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EFFICIENCY OF ORTHOPANTOMOGRAM AND CONE BEAM COMPUTED TOMOGRAPHY WHEN PLANNING IMPLANTS IN ANTERIOR MANDIBLE

ЕФИКАСНОСТА НА ОРТОПАНТОМОГРАМ И КОНУСНО ЗРАЧНА КОМПЈУТЕРИЗИРАНА ТОМОГРАФИЈА ПРИ ПЛАНИРАЊЕ ИМПЛАНТИ ВО АНТЕРИОРНА МАНДИБУЛА

Dovolani T., Velichkovski B., Dimitrovski O.

[1]University "Ss. Cyril and Methodius" - Faculty of dentistry - Skopje, [2]Private dental clinic: Nova Dental Group - Skopje, Republic of North Macedonia

Abstract

Background: The success of dental implants relies on efficiently realised treatment plan. The treatment plan is impossible without radiographic evaluation of the region planned for implant placement. **Aim:** To investigate the efficiency of cone beam computed tomography (CBCT) versus orthopantomogram, when planning implants in anterior mandible. **Materials and methods:** The participants in the study had absence of at least one tooth in the anterior mandible region. Each participant was scanned with orthopantomogram and CBCT method. Using orthopantomogram on the regions planned for dental implants, the alveolar ridge height was measured, while the alveolar ridge height and width was measured using CBCT method. Thereby, the results obtained from the two methods were compared. **Results:** Using the CBCT method, the highest mean value for vertical dimension of the alveolar ridge resulted in the left canine region (3.3): 15.33 mm. ± 3.32, and the lowest mean value resulted in the left lateral incisor region (3.2): 14.11 mm. ± 4.04. While using orthopantomogram method, the highest mean value for vertical dimension of the alveolar ridge resulted in left canine region (3.3): 15.69 mm. ± 3.68, and the lowest mean value resulted in the left lateral incisor region (3.2): 14.29 mm. ± 3.69. Thereby, the difference was not significant. Using the CBCT method, the highest mean value for horizontal dimension of alveolar ridge resulted in the right canine region (4.3): 9.52 mm. ± 1.53, and the lowest mean value resulted in the left lateral incisor region (3.2): 9.14 mm. ± 1.58. **Conclusion:** The orthopantomogram is a reliable method for determining the bone height, in the regions planned for implant placement. The CBCT method is a priority method when planning implants, because it enables measuring not only the bone height, but also the bone width. **Keywords:** Dental implants, orthopantomogram, cone beam computed tomography, anterior mandible.

Апстракт

Вовед: Успехот со дентални импланти зависи од ефикасно изведен план на третман. Планот на третман е невозможен без радиографска евалуација на регијата планирана за импланти. **Цел:** Испитување на ефикаситетот на конусно зрачна компјутеризирана томографија (КЗКТ) спроти ортопантомограмот, при планирање импланти во антериорна мандибула. **Материјал и метод:** Испитаниците вклучени во студијата, имаа отсуство на најмалку еден заб во регија на антериорна мандибула. Секој испитаник се снимаше со ортопантомограм метод и метод на КЗКТ. Со користење на ортопантомограм, кај регии планирани за импланти се одредуваше висината на гребен, додека со метод на КЗКТ се одредуваше висината на гребен и ширината на гребен. Притоа се споредуваа резултатите добиени преку двете методи. **Резултати:** При користење на метод на КЗКТ, најголемата средна вредност за вертикална димензија на гребен, резултира во регија на лев канин (3.3): 15.33 mm. ± 3.32, а најмала средна вредност во регија на лев латерален инцизив (3.2): 14.11 mm. ± 4.04. При користење на ортопантомограм, најголемата средна вредност за висина на гребен резултира во регија на лев канин (3.3): 15.69 mm. ± 3.68, а најмала средна вредност во регија на лев латерален инцизив (3.2): 14.29 mm. ± 3.69. При што разликата не беше значајна. Најголема средна вредност за хоризонтална димензија на гребен, резултира во регија на десен канин (4.3): 9.52 mm. ± 1.53, а најмала средна вредност во регија на лев латерален инцизив (3.2): 9.14 mm. ± 1.58. **Заклучок:** Ортопантомограмот е сигурен метод за одредување на висина на гребен, во регии планирани за импланти. Методот на КЗКТ е приоритетен метод при планирање импланти, бидејќи овозможува одредување на висина на гребен и на ширина на гребен. **Клучни зборови:** Детални импланти, ортопантомограм, конусно зрачна компјутеризирана томографија, антериорна мандибула.

