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ACCURACY OF LINEAR MEASUREMENTS OBTAINED FROM TWO DIFFERENT SOFTWARE PROGRAM IN CONE-BEAM COMPUTED TOMOGRAPHY SCANS OF DRY HUMAN MANDIBLES

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ABSTRACT

Objectives: The aim of this study is to evaluate the accuracy of linear measurements performed with two different CBCT software. (Romexis® software and ONDEMAND 3 D software).

Methods: The sample consisted of fifteen dry mandibles marked with radiopaque markers of gutta-percha balls (size 80, 1.5 mm long) which were glued on the marked anatomical landmarks with cyanoacrylate gel, ten linear measurements were conducted on the dry mandibles using digital caliper to provide gold standard measurements. The mandibles were scanned by using Planmeca ProMax 3D Mid and images were exported into (DICOM) file then imported in to two software programs. The same ten linear measurements were conducted on the scanned images by using measure length tool of both romexis and Ondemand software programs.

Results: Intra-examiner reliability of gold standard and image measurements were found to be excellent, Inter-examiner reliability of physical and Romexis® software was found to be excellent (ICC>0.9) and the Inter-examiner reliability of physical and ONDEMAND 3 D software was found to be poor (ICC <0.5)

Conclusions: Romexis® software is more reliable method for planning surgical procedure in the dental practice than ONDEMAND 3 D software.

Keywords: Linear measurements, CBCT, dry mandible and software programs.

INTRODUCTION

CBCT is an image technique and volumetric reconstruction technique that allows us to obtain linear measurements using computer. CBCT can be applied in oral and maxillofacial surgery for surgical evaluation and treatment planning such as in orthognathic surgery and implant surgeries as well as in assessment of maxillofacial trauma. **(Blessmann M et al., 2007 and Natalia Z et al., 2013).**

Nowadays there are wide variety of many types of third party software which are highly indicated in the field of dentistry for assessment and analysis

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of many measurements to achieve proper treatment plan, such as surgical guide construction, implant placement and identify the bone interface ,so it is highly indicated to select proper software for obtaining high accurate linear measurements by length measurement tool**. (Fokas et al., 2018, Kamiyama et al., 2012, , Luangchana et al., 2015, Sabban et al., 2015, , Torres et al., 2012, Ganguly et al., 2016, Vasconcelos et al., 2015, Freire-Maia et al., 2017, Silva et al., 2017),**

There was a previous study to assess the accuracy of CBCT measurements in cases with periodontal disorder and another study to assess the accuracy of linear measurements from CBCT images by using different types of software programs**. (Sreih et al., 2019, Tolentino et al., 2018).**

The aims of this study is to measure the accuracy of the linear measurements recorded from CBCT images using Romexis® 3D imaging software and ,On Demands 3D software ,digital caliper was used to assess the linear measurements which represent the gold standard to assess the accuracy of CBCT linear measurements, it is very indicated to achieve high accuracy of linear measurements from 3rd party software program for proper treatment planning of orthognathic surgery, construction of surgical plates and proper analysis of the CBCT images for orthodontic treatment.

MATERIALS AND METHODS

Subject and study design

The current study was conducted on fifteen dry human mandibles. They were free from any pathological defects or fracture. Age and sex were not considered in this study. The mandibles were obtained from the Anatomy Department, Faculty of Medicine, Cairo University.

CBCT imaging of the Mandibles

The mandibles were scanned by using Planmeca Pro Max 3D Mid CBCT machine in Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Cairo University. Field of view (20 cm x10.2 cm), voxel size 400μm, 90 kVp, 10 mA and exposure time of 13.5 seconds.

Linear measurements of dry mandibles (gold standard):

The selected landmarks were detected on each mandible with placement of radiopaque markers of gutta-percha balls (size 80, 1.5 mm long) which were glued on the marked anatomical landmarks with cyanoacrylate gel**. (Table1).**

TABLE (1): Anatomical points used as references for the measurements.

C	Coronoid
MF	Mental foramen
MCO	Most medial point of the condyle in coronal plane.
Lco	Most lateral point of the condyle in coronal plane.
Ment	Most medial point of mental foramen.
MCC	Maximum chin convexity.

