. On analysis, the Chi-square test and Fischer's exact test were used for categorical variables and independent sample t-test was used for continuous variables. $p \leq 0.05$ was considered statistically significant.

Results

Mean age of group I patients was 59.6 years and mean age of group II patients was 58.1 years old. Males represented 54.5% of patients in group I while males represented 37.5% of group II. No significant differences were observed between patients of study groups regarding their age and gender (Table 1).

Implant in the right side was present in

Table 1: Distribution of demographic characteristics according to study groups

Variable	Pre-OPG (group I)		Pre-CBCT (group II)		P value
	No.	%	No.	%	
Age					0.3* NS
<40 years	0	0	1	6.3	
40-49 years	5	15.2	4	25.0	
50-59 years	9	27.3	4	25.0	
≥60 years	19	57.6	7	43.8	
Total	33	100.0	16	100.0	
Mean±SD (years)	59.6±8.4		58.1±6.5		0.5** NS
Gender					0.2* NS
Male	18	54.5	6	37.5	
Female	15	45.5	10	62.5	
Total	33	100.0	16	100.0	

54.5% of group I patients, while the right side implant represented 43.8% of group II patients. In both groups the first molar site for implant placement showed higher percentage in comparison to other sites of implant placement of study groups, it is shown in group I as 45.5% while in group II as 50%. No significant differences were observed between patients of study groups regarding sides and sites of implants (Table 2).

The distribution of distance of implant to IAC according to study groups are shown in table 4 and figure 2 which shows that the distance between implant and IAC for group I patients were as following: in a safety zone for 30.3%, b- risky zone for 15.2%, c- error & high risk for 21.2%, d- traumatized for 33.3%, while this distance for group II patients were as following a- safety zone for 75%, b- risky zone for 6.3%, c- error & high risk for 12.5%, d- traumatized for only one patient. There was a significant difference between group I patients and group II patients in all zones for the distance between the implant and IAC (P=0.02) as shown in table 3.

Table 2: Distribution of implant characteristics according to study groups.

Variable	Pre-OPG (group I)		Pre-CBCT (group II)		P value
	No.	%	No.	%	
Side of implant					
Right	18	54.5	7	43.8	0.4* NS
Left	15	45.5	9	56.3	
Total	33	100.0	16	100.0	
Site of implant					
Second premolar	9	27.3	2	12.5	0.4** NS
First molar	15	45.5	8	50.0	
Second molar	9	27.3	6	37.5	
Total	33	100.0	16	100.0	

Table 3: Showed the analysis of data for distances between the dental implant and inferior alveolar canal in both groups of study.

Distance groups	Pre-OPG (group I)		Pre-CBCT (group II)		P value
	No.	%	No.	%	
Safety zone	10	30.3	12	75.0	0.02*S
Risky zone	5	15.2	1	6.3	
Error and high risk	7	21.2	2	12.5	
Traumatized	11	33.3	1	6.3	
Total	33	100.0	16	100.0	