Introduction

The therapy for partial and total edentulism, still presents a challenge for the dental discipline. The treatment options for partial and total edentulism are the classical prosthesis and the implant retained prosthesis[1]. The implant retained prosthesis are more efficient option for the treatment of partial and total edentulism compared with the classical prosthesis, because they protect the natural teeth from invasive prosthetic procedures, and also they reduce the bone tissue resorption process[2]. The bigest challenge even from the implantation procedure, is the dental implant treatment plan, whose goal is the placement of implants in the most optimal number, dimension and position[3]. The dental implant treatment plan is formulated based on the information gathered from the anamnesis, clinical examination and radiographic evaluation[4]. Radiographic evaluation for planning of the implantation procedure, is performed with the use of different radiographic modalities, which have undergone development paralleling the technological development of implantation techniques and implant designs. Till the 1990-is the two-dimensional orthopantomogram method was accepted as a standard method during planning of an implantation procedure[3]. In the latter years, as a radiographic method of choice for implant planning, is recommended the three-dimensional method of cone beam computed tomography (CBCT). Through this method are obtained number of images that is cross sections, in vertical, antero-posterior and horizontal plan of the maxillofacial region[5]. Dental implants are produced in different diameters and lengths, so the diameter varies from 3 to 7 mm., and the length varies from 6 to 18 mm.[6]. Key positions for the placement of implants, are the end retainers for the prosthetic suprastructure, and the jaw regions with reduced biomechanical forces that are damaging for the implant and the surrounding bone[7]. When planning implants in edentulous regions, the height of the residual alveolar ridge, determined through radiographic methods, presents the distance from the crestal part of the alveolar ridge to the neighbouring anatomical structure,while the width of the residual alveolar process presents the distance from the buccal side of the alveolar ridge to the lingual side of alveolar ridge[8]. Radiographic evaluation in the regions planned for implant placement, plays a crucial role in identification and analysis of anatomical-sceletal relationship of important neighbouring anatomical structures. Respectively in the mandibular jaw, the focus is directed on these structures: canalis nervus alveolaris inferior, anterior loop of canalis nervus alveolaris inferior, foramen mentalis, and mandibular incisive canal[2]. The mandibular incisive canal is characterised with anatomical variations in the aspect of number, location and dimensions of the neurovascular bundle. Thereby injuring this anatomical structure should be avoided during implantation procedure in the anterior mandible region[9]. According to some authors, orthopantomogram is an efficient method for implant planning, but according to other authors this method can lead to falsely chosen implants' length. The CBCT method improves the ability for planning of implants` length[10]. Orthopantomogram as a two-dimensional method, does not offer information about the width of the alveolar ridge, and does not allow choosing the appropriate diameter of implants[11]. The CBCT method as a three-dimensional method offers detailed information on the anatomical variations and pathologies, that orthopantomogram cannot offer, and in this way increasing the precision during the planning of the implantation procedure[12].

Aim

The aim of this study was investigation of the efficiency of the CBCT method and orthopantomogram when planning implants in the anterior mandible.

Material and methods

I individuals from both genders (men and women) with over 18 years of age were included in the study. Every individual had absence of at least one tooth in the anterior mandibular region, and absence of absolute contraindications for dental implants placement. Each participant in the study underwent an orthopantomogram scanning and CBCT scanning. The device "Rotograph Prime 3D" was used to perform the scanning, in the private dental clinic "Nova Dental Group" in Skopje. The device used electricity from 2 mA-12 mA, and voltage from 60 kV-86 kV. The orthopantomogram presented a single image for the maxillofacial region, while numerous images (cross sections) in vertical, antero-posterior and horizontal plan for the maxillofacial region were obtained through the CBCT method. The pixels dimension in orthopantomogram image, and in the CBCT images was 120 μm., and the voxels dimension in the CBCT images was 0.175 mm.. The number of shades of gray in orthopantomogram images, and the CBCT images was 65536. Implant planning through orthopantomogram was performed using the software "Villa Quickvision" and implant planning through CBCT images was performed using the software "3D Planner". The planned implants had diameter from 3 to 7 mm., and length from 6 to 18 mm., depending on the given case. When planning implants in orthopantomogram images, we used the tool "ruler", respectively for determining the vertical dimension of the alveolar ridge we measured the distance from the crestal part of the alveolar ridge to the roof of the mandibular incisive canal. When planning implants in CBCT images we used the tool "point to point measurements". Respectively, using this tool we measured the vertical dimension of the alveolar ridge, and also the horizontal dimension of the alveolar ridge. For determining the horizontal dimension (width) of the alveolar ridge we measured the distance from the buccal side of the ridge to the lingual side of the ridge.

