http://jurnal.pdgi.or.id/index.php/jrdi/index

Bone height and width evaluation before dental implant placement on panoramic radiographs: a scoping review

Shely Levita Asmarani[1*], Azhari[2], Farina Pramanik[2]

ABSTRACT

Objectives: The aim of this study is to evaluate the bone height and its width on panoramic radiography prior to dental implant placement.

Review: This study was carried out using scoping review methods. The referenced articles were published between 2010-2021 in English or Indonesian. The search was performed using PubMed and PMC database with keywords "(((Evaluation) AND (Presurgical)) AND (Dental Implant)) AND (Radiograph)) AND (Panoramic)" and Science Direct with keywords "presurgical evaluation dental implant in panoramic radiograph". Preferred Reporting Items for Systematic Review and Meta-analysis Scoping Review (PRISMA-Scr) was utilized to perform the article finding process. It is found that the height of alveolar bone after being assessed by panoramic radiograph is between 7.95-23.42 mm while the alveolar bone width is between 7.04-10.41 mm.

Conclusion: Panoramic radiograph can be performed to evaluate bone height and width before the dental implant placement procedure.

INTRODUCTION

Tooth loss is a common problem, interfering with aesthetic, mastication, speech, and social relations.[1] According to the 2010 RISKESDAS (*Riset Kesehatan Nasional*) report, tooth loss index in Indonesia is around 79,6%, while the 2013 report states that the national prevalence rate of dental and oral diseases is around 25,9%. Tooth loss (nationally) in ages 35-44 years reaches 0,4%, increasing at the age of 65 years and over to 17,6%.[2]

Recent popular treatment for tooth loss is dental implant, by implanting dental protheses into the jawbone.[3] Implant treatment is an alternative for tooth loss which can overcome various limitation problems of conventional dentures.[4] Implant treatment in Indonesia is widely used among the elderly, the group of people who are vulnerable to tooth loss.[5]

Radiographs are very important in evaluating the bone and determining the exact height and width of the alveolar ridge prior to implantation.[6] An assessment of the available alveolar bone morphology is needed in planning implant treatment, as it can determine the success and failure of treatment.[7,8] Panoramic radiographs is a standard examination tool in planning implant placement by providing information about the shape of the jaw, maxillary sinus floor and nasal cavity floor positions, and assessing vertical bone availability.[9] Panoramic radiographs are commonly used by dentists because of the wide coverage (32,5%), the cost (11.25%), which combines to 6,25%, as well as providing information about maxillary sinus floor and nasal flor positions, pathological conditions, and assessing vertical bone availability.[7,9,10] Barunawaty et al. did a survey and conducted that out of 18 implant practitioners in Jakarta, 44,44% use periapical radiographs, 94,44% use panoramic radiographs, and 38,89% use combination of both in implant treatment.[4]

Alveolar bone quality and quantity are parameters that affect the success of implant treatment. Good bone support is required for getting bone integration from the implant.[11] Treatment success can be seen from pre-placement evaluation.[12] The principle of placing an implant in the maxilla is 1 mm lower than maxillary and nasal sinus floors, avoiding the incisor canal, and for mandibular implants is 5 mm anterior to the mental foramen, 2 mm above mandibular canal, 3 mm from nearby implants, and 1,5 mm from nearby tooth root.[13]

Studies about the use of panoramic radiographs for bone height and width evaluation prior to dental implant placement has been found in the last 10 years, but not one with scoping review level study design that discusses this subject. This study

[1]Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia 40132

[2]Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia 40132

*Correspondence to:
Shely Levita Asmarani
✉ shely17001@mail.unpad.ac.id

aimed to evaluate bone height and width on panoramic radiographs prior to dental implant placement.

REVIEW

This is a qualitative-descriptive study with scoping review as the method. The frameworks are to identify research questions, identify relevant studies, select study articles as a whole, map data, compile, summarize, report results, and consult.[14,15] Inclusion criteria for the samples are full-text articles discussing the analysis before implant placement using panoramic radiography techniques, articles in English or Indonesian, and published within 2010-2021. Articles were retrieved from PubMed and PMC with Boolean operators, using keywords "((Evaluation) AND (Presurgical)) AND (Dental Implant)) AND (Radiograph) AND (Panoramic))". Articles were also retrieved from Science Direct using keywords: presurgical evaluation dental implant in panoramic radiograph.

