Assessment Of Interdental Alveolar Bone Defects Using Cone Beam Computed Tomography

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Abstract:

purpose:

1. **Assessment of the accuracy of different voxel sizes of CBCT in evaluation of various infrabony defects (both linear and volumetric).**
2. **Accuracy of 2 different software systems in volumetric measurements of alveolar bone defects.**

***Methods*: This study included 2 parts. An in vitro study included 10 dry mandibles, 60 classified artificial defects were created on the mandibles. Linear and volumetric measurements were done on mandibles and CBCT. The data then compared with CBCT data with different voxel sizes on 2 different software programs. An in vivo study on 5 patients with periodontal bone defects and scheduled for flap surgery. Linear and volumetric measurements were done both intra-surgical and on CBCT. Data analyzed and compared on 2 different software programs.**

***Results*: no significant difference in both linear and volumetric measurements of all alveolar bone defects when comparing CBCT with actual measurements. No significant difference between the 2 software packages used for volume evaluation. No difference between 0.1 and 0.2 mm voxels.**

***Conclusions*: This study shows that CBCT is very accurate in identifying and quantifying alveolar bone loss and thus can be used in diagnosis of periodontal diseases. Both software used can give accurate results. Smaller voxels give more accurate results.**

Key words: CBCT, alveolar defects, voxel size, software packages.

Introduction

New scientific advances in radiology which has occurred in recent few years have resulted in considerable improvements in periodontal disease diagnosis, treatment, and prognosis. In addition to improvements in quality of the image and reductions in radiation dose(1,2).

Radiographs give useful informations which add to the informations from the clinical periodontal examination of the patient(3). These informations help to develop an accurate diagnosis and treatment planning. A principal aim of using radiographs in the examination of periodontal diseaeses is the assessment of the quantity and pattern of alveolar bone resorption(4).

Digital volume tomography (DVT) is another name for cone-beam CT because the cone-beam geometry allows scanning of a large volume of tissues with a single rotation giving rise to a digital image(5).

CBCT as a diagnostic tool is widely used in dentoalveolar surgeries, implantology, general or specialized dentistry (orthodontics, endodontics, periodontics, and forensic dentistry), and otolaryngology(6,7).The currently available CBCT devices are capable of providing panoramic and cephalometric images. Additionally, the low footprint of these devices makes it suitable for dental office placement, therefore producing high quality images of specific regions of interest(7,8,9).

In a study evaluated 2- and 3-walled defects, furcations, dehiscences and fenestrations. It was concluded that CBCT images had the highest accuracy in comparison to conventional CT, panoramic radiograph and intraoral radiographs[10].

It was found that CBCT imaging is more accurate in evaluating alveolar defects in comparison to conventional periapical imaging and medical CT. Likewise, Noujeim et. al, reported that CBCT has better diagnostic accuracy than periapical radiographs in the evaluation of alveolar bone loss[11.12].

The purpose of this study was to evaluate the accuracy of CBCT in the detection of alveolar bone loss, including the 3D description of infrabony defects (invitro and invivo).

1. Materials and Methods

Part I:

Ten dentulous dry mandibles were used to give the gold standard. A total number of 60 bony defects were created using burr. The defects were divided into 3 categories 20 one-walled, 20 two-walled and 20 three-walled)

- ➢ Linear measurements were done on mandibles using a digital caliper with a resolving capacity of 0.1 mm.
- ➢ Volumetric measurements were done as follow:

Impressions of intraosseal cavities were obtained with low viscosity vinyl poly-dimethyl siloxane impression material which was placed with a carrier into the simulated defects through the sockets. The teeth were then repositioned in the

sockets before setting of the impression material to allow the excess silicone to flow throughout the sockets. After the polymerization, excess silicone impression was trimmed carefully to confine the impression to the boundaries of the simulated defect only then, it was removed from the defect and the impression was weighed using an analytical balance. Then the volumes were calculated using the density and mass law (Density is defined as mass per unit volume d = m/V).