Ten linear Measurements were taken by radiologist with ten years' experience in 2 different sessions in standardized and comfortable optimum viewing conditions. **(Table2).** Observer conducted the measurements, and repeated them after 2weeks interval for intra-observer reliability. The linear measurements were taken and recorded using digital caliper with (0-150) mm measuring range and ±0.3 mm resolution accuracy. Direct linear measurements were taken from the middle of one gutta percha marker to the middle of the other one**. (Figure 1,2)**

TABLE(2): Description of the linear measurements used between different anatomical points.

	Measurements	Definitions
1	c^R-c^L	Inter-coronoid width. Linear distance between coronoid points
2	**Mf^R-Mf^L**	Inter-mental foramen width. Linear distance between mental foramen points
3	**C^R-Mf^R**	Linear distance between right coronoid point and right mental foramen
4	**C^R-Mf^L**	Linear distance between right coronoid point and left mental foramen
5	**C^L-Mf^L**	Linear distance between left coronoid point and left mental foramen
6	**C^L-Mf^R**	Linear distance between left coronoid point and right mental foramen
7	**Mco-Lco R**	Width of the right condyle
8	**Mco-Lco L**	Width of the left condyle.
9	**RtMent-MCC**	Most medial point of of the right mental foramen to maximum chin convexity.
10	**Lf Ment-MCC**	Most medial point of left mental foramen to maximum chin convexity.

N.B R= right L= left

Fig. (1): Showing inter mental distance using digital caliper

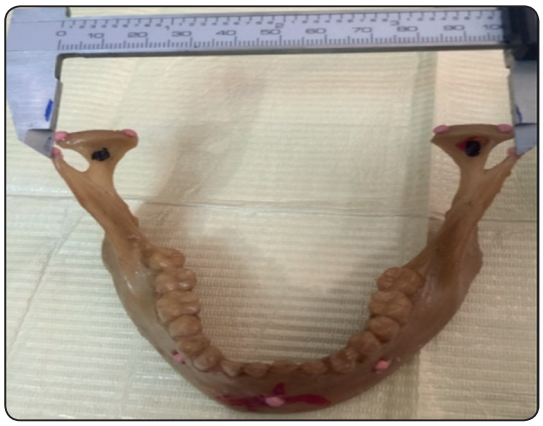

Fig. (2): Photograph of the mandible showing direct linear measurement of the distance between the Rt and Lf coronoid processes

Computer and software programs used

The CBCT images for each mandible were exported in (DICOM) file. The images were then transferred to a laptop, **(Lenovo idea pad, china).**

(Romexis® 3.6 software (Planmeca, Helsinki, Finland), and (ONDEMAND 3D software, Cybermed Inc.Korea) have been installed to the previous mentioned laptop.

Analysis of images and linear measurments:

CBCT images were exported in Digital Imaging and Communications in Medicine (DICOM) format .The DICOM datasets were imported into the software programs (Romexis® and OnDemand 3D software)

Linear Measurements from (Axial cut CBCT images)

The same previously mentioned linear measurements which were taken on the dry mandible were obtained from CBCT images of the mandibles for a later comparison with the gold standard.

Linear measurements had been taken using the function “Measure Length” of the softwares (Romexis® 3.6 software (Planmeca, Helsinki, Finland). And (ONDEMAND 3D software ,Cybermed Inc.Korea) to measure distances on the axial cuts CBCT images, the gutta percha markers were clearly displayed, and, by using the built- in ruler, the linear measurement was taken between the mid-points of the two designated gutta percha points and recorded**. (Figures 3a,b), (Figure4a,b).**