Data collection from the articles was carried out by using Preferred Reporting Items for Systematic Review and Meta-analysis Scoping Review (PRISMA-ScR). The instruments used were laptop, internet, software Microsoft, and search engines (PubMed, Science Direct, and PMC). This study was conducted from January – March 2021. Research topics were determined through questions using PICO: population (patients with dental implant treatment), intervention (panoramic radiographs), comparison (none in this study), and outcome (radiograph evaluation results). Data analysis was carried out with the principle of thematic analysis: identifying and analyzing themes or problems from various studies then putting out a conclusion. The collected data will be presented in the form of tables and narratives. The table consists of the author's name and year of publication, article title, type of study design, author's location, number and type of participants, age, type of panoramic radiography machine, measurement method, installation location, research results.
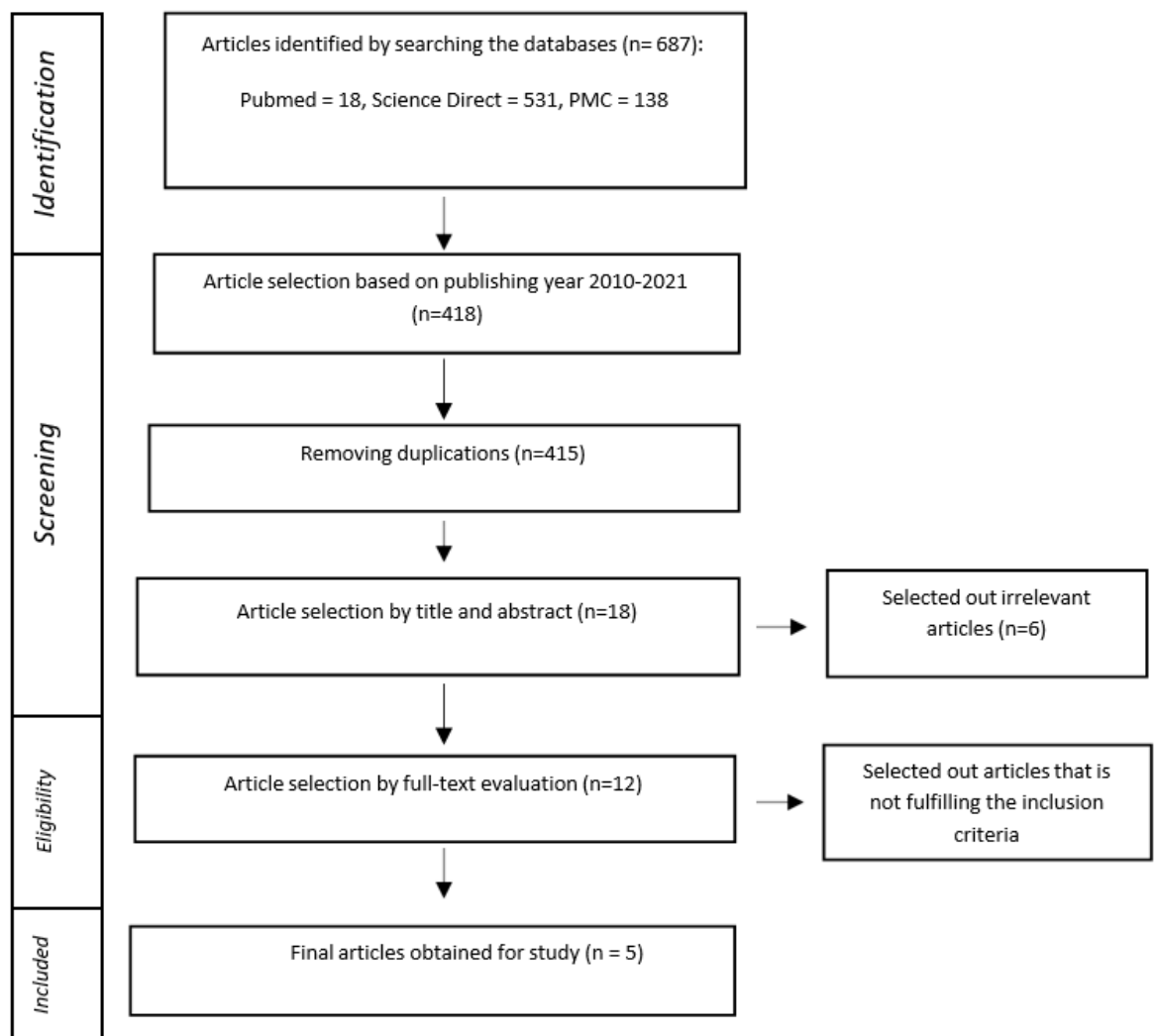

