

Reliability and Reproducibility of Linear Measurements of Alveolar Ridges Using Cone-beam CT Made by Radiologists and Periodontists

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Received: 15 February 2015; Accepted: 5 July 2015

J Periodontol Implant Dent 2015;7(2):35–38 | doi: 10.15171/jpid.2015.007

This article is available from: <http://dentistry.tbzmed.ac.ir/jpid>

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Abstract

Background and aims. The aim of this study was to evaluate the intra- and inter-examiner reliability and reproducibility of linear measurements on cone-beam computed tomography (CBCT) images made by calibrated radiologists and periodontists.

Materials and methods. The alveolar ridge dimensions were measured on selected CBCT images by two calibrated radiologists and two periodontists. Intra- and inter-examiner reliability was evaluated by intra-rater and intra-class correlation coefficients (ICCs).

Results. Intra- and inter-examiners ICCs obtained with the different methods showed almost perfect matches. The results demonstrated high examiner reproducibility for linear parameters of alveolar ridges on CBCT images in presurgical implant site assessments.

Conclusion. The alveolar ridge dimensions provided by the radiologists might be useful for the periodontists. The measurements with small differences were related to the experience and skills of the examiner, inclination measurement, selection of the exact level of the alveolar crest and the ability to detect the exact anatomic borders on CBCT images.

Key words: Cone-beam computed tomography, dental implants, linear measurements.

Introduction

The introduction of cone-beam computed tomography (CBCT), also called cone-beam volumetric tomography (CBVT), provides 3D images with a considerable reduction of the radiation dose compared with CT examinations.^{1,2} Image quality, particularly regarding hard tissues, is comparable with CT images.³

CBCT is a technique that has been proposed for maxillofacial imaging.^{1,4-9} The use of CBCT has increased in various clinical situations in recent years.¹⁰⁻¹³ The major use of CBCT is presurgical implant planning. The linear measurement of distances is often used in presurgical implant planning for the detection of the exact amount of alveolar bone width and height.¹⁴

High repeatability and reproducibility of such measurements are important in clinical practice. This is essential in evaluating the consistency of diagnosis between different observers and follow-up patients over a period of time.¹⁵ The intra- and inter-examiner correlations proved to be a positive method in several studies of the CBCT; in addition, the available software yielded precise measurements made by different professionals.^{2,13} In daily practice, it is noted that often what the radiologist marks in the printed films is not the accurately measured region for implant surgery.¹⁵ The aim of this study was to evaluate the intra- and inter-examiner reliability and reproducibility of linear measurements on cone-beam tomography (CBCT) images made by calibrated radiologists and periodontists.

Materials and Methods

In this study, the CBCT scans of a private clinic were evaluated to assess 23 cross-sectional CBCT images of alveolar ridges in different areas of jaws. CBCT scans were provided with SORDEX SCANORA 3D scanner machine (Helsinki, Finland. Voxel size: 20 μ m, Field of view: 7.5 \times 10 cm). We drew an arch in axial images and reconstructed panoramic and cross-sectional images were obtained automatically. Four examiners, including two periodontists and two oral and maxillofacial radiologists, participated in this study. They measured each alveolar ridge on selected CBCT images in three dimensions; the first dimension was the buccolingual width of alveolar ridge at the region of crest, the second dimension, the buccolingual width of alveolar ridge at the region of 3 mm apical to alveolar crest and the third, the alveolar ridge height in selected cross-sectional CBCT images. Each examiner repeated

these measurements in all the 23 selected images using the three-dimensional CBCT again after a month to evaluate intra-examiner error.

Measurements were made using a computer mouse to position the two-dimensional measurement tool cursor at one end to the other end. SCANORA software allows the users to measure linear distances.

The agreement between the four examiners in the measurements and the agreement between two groups (two radiologists as a group, two periodontists as another group) were assessed using interclass correlation coefficients (ICC).

Intra-examiner reliability, including the agreement between each examiner in these two series of measurements and the agreement in each group (two radiologists as a group, two periodontists as another group) was assessed by intra-class correlation coefficients (ICC).

When ICC values were closer to 1, reliability and reproducibility were stronger; ICC values >0.75 showed good reliability. The significance level was considered to be 5% ($P \leq 0.05$).

The research project respected the Helsinki ethics declaration and was accepted ethically in the Ethics Committees of Shahid Beheshti University of Medical Science.

Results

The overall agreement between the four examiners was assessed and it was good in the first dimension (buccolingual width of alveolar ridge at the region of crest) and the inter-examiner measurement error was 4.09 mm (ICC: 0.768). This agreement was stronger in the second dimension (the buccolingual width of alveolar ridge at the region of 3 mm apical to the alveolar crest in 23 selected CBCT images) and ICC was 0.908 and the inter-examiner measurement error was 1.83 mm. It was also strong in the third dimension (alveolar ridge height). ICC was 0.930 and the inter-examiner measurement error in the third dimension was 2.01 mm.