Radiographic examination:

Mandibles were scanned with CBCT unit (iCAT Next Generation, Imaging Science International, ISI, Hatfield, PA, USA) with fixed FOV (field of view) of 16cm diameter X 4cm height and 3 different scanning voxels as follow:

1. A low dose scan of 0.25 mm voxel size,
2. Scan of 0.2 mm voxel size, 8 cm diameter and 6 cm height.
3. A high dose scan of 0.1 mm voxel size,

Scans were made with the mandibles submerged into water to provide soft tissue simulating effect.

Measurements were done according to line connecting the gutta percha as follow:

- Linear measurements of the defects (width, height, depth).
- Volumetric measurements of the defects using 2 different software systems.

Part II:

Five patients presenting alveolar bone defects and scheduled for periodontal flap surgery were included in this study.

- Linear measurements were done using a digital caliper and a digital magnification lens.
- Volumetric measurements were made with silicone impression material and the volumes were calculated using mass and density law as described above.

Radiographic examination:

CBCT was performed on the region of interest with iCAT Next Generation CBCT machine using the most appropriate imaging protocol according to the results from part I (FOV 16 cm diameter x 4cm height and resolution 0.2 voxel size).

Volumetric measurements of the defects were done by using 2 different software systems (Ondemand 3D App, Osirix MD Dicom Viewer).

CBCT measurements:

The CBCT measurements followed the same pattern as clinical measurements.

DICOM files were exported from the CBCT scanner and imported to the Ondemand 3D App software and reconstructions were made. This software was used for conducting linear measurements of both artificial and natural bony defects. The linear measurement tool of the software was used to record the measurements directly from the computer monitors. Measurements of all types of the defects were made for each voxel size. Ondemand 3D App software also was used for volumetric measurements of the defects. The volume of the defect was calculated by multiplying the three dimensions of the defect length (MD dimension), width (BL dimension) and height (depth).

The same images were also obtained in the Osirix MD v. 1.2 64 bit software installed in an iMac OS X v. 10.68 (Apple Inc. Cupertino, CA). Osirix software was used for

calculating the volumes of the defects using the region of interest (ROI) tool. The data collected are subjected to statistical analysis.

Statistical analysis

Data were fed to the computer and analysis was done by using IBM SPSS software package version 20.0. Quantitative data were described using mean, standard deviation for parametric data after testing normality using Shapiro-Wilk test. Statistical significance of the results was set at $P \leq 0.05$ value and 2 tailed tests were used for all.

Paired sample t test was performed for parametric quantitative variables, to compare between two studied techniques in same patient .One way random effects analysis of variance (ANOVA) was used for parametric quantitative variables, to compare between more than two studied groups with post Hoc Tukey test.

2. Results

Part I (IN VITRO):

There is no significant difference in all linear measurements of the defects on all CBCT data. There was no significant difference between voxels except in BL width and depth between 0.1 mm and 0.25 mm voxels (p2=0.02*, p2=0.02* respectively) and between 0.2 mm and 0.25 mm voxels (p3<0.001*, p3=0.025* respectively).

There is no significant difference between the actual volumes and estimated volumes in CBCT data except by 0.25 mm voxel ($p \leq 0.05$). When comparing the data from the 2 software programs, there is no significant difference between the two software programs ($p > 0.05$). When comparing the data from different voxels, there was a significant difference between 0.1 mm and 0.25 mm voxels and also between 0.2 mm and 0.25 mm voxels by Ondemand 3D App (p2=0.041*, p3=0.079* respectively) also, between 0.1 mm and 0.25 mm voxels and also between 0.2 mm and 0.25 mm voxels by Osirix (p2=0.049*, p3=0.034* respectively).

There is no significant difference between the actual volumes and estimated volumes in all CBCT data ($p > 0.05$). There is no significant difference between the two programs in. There is no significant difference between the different voxel sizes by both programs ($p > 0.05$).

Part II (IN VIVO):

There is no significant difference in all linear measurements ($p > 0.05$). There is a significant difference between the actual volumes and the estimated volumes on the Ondemand 3 D App (p1=0.01*), but no significant difference on the Osirix (p2=0.64). There is no significant difference between the two programs.

3. discussion

Up till now, only one study performed 3-dimensional volumetric as well as linear measurements of alveolar bone defects[12]. This study is the second study to evaluate the volumes of bony defects along with the linear measurements. Like some similar previous studies [12,13] , we made in vitro measurements of bony defects by utilizing CBCT.