Figure 1. Study Selection According to PRISMA-ScR

SEARCH AND SELECTION OF STUDIES

The search using keywords and selection from search engines via three databases (PubMed, Science Direct, and PMC) result in total 687 articles, consisting of 18 articles from PubMed, 531 articles from Science Direct, and 138 articles from PMC. Articles were then filtered based on the publishing year (2010-2021), leaving 418 articles. Those articles were filtered again by selecting out duplicate articles, leaving 415 articles. The third filtration was done based on the title and abstract, leaving 18 articles. The last filtration was done by examining through the entire content of each article, and that resulted in 5 articles that were obtained as samples in this study. The flow chart of the search results and study selection in this study can be seen in Figure 1.

STUDY CHARACTERISTICS

Table 1 shows the characteristics of the studies used in the articles covered. Five articles included use retrospective study design. The level of evidence assessment found that the articles used were at level 2. Each of these research articles was conducted in a different country; 2 articles were conducted in India, 1 article in Germany, 1 article in Turkey, and 1 article in South Korea.

Table 2 shows the characteristics of the participants. Participants for panoramic radiographic examination before dental implants were mostly male, with the number of 79, 33, 14, 50, and 71, 54, 13, 35 women. There is 1 article with an average participants' age of 44.5 years, 1 article with participants in ages from 19-60 years, and 1 article with an average participants' age of 54.7±12.5

Table 1. Characteristics of the Studies

Author	Year of Publication	Title	Study Design	Country	Scopus Quartile
Patel et al.[16]	2020	Presurgical assessment of alveolar ridge dimensions before dental implant procedures OPG & CBCT – A comparative study based on Fryback & thornbury model	Retrospective	India	Q4
Fortes et al.[17]	2018	Influence of 2D vs 3D imaging and professional experience on dental implant treatment planning	Retrospective	Germany	Q1
Athota et al.[18]	2017	A comparative study of digital radiography, panoramic radiography and computed tomography in dental procedures	Retrospective	India	Q4
Apaydin et al.[19]	2018	Accuracy of digital panoramic radiographs on the vertical measurements of dental implants	Retrospective	Turkey	Q4
Kim et al.[20]	2011	Magnification rate of digital panoramic radiographs and its effectiveness for pre-operative assessment of dental implants	Retrospective	South Korea	Q1

Table 2. Characteristics of the Participants

	Characteristics of Participants	Articles
Sex (M/F)	79/71 participants	1
	33/54 participants	1
	14/13 participants	1
	50/36 participants	1
	N/A	1
Age	19-60 years old	1
	20-69 years old (mean: 44,5 years old)	1
	54,7 +/- 12,5 years old	1
	N/A	1
	N/A	1
Systemic disease conditions	N/A	5
Bad habits	N/A	5
Involvement of other abnormalities	N/A	5

Table 3. Characteristics of the Panoramic Radiographic Study

Machine Type	kV	mA	Time
Paxl3D Smart (Vatech Co. Ltd., Hwaseong-si, Gyeonggi-do, Korea)	74 kVp	12 mA	10 seconds
Vatech PaxX – 400 C (Vatech Global, Gangnam Gu, Korea)	-	-	-
Planmeca Proline EC Panoramic	-	-	-
Orthopantomograph OP200D (Instrumentarium, Tuusula, Finland)	66 kV	10 mA	16 seconds
Orthopantomograph OP100	-	-	-

years. There were no systemic disease conditions, bad habits, and involvement of other abnormalities that occurred in these participants. There is 1 article that does not mention the characteristics of participants.

Table 3 shows the characteristics of the panoramic radiographic study. One article uses a Paxl3D Smart (Vatech Co Ltd) panoramic engine (74kVp/12 mA) with a time of 10 seconds, one article uses a Vatech PaxX – 400 C engine, one article uses a Planmeca Proline EC Panoramic engine, one article uses a 66 kV/10 panoramic engine mA with a time of 16 seconds, and one article using the Orthopantomograph OP100 machine. There are 3 articles that do not mention the type of machine used, the range of tube voltage (kV), tube current (mA), andexposure time.