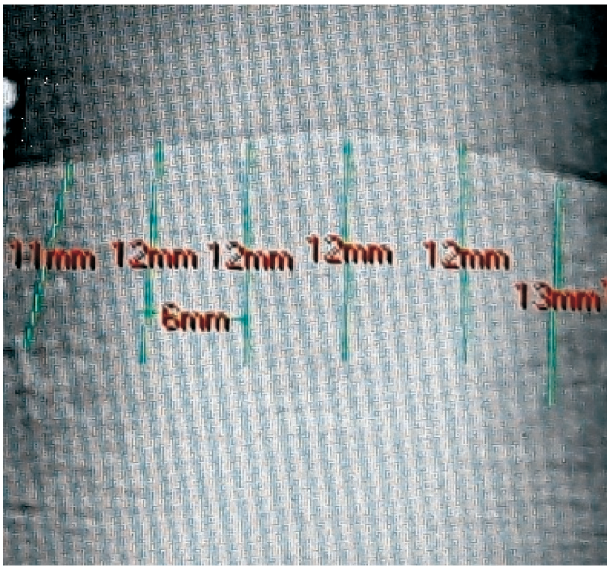

Figure 1. Vertical dimension of the alveolar ridge in the anterior mandibular region (orthopantomogram).

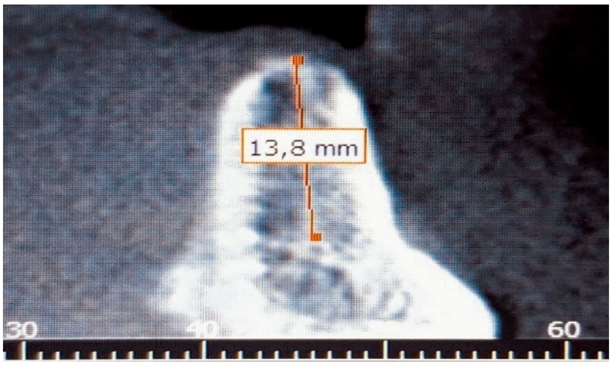

Figure 2. Vertical dimension of the alveolar ridge in the anterior mandible region. (CBCT image).

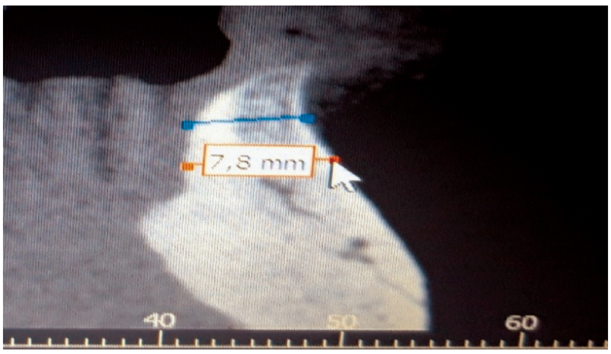

Figure 3. Horizontal dimension (width) of the alveolar ridge in the anterior mandible region (CBCT image).

Results

With orthopantomogram and CBCT method, implants in 21 individuals in the region of anterior mandible were planned, from which 13 men and 8 women. The age of the individuals varied from 40 to 75 years (mean 61).

Table 1 shows the minimum value, the maximum value, and standard deviation, for vertical dimension in the anterior mandible region, using the CBCT method. Respectively, the highest mean value resulted in the left canine region (3.3): 15.33 mm. ± 3.32, and the lowest mean value resulted in the left lateral incisor region (3.2): 14.11 mm. ± 4.04.

Table 1.