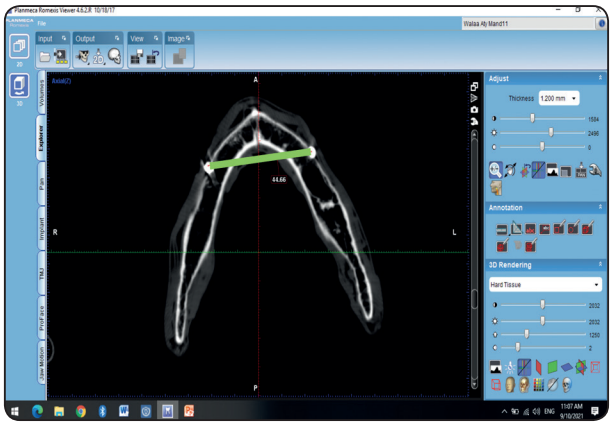

Fig. (3a) :Showing inte rmental distance using Romexis 3D ruler

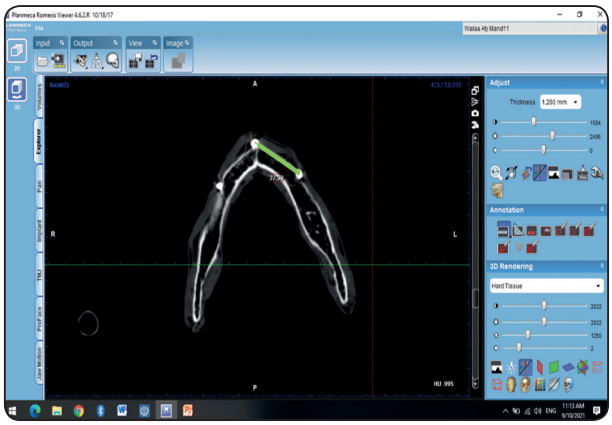

Fig. (3b): Showing linear distance from Lf mental foramen to maximum Chin convexity using Romexis 3D ruler

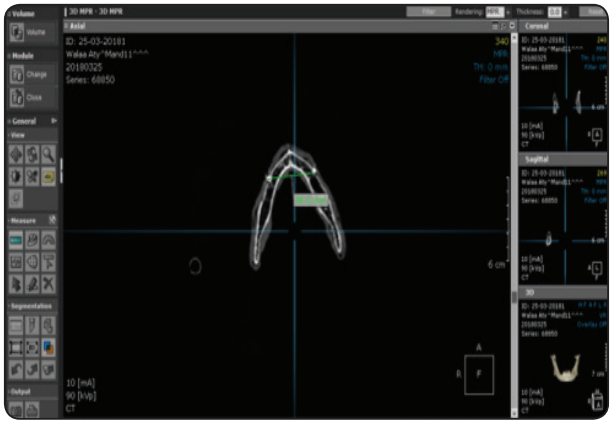

Fig. (4a): Showing inter mental distance using OnDemand3D ruler

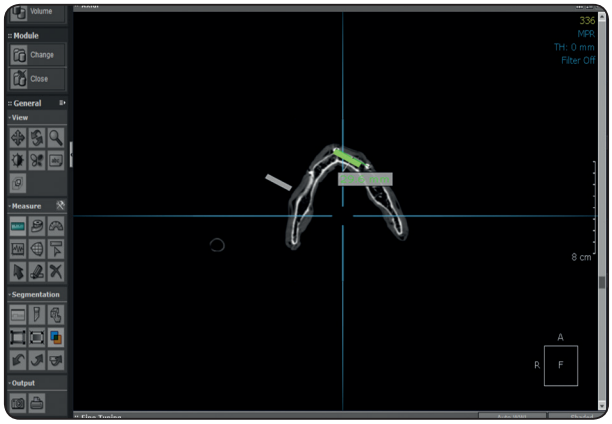

Fig. (4b): Showing linear distance from Lf mental foramen to maximum Chin convexity using OnDemand3D ruler

All caliper and CBCT measurements (millimeter) were separately recorded by well-trained single examiner of more than ten years' experience. The examiner measured the distances using digital caliper, Romexis® and ONDEMAND softwares, with calculation of the average of the measurements to achieve intra operator reliability

Reproducibility of measurements was assessed by repeating 60% of the measurements after a 2 weeks interval to eliminate memory bias.

Statistical analysis

The measurements of this study were calculated with the program (SPSS) version 18. The reliability of the gold standard (Physical) measurements, and the Ondemand and Romexis measurements were measured using the intra class correlation coefficient.

Wilcoxon Signed Rank test was used to assess the significance of the difference between the means of the absolute errors obtained by Ondemand and Romexis. Statistical significance was set at a p-value ≤ 0.05. Koo, T.K., Li, M.Y., 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J. Chiropractic

Medicine 15, 155–163.