Table 4 shows the study characteristics of evaluating bone height and width on panoramic radiographs before dental implant placement in the articles covered. There is 1 article with 94 participants having 150 installation locations consisting of anterior maxilla, anterior mandible, posterior maxilla, and posterior mandible, and mentions the availability of bone in the anterior maxilla with a height of 11.47 mm and a width of 7.04 mm, in the anterior mandible with the width of 8.15 mm and height of 7.95 mm, in the maxillary posterior with the width of 5.37 mm and the height of 14.15 mm, and in the mandibular posterior 10.41 mm wide and 13.75 mm high. One article with 87 participants had 228 insertion sites, namely on the lower jaw consisting of 43 premolars, 70 molars, 8 canines, 1 incisor and on the maxilla consisting of 38 premolars, 29 molars, 12 canines, and 27 incisors, with a height of 10.8 mm and 10.0 mm wide. One article with 20 participants had 27 locations on mandibular molars, with bone height availability at 46: 22.47 mm, 16.02 mm, 23.42 mm, 20.95 mm, 20.49 mm, 17.43 mm, 21.51 mm, 13.98 mm, 17.38 mm, 18.95 mm, 17.61 mm, and 18.19 mm; on tooth number 47 consisting of 22.29 mm, 19.48 mm, 17.95 mm, 16.66 mm, and 16.72 mm; on tooth number 36 consisting of 18.3 mm, 22.71 mm, 20.87 mm, 13.66 mm, 22.27 mm, 20.16 mm, and 22.95 mm; and on tooth number 37 consisting of 20.25 mm, 19.91 mm, and 19.09 mm. One article with 88 participants had insertion sites consisting of 53 at the anterior, 69 premolars, and 118 molars, citing the availability of bone with a height of 10.9 mm. One article with 86 participants had placement on the maxilla consisting of 70 molars, 45 premolars, 24 at the anterior, and on the mandible consisting of 55 molars, 14 premolars, and 13 at the anterior, with a bone height of 11.26 mm. No bone density is mentioned in all included articles.

DISCUSSION

This study aims to determine the evaluation of bone height and weight on panoramic radiographs prior to dental implant placement, which is important in seeing locations with good primary stability, thus will determine the success of implant treatment.[11] According to the final result of the articles analysis, the available alveolar bone height for dental implants varies greatly. Argosurio's research concluded that the ideal height should be around 12-14 mm. There is no study that states the ideal alveolar bone length for dental implants.[16] The ideal alveolar bone height for dental implant placement concluded from this study is 7,95 – 14,15 mm.[17–20] Athota et al.[21] concluded that the ideal alveolar bone height for implant placement is 13,66 – 23,42 mm. Articles analysis in this study concluded that the ideal alveolar bone width for dental implant placement is in the range of 7,04 - 10,41 mm.[17,18]

Dau et al[22], Sahota et al[23], and Vazquez et al[9] mentioned that implant placement are more common in the posterior mandible. These included articles[17,18,21] are also in line with the statement. The majority of implants were found in men, with the number of 176 out of 350 participants.[17,18,20,21] The number of male participants was also higher in both studies of Ozalp et al[24] (53%), and Pertl et al[25] (60%).

Panoramic radiographs can be used to evaluate bone height prior to dental implant placement, especially in the mandible posterior. The ideal alveolar bone height for implant placement in the mandible is at least 2mm above the mandibular canal.[13,17,19,20] This is in accordance with Kyung et al[26], Ozalp et al[24], and Christos et al[27], that panoramic radiography is safe enough to see bone height in planning for mandibular implants within 2 mm of the mandibular canal.

The anatomy must be considered for there are nerves, maxillary sinuses, nasal floor, and other anatomical structures located in the area where the

Table 4. Characteristics of Bone Height and Width Evaluation on Panoramic Radiographs Before Dental Implant Placement