Variable	N	Mean	Min.	Max.	Std.Dev.
6.3.1	17	14,25	9,00	20,00	3,39
6.3.2	16	14,11	8,00	20,60	4,04
6.3.3	12	15,33	9,00	19,50	3,32
6.4.1	16	15,04	9,00	20,00	3,75
6.4.2	15	14,20	9,00	21,00	3,46
6.4.3	13	14,38	8,00	20,50	4,03

Table 2 shows the mean value, the minimum value, the maximum value and the standard deviation for vertical dimension of the residual alveolar ridge, measured in orthopantomogram images. Respectively the highest mean value resulted in the left canine region (3.3): 15.69

Table 2.

Variable	N	Mean	Min.	Max.	Std.Dev.
6.3.1	18	15,06	9,00	20,00	3,21
6.3.2	17	14,29	7,00	21,00	3,69
6.3.3	13	15,69	7,00	20,00	3,68
6.4.1	18	14,72	9,00	20,00	3,53
6.4.2	17	14,65	9,00	22,00	3,37
6.4.3	14	14,71	8,00	23,00	4,08

mm. ± 3.68, and the lowest mean value resulted in the left lateral incisor region (3.2): 14.29 mm. ± 3.69.

Table 3 shows the analysis of differences for vertical dimension of the alveolar ridge, measured with the CBCT method and the orthopantomogram method. Whereby the results obtained using the orthopantomogram were higher compared with those using the CBCT method (with the exception of the right central incisor region). But for all the regions, for p>0.05, the differences in results obtained using CBCT method and orthopantomogram, were not statistically significant.

Table 3.

Variable	Mean CBCT	Mean Ortho.	t-value	p
6.3.1	14,25	15,06	-0,72	0,48
6.3.2	14,11	14,29	-0,13	0,89
6.3.3	15,33	15,69	-0,26	0,80
6.4.1	15,04	14,72	0,26	0,80
6.4.2	14,20	14,65	-0,37	0,71
6.4.3	14,38	14,71	-0,21	0,83

Table 4 shows the mean value, the minimum value, the maximum value and standard deviation, for the horizontal dimension of the alveolar ridge in the anterior mandible region, using the CBCT method. Respectively, the highest mean value resulted in the right canine region (4.3): 9.52 mm. ± 1.53, while the lowest mean value resulted in the left lateral incisor region (3.2): 9.14 mm. ± 1.58. The minimum value was registered in the right central incisor region (4.1): 5.50 mm., and the maximum value was registered in the left central incisor region (3.1): 13.00 mm.

Table 4.

Variable	N	Mean	Min.	Max.	Std.Dev.
6.3.1	17	9,39	6,00	13,00	1,83
6.3.2	16	9,14	6,70	11,70	1,58
6.3.3	12	9,17	7,40	11,50	1,31
6.4.1	16	9,36	5,50	12,00	1,77
6.4.2	15	9,32	6,70	12,20	1,72
6.4.3	13	9,52	7,30	12,30	1,53