We also calculated the inter-examiner reliability between the two groups (radiologists and periodontists) and it was satisfactory in all the three dimensions mentioned above. The measurement error between the two groups was 1.11 mm in the first dimension (ICC: 0.978), 0.05 mm in the second dimension (ICC: 0.990) and 0.03 mm in the third dimension (ICC: 0.986).

The agreement between each examiner in his two series of measurements (each examiner repeated the measurements a month later again) was satisfactory. Intra-examiner measurement error was higher in pe-

riodontists relative to radiologists in all the three dimensions mentioned above. In the first dimension, for the radiologists it was 0.1 mm and 0.11 mm but for the periodontists it was 1.20 mm and 3.31 mm. In the second dimension, it was 0.33 mm and 0.50 mm for the radiologists and 0.97 mm and 0.87 mm for periodontists. This error in the third dimension was 0.05 mm, 0.47 mm for the radiologists and 0.96 mm 0.81 mm for the periodontists. The highest intra-examiner measurement error was 3.31 mm in the first dimension that was measured by a periodontist.

Intra-examiner reliability between periodontists was good. ICC in the first, second and third dimensions were 0.834, 0.922 and 0.959, respectively, and the measurement errors were 5.44 mm, 2.32 mm and 3.23 mm, respectively. Intra-examiner reliability between radiologists was well assessed. ICC was 0.773, 0.920 and 0.890 in the first, second and third dimensions, respectively. The errors were 4.26 mm, 2.29 mm and 1.33 mm, respectively.

Discussion

There are various previous studies regarding the analysis of accuracy for panoramic radiographs^{1,16-18} and digital radiography.¹⁹ However, there are few reports regarding the cone-beam tomography, especially with the intra-examiner and inter-examiner evaluation.^{10,11,20}

Fatemitabar et al²¹ evaluated the accuracy of CBCT (PLANMECA), and found the mean differences varying from 0.37 mm to 0.58 mm for CBCT, and 0.37 mm to 0.72 mm for a 64-channel CT (Siemens). Pinsky et al²² found that CBCT (i-CAT) could be an accurate diagnostic tool for small osseous defects. They found mean differences varying from -0.01 mm to 0.27 mm for width and height accuracy. Stratemann et al²³ also found high accuracy in the CBCT images for linear distances compared to the real measurements. The error was small for two evaluated CBCT systems, varying from 0.41±0.07 mm for NewTom 9000 0.22±0.00 mm for CB Hitachi MercuRay. Kamburoglu et al found the inter-observer reliability to be 0.995 to 1 and intra-observer reliability to be 0.992 to 1. Oz et al²⁴ also found high inter-observer reliability of the CBCT measurements in the craniofacial area. Patcas et al²⁵ evaluated the accuracy of linear intraoral measurements using CBCT. The radiological measurements were accurate, with a mean difference from the anatomical measurements of 0.14 mm. Dalessandri et al²⁶ in an ex vivo study evaluated measurement reliability using two different CBCT scanners for orthodontic purposes. They found that both scanners were

reliable for linear measurements.

In this study, there was acceptable inter- and intra-examiner reliability between linear measurements made by radiologists and periodontists. The higher measurement error was an inter-examiner one between four participants. The amount of this error was 4.09 mm and it might be important in clinical practice but when we evaluated the inter-examiner reliability between the two groups, the amount of this error was less than 1.1 mm, which appears to be acceptable in most clinical situations when the radiologists mark the alveolar ridge dimensions on CBCT images for periodontists. It is interesting that the highest inter-examiner error was in the first dimension (determining buccolingual width of alveolar ridge at crest region). The difficulty of selecting the exact level of the alveolar crest might explain the higher measurement error.

Radiologists had lower measurement errors relative to periodontists in the repetition of measurements after a month (intra-examiner error), which might be explained by the level of experience and skills of radiologists in CBCT measurements. Radiologists had the highest error in the second dimension and periodontists in the first dimension.

Other factors contributing to these small discrepancies are differences in the inclination of measurements and the ability to detect the exact borders of anatomic landmarks such as the inferior border of maxillary sinus, nasal fossa and the superior border of the inferior alveolar canal.

Conclusion

There was an acceptable inter- and intra-examiner reliability in CBCT measurements between radiologists and periodontists, making the alveolar ridge dimensions provided by radiologists useful for periodontists. Small differences in measurements was attributed to experience and skills of examiners, inclination measurements, selection of the exact level of the alveolar crest and the ability to detect the exact anatomic borders on CBCT images.

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