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Comparison of the accuracy of linear measurements in CBCT images with different field of views

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ABSTRACT | *Objective*: This study sought to investigate the effect of the field of view (FOV) on linear measurements of cone beam computed tomography (CBCT) images. *Methods*: In this in vitro study, five dry human skulls were used. After using red wax to simulate soft tissue, the skulls were scanned using Galileos CBCT scanner (Sirona, Bensheim, Germany) with exposure parameters of 85 kVp and 21 mAs and voxel size of 0.280 mm; once with FOV of 15 cm × 8 cm and once again with 15 cm × 15 cm. The measured distances were the distance between the center of the bilateral mental foramen in the axial view (MM), the distance between the alveolar crest and the mandibular inferior border in the sagittal view on the midline (CB), and the depth of the socket of the left mandibular central incisor (L1). Descriptive statistics as well as Pearson's correlation coefficient were used for statistical analysis ($\alpha = 0.05$) using SPSS software (v. 25, IBM, NY, USA). *Results*: The measurements obtained with small and large FOV and with the dry skull were not significantly different ($p > 0.05$). The measurements obtained in small FOV had excellent correlation coefficient when compared with those obtained with the dry skull, with values of 0.890 for MM, 0.954 for CB, and 0.921 for L1 ($p < 0.001$). The measurements in large FOV also had excellent correlation coefficient when compared with those on the dry skull, with values of 0.894 for MM, 0.949 for CB, and 0.902 for L1 ($p < 0.001$). *Conclusion*: According to our findings, linear measurements obtained by CBCT scans in small and large FOVs were not significantly different than those on dry skulls. Since the linear measurements are accurate regardless of FOV size, selection of FOV must be based on patient factors, such as area of interest and radiation dose.

DESCRIPTORS | Cone Beam Computed Tomography; Linear Measurement; Mandible.

RESUMO | **Comparação da precisão de medições lineares em imagens CBCT com diferentes campos de visão** • *Objetivo*: O objetivo do presente estudo é investigar o efeito do campo de visão (*field of view* – FOV) em imagens de tomografia computadorizada de feixe cônico (CBCT) na medida linear. *Métodos*: Neste estudo in vitro, foram utilizados cinco crânios humanos secos. Depois de usar cera vermelha para simular tecidos moles, os crânios foram escaneados usando o scanner GALILEOS CBCT (Sirona, Bensheim, Alemanha) usando parâmetros de exposição de 85 kVp e 21 mAs e o tamanho de voxel de 0,280 mm; uma vez com FOV de 15 cm × 8 cm e outra com 15 cm × 15 cm. As medidas usadas foram as distâncias entre o centro dos forames mentuais bilaterais, na visão axial (MM): a distância entre a crista alveolar e a borda inferior da mandíbula, na visão sagital na linha média (CB); e a profundidade do soquete do incisivo central da mandíbula esquerda (L1). Estatística descritiva e o coeficiente de correlação de Pearson foram utilizados para análise estatística ($\alpha = 0{,}05$) *usando o software SPSS (v. 25, IBM, NY, EUA)*. *Resultado*: As medidas obtidas com FOV pequeno e grande e com o crânio seco não foram significativamente diferentes ($p > 0{,}05$). As medidas feitas com FOV pequeno apresentaram excelente coeficiente de correlação em relação ao crânio seco, com valores de 0,890 para MM, 0,954 para CB e 0,921 para L1 ($p < 0{,}001$). As medidas feitas no FOV grande também apresentaram excelente coeficiente de correlação em relação ao crânio seco, sendo 0,894 para MM, 0,949 para CB e 0,902 para L1 ($p < 0{,}001$). *Conclusão*: De acordo com nossos resultados, as medidas lineares obtidas por CBCT em FOV pequenos e grandes não foram significativamente diferentes das medidas obtidas com crânios secos. Como as medições lineares são precisas, independentemente do tamanho do FOV, a seleção do FOV deve ser baseada de acordo com os fatores do paciente, como área de interesse e dose de radiação.

DESCRITORES | Tomografia Computadorizada de Feixe Cônico; Medida Linear; Mandíbula.