**** Fishers exact test, S=Significant.***

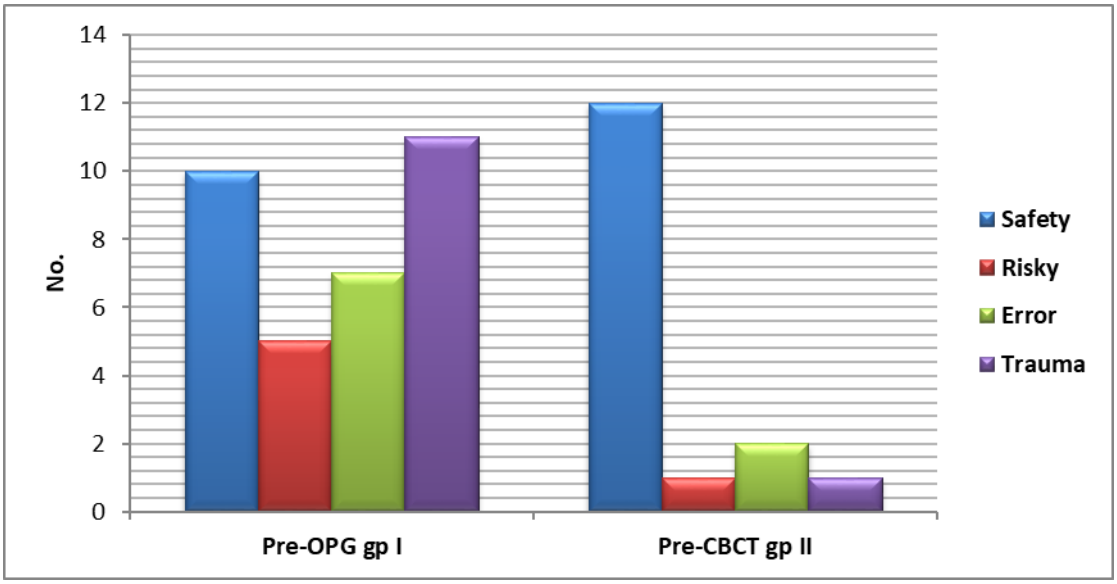

Figure 2: Distribution of different distance zones of an implant to IAC according to both groups of study.

Discussion

The results of this study indicated that the placement of dental implant in lower premolar and molar region showed high risk of trauma to IAC which was about 33.3% of patients evaluated with OPG while in CBCT group patient showed less risk to trauma which was about 6.3% and this result especially for OPG group were higher than that result which reported by Sahota et al[14] they showed in this study 22% risk of trauma in OPG group and 5% in CBCT group patient. Our study agrees with the results of de Mello et al[15] study which proved that CBCT is more accurate in the placement of dental implant than other imaging modalities. This study showed that the postoperative IAC trauma percentage in patients evaluated preoperatively with CBCT was 6.3% which was higher than trauma proportion of 3% detected by Angelopoulos et al[16] and Sahota et al[14] as 5%, this higher percentage of trauma by CBCT in our study was attributed to surgical procedure error in an attempt to bypass IAC cause trauma to the canal.

During oral surgery, the inferior alveolar nerve is the most common nerve exposed to injuries (64.4%), followed by the lingual nerve (28.8%).[17] Hillerup et al reported that the main risk factors for inferior alveolar nerve injury were 3rd molar surgery, injection of local anesthesia, endodontic treatment and dental implant surgery.[18]

The result of this study disagree with what conducted recently by Shahidi et al [19] as they revealed that OPG can be used safely in the pre-surgical phase of dental implant placement in posterior alveolus of the mandible, especially in routine and simple cases and this is due to limitation of OPG in providing the required for placement of dental implant and its correct relation to the inferior alveolar canal which can be more clarified by using CBCT as shown by Mirbeigi et al[20] in this study observed that CBCT was a most accurate diagnostic tool for assessment of inferior alveolar canal. Kamrun et al[21] study revealed that OPG is still the most widely used radiographs for evaluation of dental implant surgery as these techniques are accompanied by low cost, easily obtainable and with low radiation exposure compared to CT scan. Vazquez et al[22] study suggested that panoramic radiographs in conjunction with periapical radiographs are satisfactorily for the bone volume assessment in anatomical important regions such as the molar region, where the presence of inferior alveolar nerve makes implant placement challenges, and all of these studies are inconsistent with our study findings.

Dental implant becoming the treatment of choice for edentulous patients, especially with an appropriate preoperative CBCT planning which provided high-resolution images, enhancing the ability to recognize

the anatomical structures and accurate implant placement in comparison to other radiographic diagnostic techniques.[14]

From the result of this study indicated that the use of CBCT in pre-implant planning and evaluating the anatomical structure can provide the require information for a surgeon for proper assessment and evaluating the risk of trauma to any adjacent vital structure in comparing to other modality of imaging which available nowadays.

Conclusion

Cone beam computed tomography (CBCT) using for pre-implant evaluation provide more accurate information and de-crease the risk of trauma to an adjacent vital structure. Orthopantomogram (OPG) showed less accurate information than CBCT and showed a high risk of trauma if used as a preliminary diagnostic tool for implant placement.

Conflict of interest

The authors reported no conflict of interest.