RESULTS

I- ICC between different modalities (inter-examiner reliability)

a) Physical and Romexis measurements

(ICC>0.9) for left and right coronoid to the contralateral mental foramen, for left coronoid to the ipsilateral mental foramen and for right to left mental foramen. Right coronoid to the ipsilateral mental foramen and inter coronoid distance measurements' reliability was good (ICC *between 0.75 and 0.9*), while left and right condylar width reliability was moderate (ICC *between 0.5 and 0.75*). Right and Left mental foramen to chin convexity measurement had poor reliability (ICC *less than 0.5*) **(Table 1)**

b) Physical and ondemand measurements

The inter-examiner reliability of physical and ondemand measurements was found to be poor (ICC *less than 0.5*) for all measurements (Table 2)

II- Comparison of errors from the both software programs

The mean, standard deviation, median and range of the absolute error (mm) from physical values for Romexis and ondemand .**Fig. (4-5)**

There was no statistically significant difference in error values found Romexis and ondemand (p=value > 0.05) for all measurements; except Right coronoid To left mental foramen, Right mental to chin convexity and right to left mental foramen; where Ondemand recorded significantly higher value of error (p=0.041, p=0.005, p=0.001 respectively), while regarding left condylar width, Romexis recorded significantly higher value of error (p=0.005).

TABLE (1) Intraclass correlation (ICC) between Romexisus and physical measurements

Average Measures	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
1- Lf.coronoid To Rt mental	.932	.742	.979	19.206	14	14	.000*
2- Rt.coronoid To Lf mental	.956	.869	.985	21.456	14	14	.000*
3- Lf.Coronoid to Lf Mental foramen	.975	.927	.992	39.306	14	14	.000*
4- Rt.coronoid to Rt.mental F	.889	.668	.963	10.127	14	14	.0008
5- Lf. mental to chin convexity	.253	0	.665	1.893	14	14	.122ns
6- Rt.mental to chin convexity	0	0	.624	.954	14	14	.534ns
7- Rt-Lf mental foramen	.949	.664	.986	33.329	14	14	.000*
8- Inter-coronoid distance	.844	.553	.947	6.782	14	14	.000*
9-Lf. Cond width	.652	-.058	.884	2.791	14	14	.032*
10- Rt.Cond width	.646	.003	.879	2.902	14	14	.028*

Significance level P≤0.05, *significant, ns=non-significant

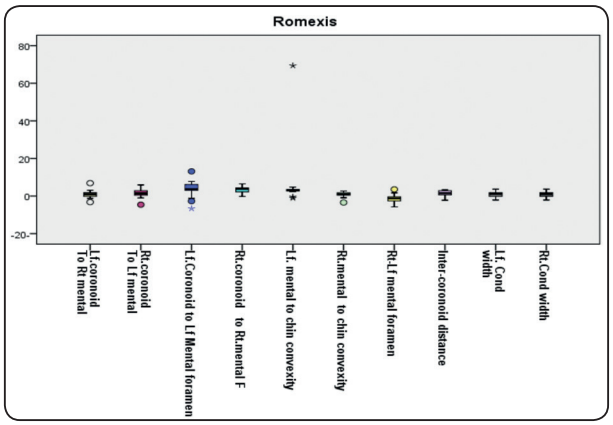

Fig. (5) The interquartile range and outliers of the absolute error values from physical measurements for the Romexis measurements.

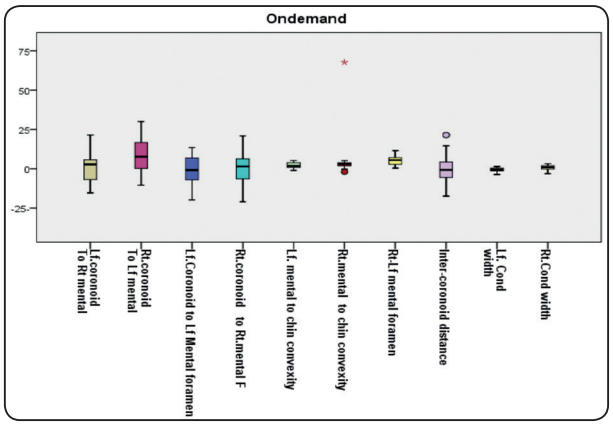

Fig. (6) The interquartile range and outliers of the absolute error values from physical measurements for the Ondemand measurements.