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INTRODUCTION

Cone beam computed tomography (CBCT) is the main three-dimensional imaging technique in the field of dentistry.[1] One of the important features of CBCT imaging is its ability to optimize the field of view (FOV) in relation to the region of interest. FOV can be modified mechanically or electronically based on the scanner settings. Different CBCT scanners provide different FOV sizes and options. Based on CBCT scanner specifications, FOV can range from 20 mm × 20 mm to 300 mm × 300 mm, which can be made available via vertical stitching.[2] Smaller FOVs theoretically allow for lower radiation doses and images with less noise.[3,4]

Measurement accuracy in CBCT images is an important factor to assess impacted teeth, localization of foreign bodies, and bone evaluation prior to implant placement. Several studies have been performed on the effects of different factors on the measurement accuracy of different CBCT images. For instance, Ganguli, Ramesh, and Pagni investigated the effect of voxel size and FOV on accuracy of linear measurements in the edentulous area.[5] Their findings showed that CBCT measurements are accurate regardless of voxel size or FOV setting. However, for larger distances, the measurements were less reproducible compared with smaller ones.[5] A systematic review on the subject reported a wide range of error in linear measurements of CBCT images with both over- and under-estimation of distances. Nevertheless, the authors concluded that CBCT can be considered as an appropriate diagnostic tool for implant preoperative planning.[6] This study sought to further investigate the effect of FOV on linear measurements in CBCT images.

MATERIALS AND METHODS

The protocol for this study was approved by the Ethics Committee in Isfahan University of Medical Sciences (#IR.MUI.RESEARCH.REC.1398.695). This experimental in vitro study was performed on 5 human dry skull models obtained from the Department of Oral Radiology, Isfahan University of Medical Sciences. In order to simulate the soft tissue, the mandible was covered with 1 cm of red wax. The skulls were scanned using Galileos CBCT scanner (Sirona, Bensheim, Germany) with the exposure parameters of 85 kVp and 21 mAs and voxel size of 0.280 mm, once with FOV of 15 cm × 8 cm and once again with 15 cm × 15 cm. The measured distances where as follows:

a. the distance between the center of the bilateral mental foramen in the axial view (MM)
b. the distance between the alveolar crest and the mandibular inferior border in the sagittal view on the midline (CB)
c. The depth of the socket of the left mandibular central incisor (L1)

The distances were measured in all image sets using the Sidexis software (Sirona, Bensheim, Germany). All distances were recorded by a trained senior dental student twice. Additionally, the distances were measured in the dry skull using digital caliper.

Descriptive statistics as well as Pearson's correlation coefficient were used for statistical analysis ($\alpha = 0.05$) using SPSS software (v. 25, IBM, NY, USA).

RESULTS

The distances measured in small and large FOV were not significantly different than those on the dry skull ($p > 0.05$). Additionally, the measurements obtained in small and large FOV were not significantly different from each other ($p > 0.05$). (Table 1) The measurements in small FOV had excellent correlation coefficient when compared with the dry skull, with values of 0.890 for MM, 0.954 for CB, and 0.921 for L1 distances ($p < 0.001$). The measurements in large FOV also had excellent correlation coefficient when compared with those on the dry skull, with values of 0.894 for MM, 0.949 for CB, and 0.902 for L1 distances ($p < 0.001$).

TABLE 1 | Descriptive statistics for measured distances

		Minimum	Maximum	Mean (SD)	p-value
MM	Small FOV	40.23	61.01	53.13 (6.28)	0.757
	Large FOV	40.17	61.34	53.10 (6.05)	
	Dry skull	39.60	60.21	52.29 (6.28)	
CB	Small FOV	28.30	36.09	32.64 (2.61)	0.783
	Large FOV	28.12	36.30	32.78 (2.73)	
	Dry skull	27.20	35.32	32.03 (2.53)	
L1	Small FOV	10.56	14.03	12.19 (1.10)	0.760
	Large FOV	11.04	14.34	12.32 (1.01)	
	Dry skull	10.35	13.10	11.97 (0.90)	

MM: distances between bilateral mental foramen; CB: distance between the alveolar crest and the inferior border in the midsagittal plane; L1: The depth of the alveolar socket of the left mandibular central incisor; FOV: field of view.

DISCUSSION

Based on our findings, no significant difference was observed between the measurements in CBCT images with small FOV and large FOV and the real distances on the dry skull. Additionally, all the CBCT measurements had excellent correlation with measurements on the dry skull.