Discussion

When we were planning implants in the anterior mandible region with the use of the CBCT method, we measured the height and the width of the residual alveolar ridge. While when we planned implants using the orthopantomogram, we measured only the height of the alveolar ridge. Using the CBCT method we planned 89 implants in total, that is, in the central incisor region, in the lateral incisor region, and in the canine region. Using the CBCT method, the highest mean value for the height of the alveolar ridge in the anterior mandible region resulted in the left canine region (3.3): 15.33 ± 3.32 mm., while the lowest mean value resulted in the left lateral incisor region (3.2): 14.11 ± 4.04 mm. Therefore, the analysis for the differences in results for the vertical dimension measured with the CBCT method and the orthopantomogram, showed that greater values for alveolar ridge height, compared with the CBCT method (exeption the right central incisor region) were measured using the orthopanomogram. For all the regions, the differences were not statistically significant. These results of our study, are in agreement with the those of the authors Dagassan-Berndt et Zitzmann[13] who presented significantly higher values for the alveolar ridge height obtained with orthopantomoram, compared with the use of the CBCT method, while the author Guerrero[14] concluded that in the anterior mandible region, the differences in implant length, planned using orthopantomogram and the CBCT method, were not significant. In the study of the author Hu et al.[15] a comparison of the alveolar ridge height measured with orthopantomogram and CBCT method with the implants length placed in jaw samples was made. It showed a significant difference in alveolar ridge height using the orthopantomogram method and the CBCT method, in relation to the implants' length placed in the jaw samples. But the differences were greater using the orthopantomogram, compared with the CBCT method. The author Brito[16] concluded that using the orthopantomogram, the mandibular incisive canal was observed in 5.5% of the cases, and by using the CBCT method the same was observed in 24.4% of the cases. And the differences were statistically significant. Mello[17] showed that the length of the implants planned using orthopantomogram and those planned using CBCT, agreed in 50.5% of the cases. While the length of the implants planned using orthopantomogram agreed with the length of the implants placed in the surgical phase in 40% of the cases, while using the CBCT method this agreement was in 69.5% of the cases. Luangchana[18] investigated the absolute error during measurements for the vertical dimension of the alveolar ridge using the orthopantomogram and the CBCT method, versus the physical measurements for the vertical dimension of the alveolar ridge in jaw samples. Where the absolute error in measurements using CBCT in the mandible resulted in values ranging from 0.39 to 0.66. While the absolute error in measurements using orthopantomogram resulted in values ranging from 1.11 to 1.53. Also, the errors in measurements in the mandible were lower, in relation to those measured in the maxilla. Also, the errors were lower using the CBCT method compared with those using orthopanotmogram. In our study, when measuring the horizontal dimension of the alveolar ridge using the CBCT method, the highest mean value for the width of the alveolar ridge resulted in the right canine region (4.3): 9.52 mm. ± 1.53, while the lowest mean value resulted in the left lateral incisor region (3.2): 9.14 mm. ± 1.58. While using the CBCT method, we planned implants in edentulous regions where there was a presence of miminum 5 mm. of bone width and minimum 7 mm. of bone height. When planning implants using orthopantomogram, we were basing only in the presence of minimum 7 mm. bone height, not having information about the bone width in that region. Goller et al.[19] concluded that the width of the alveolar process in the anterior mandible region, measured using the CBCT method, varied in values from 3.3 to 13.4 mm.. Mello[17] concluded that narrower implants were planned using orthopantomogram, compared with those planned using CBCT. Hu et al.[15] suggests using osteometer (intraoraly on exposed bone, or extraoraly on study models), for determining the alveolar ridge width, in cases where orthopantomogram is used for implant planning. In the study of Jalaluddin[20] it was concluded that the CBCT method is highly precise in determining of the alveolar ridge width, same as the method which uses osteometer for determining the width of a surgically exposed alveolar ridge. Dagassan-Berndt et al.[21] showed that the dimensions of the implants planned using orthopantomogram were in agreement with the dimensions of the implants placed in the surgical phase in 34.4% of the cases, while the dimensions of the implants planned using CBCT were in agreement with the dimensions of the implants placed in the surgical phase in 46% of the cases. Guerrero[14] showed that the diameter of the implants planned using CBCT remained unchanged with that of the implants placed in the surgical phase in 88.5% of the cases. While the diameter of the implants planned using orthopantomogram remained unchanged with that of the implants placed in the surgical phase in 92.1% of the cases. But there was not a significant difference in the results, between the two methods used.

Conclusion

Orthopantomogram is an efficient method for determining the alveolar ridge height, in regions planned for implant placement. The CBCT method is a priority method in formulating implant treatment plan because it allows measuring not only the alveolar ridge height, but also the alveolar ridge width, therefore increasing the precision when choosing the adequate dimensions of implants.