Number of Participants	Location of Implant Placement	Relation with Closest Anatomy	Bone Availability			Density
			Locations	Width	Height	
94	150 locations: 24 anterior maxilla 16 anterior mandible 30 posterior maxilla 80 posterior mandible	Mandibular canal	Anterior maxilla Anterior mandible Posterior maxilla Posterior mandible	7,04 mm 8,15 mm 5,37 mm 10,41 mm	11,47 mm 7,95 mm 14,15 mm 13,75 mm	N/A
87	228 locations: Mandible 43 premolar 70 molar 8 canine 1 incisor Maxilla 38 premolar 29 molar 12 canine 27 incisor	N/A	Mandibular premo-lar	10 mm	10,8 mm	N/A
20	27 locations (mandibular molar)	Superior border of the inferior alveolar canal to the crest of the alveolar bone	46 tooth	N/A	22,47 mm 16,02 mm 23,42 mm 20,95 mm 20,49 mm 17,43 mm 21,51 mm 13,98 mm 17,38 mm 18,95 mm 17,61 mm 18,19 mm	N/A
			47 tooth		22,29 mm 19,48 mm 17,95 mm 16,66 mm 16,72 mm	
			36 tooth		18,3 mm 22,71 mm 20,87 mm 13,66 mm 22,27 mm 20,16 mm 22,95 mm	
			37 tooth		20,25 mm 19,91 mm 19,09 mm	
88	240 locations: 53 anterior 69 premolar 118 molar	N/A	Posterior maxilla	N/A	10,9 mm	N/A
86	Maxilla: 70 molar 45 premolar 24 anterior Mandible: 55 molar 14 premolar 13 anterior	N/A	Posterior mandible	N/A	11,26 mm	N/A

implant is placed. Implant placement in maxilla should be 1 mm lower than the base of the maxillary and nasal sinuses. The incisive canal should be avoided because placing the implant in direct contact with the incisive canal can lead to complications and failure of implant treatment.[28] Dental implants in the mandible should be placed at least 2mm above the mandibular canal and 5 mm anterior of the foramen mental. The mandibular canal is traversed by the inferior alveolar nerve and blood vessels consisting of the inferior alveolar vein and artery, making it necessary to determine its location to prevent complications with surrounding tissues.[13,29]

Vertical measurements on panoramic radiographs depends on the shape of the alveolar bone's slope which can lead to an incorrect interpretation of the length. Patient's position adjustment is done to prevent distortion of the panoramic radiograph.[18,20,21] Panoramic radiograph can cause distortion horizontally and enlargement vertically. Several studies have concluded that panoramic radiography is quite safe in determining bone height, while others say that inaccuracies can lead to complications, such as nerve injury and sinus perforation.[24,30]

The limitation of this study is having only one type of study design, which is retrospective study. Article search was limited, due to some articles not including the evaluation of alveolar bone height and width before dental implant placement.

CONCLUSION

This study shows that panoramic radiography can be used to evaluate alveolar bone height and width prior to dental implant placements. Bone height and width determination is needed to increase treatment success.

ACKNOWLEDGMENTS

None.

FOOTNOTES

All authors have no potential conflict of interest to declare for this article.