The present study found no significant difference between the linear measurements from gold standard and those from CBCT data. The results from our first part of the study indicate that CBCT is highly accurate for the linear measurements in all types of the bone defects. These results are similar to Fleiner et al.[14] . They evaluated the periodontal bone level by using CBCT imaging and concluded that the CBCT was accurate in assessing alveolar bone levels and description of infra-bony defects.
These results are consistent with the results of the previous in-vivo studies Banodkar, et al. [15], de Faria Vasconcelos *et al* [16].
In this study, we evaluated the accuracy of the volumetric measurements of alveolar defects by comparing the actual volume measurements in vitro and in vivo with measurements from CBCT. Our results showed that the estimated volumes on CBCT were similar to the actual volumes of all types of bony defects.

In a previous study, conducted to evaluate the accuracy of the volume estimation of the intrabony defects using CBCT images. Their results showed that the obtained results were similar to the actual volumes of bony defect[17].
This study found that there is a significant difference between measurements obtained on images with voxels of 0.1 and 0.25 mm and also between those of 0.2 and 0.25 mm. Although the most close measurements to the actual measurements was for 0.1 mm voxel , 0.2 mm also give similar results.
These results are similar to a study by Sun et al. they evaluated bone thickness on CBCT by comparing bone measurements of CBCT images with those of gold standard (measurements obtained by digital caliper) and they found that the measurements by 0.25 mm voxel were more accurate than those obtained by 0.4-mm voxel[18].
In our study, we found that there was significant differences between 0.1- and 0.2-mm as compared to 0.25 mm voxel. This is similar to the results reported by Tayman et al.[12], which reported over estimation of the volumes of alveolar bone defects which were caused by using smaller voxels. However, the design of present study was limited by relatively small sizes of the intrabony cavities. Larger voxels could be more accurate with larger defects.
Following the methodological set up, the present study also aimed to compare 2 software packages to measure the volumes of the defects (OnDemand 3D and Osirix). The results of our study revealed no differences between the measurements made by the 2 types of software programs and those of the gold standard except in one-walled defect and two-walled defect by 0.25 mm voxel. Also, in this study we found that there is no significant differences between the 2 software packages which can validate the use of both software packages for image analysis and treatment planning. This enhanced previous study by Melo *et al.*[19] who founded no statistical differences among four software packages (XoranCAT®, Dolphin®, KDIS3D® and InVivo®) in the detection of vertical root fractures.

4. Conclusions

1. This study shows that CBCT is very accurate in identifying and quantifying alveolar bone loss and
2. There is no significant difference between linear and volumetric measurements obtained from CBCT images with voxel sizes of 0.125 or 0.2 mm.
3. thus can be used in diagnosis of periodontal diseases. Both software used can give accurate results. Smaller voxels give more accurate results.
4. There is no significant difference between linear and volumetric measurements obtained from CBCT images with voxel sizes of 0.125 or 0.2 mm.

Both Ondemand 3D and Osirix software programs revealed high accuracy in volumetric measurement of alveolar bone defects

References

1. *Acar B, KamburoğluK.Use of cone beam computed tomography in periodontology. WJR2014; 6: 139-147.*
2. *Listgarten MA periodontal probing: what does it mean? J Cli Periodontal 1980; 7: 165-176.*
3. *Tugnait A, ClerehughV, Hirschmann PN. The usefulness of radiographs in diagnosis and management of periodontal diseases: a review. J Dent 2002; 28:219-226.*
4. *Mol A. Imaging methods in periodontology. Periodontology 2000, 2004; 34:34-48.*
5. *Quirynen M, Callens A, van Steenberghe D, Nys M. Clinicalevaluation of constant force electronic probe. J Periodontol1993; 64: 35–39.*
6. *Ziegler CM, Woertche R, Briefand J, Hassfeld S. Clinical indica4. tions for digital volume*

tomography in oral and maxillofacial surgery. Dentomaxillofac Radiol2002;31:126-130.