Reference

1. de Almeida HCR. et al. Clinical aspects in the treatment planning for rehabilitation with overdenture and protocol-type prosthesis. RGO, Rev. Gaúch.Odontol. vol.63 no.3 Campinas July/Sept. 2015.doi:10.1590/1981-863720150003000032920.
2. Gowd MS, Shankar T, Ranjan R, Singh A. Prosthetic Consideration in Implant-supported Prosthesis: A Review of Literature. J Int Soc Prev Community Dent. 2017 Jun;7(Suppl 1):S1-S7. doi: 10.4103/jispcd.JISPCD_149_17.
3. Albelbeisi TM, Khtob AR, Hassan NE. Cone beam computed tomography versus digital orthopantomography in treatment planning for mandibular dental implants. Alexandria Dental Journal.(2016) Vol.41 pages:199-205.
4. Zitzmann NU, Margolin MD, Filippi A, Weiger R, Krastl G. Patient assessment and diagnosis in implant treatment. Aust Dent J. 2008 Jun;53 Suppl 1:S3-10. doi: 10.1111/j.1834-7819.2008.00036.x.
5. Azeredo F, de Menezes LM, Enciso R, Weissheimer A, de Oliveira RB. Computed gray levels in multislice and cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2013 Jul;144(1):147-55. doi: 10.1016/j.ajodo.2013.03.013.
6. Misch CE, Strong JT, Bidez MW. Scientific rationale for dental implant design. December 2015. In book: Dental Implant Prosthetics(pp.340-371). doi: 10.1016/B978-0-323-07845-0.00015-4.
7. Daudt Polido W, Aghaloo T, Emmett TW, Taylor TD, Morton D. Number of implants placed for complete-arch fixed prostheses: A systematic review and meta-analysis. Clin Oral Implants Res. 2018 Oct;29 Suppl 16:154-183. doi: 10.1111/clr.13312.
8. Torkzaban P, Haghgoo JM, Khoshhal M, Arabi SR, Razaghi S. A review of dental implant treatment planning and implant design based on bone density. Avicenna J Dent Res. 2013;5(1): 10-16. doi: 10.17795/ajdr-20753.
9. Sener E, Onem E, Akar GC, Govsa F, Ozer MA, Pinar Y, Mert A, Sen B. Anatomical landmarks of mandibular interforaminal region related to dental implant placement with 3D CBCT: Comparison between edentulous and dental mandibles. Surg Radiol Anat. 2018 Jun;40(6):615-623. doi: 10.1007/s00276-017-1934-8.
10. Albelbeisi TM, Khtob A, Hassan NE. Cone beam computed tomography versus digital orthopantomography in treatment planning for mandibular dental implants.Alexandria dental journal.(2016) Vol.41 pages:199-205.
11. Özalp Ö, Tezerişener HA, Kocabalkan B, Büyükkaplan UŞ, Özarslan MM, Şimşek Kaya G, Altay MA, Sindel A. 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 Dec;48(4):269-275. doi: 10.5624/isd.2018.48.4.269.
12. 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 Aug 1;18(8):665-669. doi: 10.5005/jp-journals-10024-2103.
13. Dagassan-Berndt C, Zitzmann NU, Walter C, Schulze RK. Implant treatment planning regarding augmentation procedures: panoramic radiographs vs. cone beam computed tomography images. Clin. Oral Impl. Res. 00, 2015, 1–7. doi: 10.1111/clr.12666.
14. Guerrero ME, Noriega J, Castro C, Jacobs R. Does cone-beam CT alter treatment plans? Comparison of preoperative implant planning using panoramic versus cone-beam CT images. Imaging Sci Dent 2014 Jun;44(2): 121-8. doi :10.5624/isd.2014.44.2.121.
15. 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. doi: 10.5051/jpis.2012.42.2.39.
16. de Brito AC, Nejaim Y, de Freitas DQ, de Oliveira Santos C. Panoramic radiographs underestimate extensions of the anterior loop and mandibular incisive canal. Imaging Sci Dent. 2016 Sep;46(3):159-65. doi: 10.5624/isd.2016.46.3.159.
17. Mello LA, Garcia RR, Leles JL, Leles CR, Silva MA. Impact of cone-beam computed tomography on implant planning and on prediction of implant size. Braz Oral Res. 2014;28:46-53.doi: 10.1590/s1806-83242013005000029.
18. Luangchana P, Pornprasertsuk-Damrongsri S, Kiattavorncharoen S, Jirajariyavej B. Accuracy of linear measurements using cone beam computed tomography and panoramic radiography in dental implant treatment planning. Int J Oral Maxillofac Implants. 2015 Nov-Dec;30(6):1287-94. doi: 10.11607/jomi.4073.
19. Goller Bulut D, Köse E. Available bone morphology and status of neural structures in the mandibular interforaminal region: three-dimensional analysis of anatomical structures. Surg Radiol Anat. 2018 Nov;40(11):1243-1252. doi: 10.1007/s00276-018-2039-8.
20. Jalaluddin M, Sam G, Abd-Ellatif El-Patal M, Penumatsa NV, Aladmah A, Punde P. Evaluation of alveolar ridge dimensions using various techniques prior to implant placement: a comparative study. World J Dent 2020;11(4):299–303.
21. Dagassan-Berndt DC, Clemens W, Zitzmann NU, Schulze RK. Influence of three-dimensional imaging on implant treatment planning: implant diameter and length. J Contemp Dent Pract. June 2018;19(6):704-711. PMID: 29959300.