REFERENCES

1. Siagian KV. Kehilangan sebagian gigi pada rongga mulut. Jurnal e-CliniC. 2016;4(1):1-6.
2. Mangkat Y, Wowor VNS, Mayulu N. Pola Kehilangan Gigi Pada Masyarakat Desa Roong Kecamatan Tondano Barat Minahasa Induk. Jurnal e-GIGI. 2015;3(2):508-14.
3. Yunus B. Optimalisasi radiografi gigi konvensional untuk membantu pemasangan implan gigi. J Dentomaxillofacial Sci. 2009;8(1):11-7.
4. Yunus B. Dental Implant Criteria Before And After Placement With Panoramic Radiography. Dentika Dent J. 2010;15(1):24–46.
5. Ananda N, Sulistyani LD, Bachtiar EW. Pertimbangan Penggunaan Implan Gigi pada Lansia. Insisiva Dent J Maj Kedokt Gigi Insisiva. 2017;6(1):47–55.
6. Raymond HW, Zwiebel WJ, Schwartz JD. 25th year of publication of Seminars in Ultrasound, CT and MRI. Semin Ultrasound CT MR. 2004;25(1):1.
7. Vazquez L, Saulacic N, Belser U, Bernard JP. 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.
8. Ribeiro-Rotta RF, Lindh C, Pereira AC, Rohlin M. Ambiguity in bone tissue characteristics as presented in studies on dental implant planning and placement: A systematic review. Clin Oral Implants Res. 2011;22(8):789–801.
9. Vazquez L, Nizamaldin Y, Combescure C, Nedir R, Bischof M, Dohan Ehrenfest DM, et al. Accuracy of vertical height measurements on direct digital panoramic radiographs using posterior mandibular implants and metal balls as reference objects. Dentomaxillofacial Radiol. 2013;42(2):20110429.
10. Majid I, Mukith ur Rahaman S, Sowbhagya M, Alikutty F, Kumar H. Radiographic prescription trends in dental implant site. J Dent Implant. 2014;4(2):140-3.
11. Göçmen G, Özkan Y. Maxillary Sinus Augmentation for Dental Implants. In (Ed.), Paranasal Sinuses. London: IntechOpen; 2017.
12. Papaspyridakos P, Chen CJ, Singh M, Weber HP, Gallucci GO. Success criteria in implant dentistry: A systematic review. J Dent Res. 2012;91(3):242–8.
13. Observations I, History P. Section III Preoperative General Assessment and Treatment Planning. J Oral Maxillofac Surg. 2017;75(2):10–4.
14. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. Int J Soc Res Methodol Theory Pract. 2005;8(1):19–32.
15. Sucharew H, Macaluso M. Methods for research evidence synthesis: The scoping review approach. J Hosp Med. 2019;14(7):416–8.
16. Argosurio YN. Penatalaksanaan Implan Gigi pada Penderita Diabetes Melitus Tipe 2 (Studi Pustaka). Skripsi. FKG—USAKTI; 2014. p.8–45.
17. Patel P, Shah J, Dudhia B, Butala P. Presurgical assessment of alveolar ridge dimensions before dental implant procedures by OPG&CBCT – A comparative study based on fryback & thornbury model. J Indian Acad Oral Med Radiol. 2020;32(3):229-34.
18. Fortes JH, de Oliveira-Santos C, Matsumoto W, da Motta RJG, Tirapelli C. Influence of 2D vs 3D imaging and professional experience on dental implant treatment planning. Clin Oral Investig. 2019;23(2):929–36.
19. Apaydin BK, Yasar F, Kizildağ A, Tasdemir OU. Accuracy of digital panoramic radiographs on the vertical measurements of dental implants. Cumhur Dent J. 2018;21(3):209–15.
20. Kim YK, Park JY, Kim SG, Kim JS, Kim JD. Magnification rate of digital panoramic radiographs and its effectiveness for pre-operative assessment of dental implants. Dentomaxillofacial Radiol. 2011;40(2):76–83.
21. Athota A, Gandhi Babu D, Nagalaxmi V, Raghoji S, Waghray S, Reddy C. A comparative study of digital radiography, panoramic radiography, and computed tomography in dental implant procedures. J Indian Acad Oral Med Radiol. 2017;29(2):106-10.
22. Dau M, Edalatpour A, Schulze R, Al-Nawas B, Alshihri A, Kämmerer PW. Presurgical evaluation of bony implant sites using panoramic radiography and cone beam computed tomography-influence of medical education. Dentomaxillofac Radiol. 2017;46(2):20160081.
23. Sahota J, Bhatia A, Gupta M, Singh V, Soni J, Soni R. Reliability of Orthopantomography and Cone-beam Computed Tomography in Presurgical Implant Planning: A Clinical Study. J Contemp Dent Pract. 2017;18(8):665–9.
24. Özalp Ö, Tezerişener HA, Kocabalkan B, Büyükkaplan UŞ, Özarslan MM, Şimşek Kaya G, et al. Comparing the precision of panoramic radiography and cone-beam computed tomography in avoiding anatomical structures critical to dental implant surgery: A retrospective study. Imaging Sci Dent. 2018;48(4):269–75.
25. Pertl L, Gashi-Cenkoglu B, Reichmann J, Jakse N, Pertl C. Preoperative assessment of the mandibular canal in implant surgery: comparison of rotational panoramic radiography (OPG), computed tomography (CT) and cone beam computed tomography (CBCT) for preoperative assessment in implant surgery. Eur J Oral Implantol. 2013;6(1):73–80.
26. Hu KS, Choi DY, Lee WJ, Kim HJ, Jung UW, Kim S. Reliability of two different presurgical preparation methods for implant dentistry based on panoramic radiography and cone-beam computed tomography in cadavers. J Periodontal Implant Sci. 2012 Apr;42(2):39-44.
27. Angelopoulos C, Thomas S, 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.
28. Waasdorp J. Enucleation of the incisive canal for implant placement: A comprehensive literature review and case report. J Oral Implantol. 2016;42(2):180–3.
29. Castro MA, Lagravere-Vich MO, Amaral TM, Abreu MH, Mesquita RA. Classifications of mandibular canal branching: A review of literature. World J Radiol. 2015 Dec 28;7(12):531-7.
30. Bagchi P, Joshi N. Role of Radiographic Evaluation in Treatment Planning for Dental Implants: A Review. J Dent Allied Sci. 2012;1(1):21-5.