7. *Scarfe WC, Farman AG, Sukovic P. Clinical applications ofcone-beam computed tomography in dental practice. J CanDentAssoc2006; 72: 75-80.*
8. *Mol A, Balasundaram A. In vitro cone beam computed tomography imaging of periodontal bone. DentomaxillofacRadiol2008; 37: 319-324*
9. *Vandenberghe B, Jacobs R, Yang J. Diagnostic validity (oracuity) of 2D CCD versus 3D CBCT-images for assessing periodontalbreakdown. Oral Surg Oral Med Oral Pathol Oral RadiolEndod2007; 104: 395-401.*
10. *Mengel R, Candir M, Shiratori K, Flores-de-Jacoby L. Digitalvolume tomography in the diagnosis of periodontal defects:an in vitro study on native pig and human mandibles. J Periodontol2005; 76: 665-673.*
11. *Noujeim M, Prihoda T, Langlais R, Nummikoski P. Evaluationof high-resolution cone beam computed tomography inthe detection of simulated interradicular bone lesions. DentomaxillofacRadiol2009; 38: 156-162.*
12. *Tayman MA , Kamburoğlu K , Küçük Ö , Ateş SÖ & Günhan M. Comparison of linear and volumetric measurements obtained from periodontal defects by using cone beam-CT and micro-CT: an in vitro study. Clin Oral Invest. 2018 oct.3. doi: 10.1007/s00784-018-2665-x.*
13. *Walter C, Weiger R, Zitzmann NU. Accuracy of three-dimensional imaging in assessing maxillary molar furcation involvement. J Clin Periodontol 2010;37:436–441.*
14. *J. Fleiner, C. Hannig, D. Schulze, A. Stricker, and R. Jacobs, "Digital method for quantification of circumferential periodontal bone level using cone beam CT," Clinical Oral Investigations, vol. 17, no. 2, pp. 389–396, 2013.*
15. *Banodkar AB, Gaikwad RP, Gunjikar TU, Lobo TA. Evaluation of accuracy of cone beam computed tomography for measurements of periodontal defects. Journal of Indian Society of Periodontology, 2015; 19:285-289.*
16. *de Faria Vasconcelos K, Evangelista KM, Rodrigues CD, Estrela C, de Sousa TO, Silva MA. Detection of periodontal bone loss using cone beam CT and intraoral radiography. Dentomaxillofac Radiol 2012;41:64-69.*
17. *Kayipmaz S, Sezgin OS, Saricaoglu ST, Bas O, Sahin B, Küçük M: The estimation of the volume of sheep mandibular defects using cone-beam computed tomography images and a stereological method. Dentomaxillofac Radiol 2011; 40:165–169.*
18. *Sun Z, Smith T, KortamS, KimDG, Tee BC, FieldsH (2011) Effect of bone thickness on alveolar bone-height measurements from cone beam computed tomography images. Am J Orthod Dentofac Orthop 139:117–127.*
19. *Melo SL, Haiter-Neto F, Correa LR, Scarfe WC, Farman AG. Comparative diagnostic yield of cone beam CT reconstruction using various software programs on the detection of vertical root fractures. Dentomaxillofac Radiol. 2013;42(9):20120459.*

Comparison of volumetric measurements between truth and CBCT techniques and between Ondemand 3D App and Osirix in three walled defect

Three walled defect	**Truth**	**CBCT0.1**		**CBCT0.2**		**CBCT0.25**	
Volumetric measurement	34.1±16.8	Ondemand 3D App	Osirix	Ondemand 3D App	Osirix	Ondemand 3D App	Osirix
		33.54±16.06	33.65±15.7	34.06±15.7	33.35±14. 9	36.66±17.8	34.1±14.5
Comparison with truth		0.23	0.42	0.96	0.456	0.11	1.0
Comparison between Osirix & Ondemand 3D App		0.87		0.36		0.2	
Comparison of different voxel sizes Ondemand 3D App		p1=0.59 p2=0.06 p3=0.11					
Comparison of different voxel sizes Osirix		p1=0.71 p2=0.77 p3=0.61					

*used test :paired t test *statistically significant(p<0.05)*

Used test : Paired t test p1:comparison of CBCT 0.1 &0.2 , p2: comparison of CBCT 0.1&0.25 and ,p3: comparison of CBCT 0.2&0.25 with truth