In a study performed by Kamburoglu et al. comparing the accuracy of CBCT images obtained with different FOVs, the smaller FOVs provided higher accuracy in measuring linear dimensions of alveolar peri-implant bone defects.[7] Al-Ekrish and Ekram have also compared the reliability and accuracy of CT images and CBCT images with different FOVs in linear measurements of the implant sites in the edentulous alveolar ridge.[8] Their findings showed that linear measurement on CBCT images were more accurate than CT images.[8] Elshenawy et al., concluded that larger FOV sizes combined with voxel sizes could adversely affect the accuracy of linear measurements on CBCT images, especially in measurement of small distances.[9] Smaller FOVs generally lead to higher image quality due to decreased signal to noise ratio.[10] Therefore, identifying the edges and smaller objects will be potentially easier in images obtained with limited FOVs, which can in turn result in higher accuracy of measurements. However, these findings are subject to observer experience, object of interest, CBCT scanner characteristics, patient motion, metallic artifacts, and viewing conditions. In general, smaller FOVs are preferred for their lower radiation dose, as well as higher image quality. Additionally, in many CBCT devices, larger FOVs requires larger voxel sizes. Even in devices that enable larger FOVs and small voxel sizes, increased patient dose can limit its application. A systematic review on accuracy of CBCT measurements prior to implant placement concluded that CBCT is an appropriate diagnostic tool for preoperative planning, but a safety margin of 2 mm to adjacent vital structures must be considered.[6]

The limitations of this study include the in vitro design, which eliminates patient-induced factors, such as motion artifact. Another limitation is the used CBCT scanner, since horizontal collimation of the cone beam was not possible.

CONCLUSION

According to our findings, linear measurements obtained by CBCT scans in small and large FOVs were not significantly different than those on dry skulls. Since the linear measurements are accurate regardless of FOV size, selection of FOV must be based on patient factors, such as area of interest and radiation dose.

DECLARATIONS

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REFERENCES

1. Mehdizadeh M, Booshehri SG, Kazemzadeh F, Soltani P, Motamedi MRK. Level of knowledge of dental practitioners in Isfahan, Iran about cone-beam computed tomography and digital radiography. Imaging Sci Dent. 2015;45(2):133-5. Doi: https://doi.org/10.5624/isd.2015.45.2.133.
2. Gaêta-Araujo H, Alzoubi T, Vasconcelos KF, Orhan K, Pauwels R, Casselman JW, et al. Cone beam computed tomography in dentomaxillofacial radiology: a two-decade overview. Dentomaxillofac Radiol. 2020;49(8):20200145. Doi: https://doi.org/10.1259/dmfr.20200145.
3. de Oliveira Pinto MG, Melo SLS, Suassuna FCM, Marinho LE, Leite JBS, Batista AUD, et al. Influence of size of field of view (FOV), position within the FOV, and scanning mode on the detection of root fracture and observer's perception of artifacts in CBCT images. Dentomaxillofac Radiol. 2021;50(6):20200563. Doi: https://doi.org/10.1259/dmfr.20200563.
4. Nascimento HAR, Andrade MEA, Frazão MAG, Nascimento EHL, Ramos-Perez FMM, Freitas DQ. Dosimetry in CBCT with different protocols: emphasis on small FOVs including exams for TMJ. Braz Dent J. 2017;28(4):511-6. Doi: https://doi.org/10.1590/0103-6440201701525.
5. Ganguly R, Ramesh A, Pagni S. The accuracy of linear measurements of maxillary and mandibular edentulous sites in cone-beam computed tomography images with different fields of view and voxel sizes under simulated clinical conditions. Imaging Sci Dent. 2016;46(2):93-101. Doi: https://doi.org/10.5624/isd.2016.46.2.93.
6. Fokas G, Vaughn VM, Scarfe WC, Bornstein MM. Accuracy of linear measurements on CBCT images related to presurgical implant treatment planning: a systematic review. Clin Oral Implants Res. 2018;29(Suppl 16):393-415. Doi: https://doi.org/10.1111/clr.13142.
7. Kamburoglu K, Murat S, Kiliç C, Yüksel S, Avsever H, Farman A, et al. Accuracy of CBCT images in the assessment of buccal marginal alveolar peri-implant defects: effect of field of view. Dentomaxillofac Radiol. 2014;43(4):20130332. Doi: https://doi.org/10.1259/dmfr.20130332.
8. Al-Ekrish AA, Ekram M. A comparative study of the accuracy and reliability of multidetector computed tomography and cone beam computed tomography in the assessment of dental implant site dimensions. Dentomaxillofac Radiol. 2011;40(2):67-75. Doi: https://doi.org/10.1259/dmfr/27546065.
9. Elshenawy H, Aly W, Salah N, Nasry S, Anter E, Ekram K. Influence of small, midi, medium and large fields of view on accuracy of linear measurements in CBCT imaging: diagnostic accuracy study. Open Access Maced J Med Sci. 2019;7(6):1037-41. Doi: https://dx.doi.org/10.3889%2Foamjms.2019.232.
10. Kiarudi AH, Eghbal MJ, Safi Y, Aghdasi MM, Fazlyab M. The applications of cone-beam computed tomography in endodontics: a review of literature. Iran Endod J. 2015;10(1):16-25.