References

1. Saavedra-Abril JA, Balhen-Martin C, Zaragoza-Velasco K, Kimura-Hayama, ET, Saavedra S, Stoopen ME. Dental multisection CT for the placement of oral implants: technique and applications. Radiographics 2010; 30(7):1975–91.
2. Tyndall DA, Price JB, Tetradis S, Ganz SD, Hildebolt C, Scarfe WC. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol 2012; 113(6):817–26.
3. Gupta J, Ali SP. Cone beam computed tomography in oral implants. National Journal Maxillofacial Surgery 2013; 4:2–6.
4. Kanazirska PG, Jordanov GY, Angelova IA, Bakardjiev AG. Comparison of diagnostic capabilities of Orthopantomography and Cone beam computed tomography in determining the topographic relationship between impacted mandibular third molars and mandibular channel. JIMAB 2017; 23(2):1546–9.
5. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc 2006; 72:75–80.
6. Madhav VNV. Cone beam computed tomography in implantology. Ind J Dent Sci 2011; 3:10–5.
7. Kumar V, Satheesh K. Applications of cone beam computed tomography (Cbct) in implant treatment planning. JSM Dentistry 2013; 1:1008.
8. Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R. Cone beam computed tomography in implant dentistry: A systematic review focusing on guidelines, indications, and radiation dose risks. Int J Oral Maxillofac Implants 2014; (29 Suppl):55–77.
9. Libersa P, Savignat M, Tonnel A. Neurosensory disturbances of the inferior alveolar nerve: A retrospective study of complaints in a 10-Year period. J Oral Maxillofac Surg 2007; 65:1486–9.
10. Hegedus F, Diecidue RJ. Trigeminal nerve injuries after mandibular implant placement – practical knowledge for clinicians. Int J Oral Maxillofac Implants 2006; 21:111–6.
11. Tay AB, Zuniga JR. Clinical characteristics of trigeminal nerve injury referrals to a university centre. Int J Oral Maxillofac Surg 2007; 36:922–7.
12. Renton T, Yilmaz Z. Profiling of patients presenting with post-traumatic neuropathy of the trigeminal nerve. J Orofac Pain 2011; 25: 333–4.
13. Prasad DK, Shetty M, Mehra DR. Anatomical considerations in implant selection and positioning. Int J Oral Implantol Clin Res 2013; 4 (1):24–9.
14. Sahota J, Bhatia A, Gupta M, Singh, V, Soni J, Soni R. Reliability of Orthopantomography and Conebeam Computed Tomography in Presurgical Implant Planning: A Clinical Study. J Contemp Dent Pract 2017; 18(8):1–5.
15. Pedroso LA, Garcia RR, Leles JL, Leles CR, Silva MA. Impact of cone-beam computed tomography on implant planning and on predic-tion of implant size. Braz Oral Res 2014; 28:46–53.
16. Angelopoulos C, Thomas SL, Hechler S, Parissis N, Hlavacek M. Comparison between digital panoramic radiography and cone-beam computed tomography for the identification of the mandibular canal as part of presurgical dental implant assessment. J Oral Maxillofac Surg 2008; 66(10):2130–5.
17. Tay AB, Zuniga JR. Clinical characteristics of trigeminal nerve injury referrals to a university

centre. Int J Oral Maxillofac Surg 2007; 36:922–7.
18. Hillerup S. Iatrogenic injury to the inferior alveolar nerve: Etiology, signs and symptoms, and observations on recovery. Int J Oral Maxillofac Surg 2008; 37:704–9.
19. Shahidi S, Zamiri B, Abolvardi M, Akhlaghian M, Paknahad M. Comparison of Dental Panoramic Radiography and CBCT for Measuring Vertical Bone Height in Different Horizontal Locations of Posterior Mandibular Alveolar Process. Journal of dentistry (Shiraz, Iran) 2018; 19 (2):83–91.
20. Mirbeigi S, Kazemipoor M, Khojastepour L. Evaluation of the Course of the Inferior Alveolar Canal: The First CBCT Study in an Iranian Population. Polish journal of radiology 2016; 81, 338–41.
21. Kamrun N, Tetsumura A, Nomura Y, Yamaguchi S, Baba O, Nakamura S, et al. Visualization of the superior and inferior borders of the mandibular canal: A comparative study using digital panoramic radiographs and cross-sectional computed tomography images. Oral Surg Oral Med Oral Pathol Oral Radiol 2013; 115:550–7.
22. Vazquez L, Saulacic N, Belser UP, Bernard J. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res 2008; 19(1): 81–5.