DISCUSSION

The present study evaluated the accuracy of the linear measurement by using two software programs which have not been previously investigated for this purpose. No statistically significant difference in measurement error was found between the two programs, but the inter-examiner reliability of physical and Romexis measurements was found to be excellent and The inter-examiner reliability of physical and Ondemand measurements was found to be poor.

This in-vitro study was conducted on fifteen dry human mandibles where ten anatomical landmarks were identified on each mandible .The mandibles were free from outstanding defects to avoid abnormal appearance of the CBCT image that could adversely affect the accuracy of measurements.

In this study ten anatomical landmarks were identified on each mandible using gutta-percha rods (size 80, 1.5 mm) that were glued on the identified landmarks. Then ten linear measurements were evaluated on each dry mandible which were considered as the gold standard.

The same ten linear measurements were evaluated by using the function "Measure Length" of the both softwares : (Romexis) and (ONDEMAND) .

Then the linear measurements of both soft wares were compared to the gold standard measurements.

This study evaluate the accuracy of linear measurements on dry mandibles which recorded by using two software programs, The main advantage of this study depends on the use of dry mandibles instead of humans, as the dry mandibles was stabilized properly with avoiding of voluntary or involuntary movements of patients.

Among the increasing number of software of CBCT which is used to managing DICOM images, the present study concentrated on two software programs: Romexis software and Ondemand software program.

The accuracy and reliability of the linear measurements which was obtained in this study was achieved by standardization of the position of dry mandible

Accuracy of measurements is a degree to which a measurements represent the true measurements). Many authors have tested the accuracy of CBCT images, but there are few studies have addressed the effect of software reconstruction on accuracy of linear measurements (**Melo SL et al, 2013).**

The results which obtained in this study are compatible with previous results from another studies performed by another CBCT machine by using different types of 3rd part software. **(Al Ekrish 2011).**

In this study, there was accuracy of the romexis software program, but it could not be related to other previous studies which examine the validity of different measurements which obtained from another Cone Beam Computed Tomography machine and different software program. **(Veyre-Goulet et al., 2008, Torres et al., 2012, Luangchana et al., 2015, Sabban et al., 2015, Ganguly et al., 2016, Freire-Maia et al., 2017, Silva et al., 2017)** .

The present results of no significant difference in measurement error between Ondemand and romexis CBCT software programs is in line with the results of **Vasconcelos et al. (2015) and Silva et al. (2017)** which reported no statistically significant difference between linear measurement by using different software programs **(Vasconcelos et al., 2015, Silva et al., 2017).** The programs investigated by **Vasconcelos et al. (2015)** were KDIS 3D, OnDemand, and XoranCat, and **Silva et al. (2017)** investigated the accuracy of another software program such as Imaging Studio.

The results of the present study are also in same line with results of a previous study which compared linear measurements of CBCT scans of dry mandibles using another software programs and found no statistically significant difference between the results which were obtained from the various software programs. **(Tolentino et al., 2018).**

The present results are in line with other studies, **Baumgaertel Set al 2009, Periago DR et al 2008, Poleti ML et al 2016 and, Ballrick JW et al 2008** which reported the high accuracy of linear measurements in relation to the gold standard**. (Ballrick *et al* 2008).**

The results of the present study should not be used to indicate the complete difference in accuracy between the different software programs. But, the results of this study should be compared with previous researches which detect the different reasons of inaccuracy in linear measurement by different CBCT software programs.

One of drawbacks of the present study is that images were obtained from a certain CBCT device and certain exposures parameters, but there are many different CBCT devices and many types of software programs and exposure parameter, which could affect the accuracy of measurements which obtained from CBCT images.

CONCLUSIONS

Measurements with Romexis software revealed high accuracy when compared with measurements with a digital caliper.

Measurements of anatomic distances with Ondemand software packages revealed moderate to poor accuracy when compared with measurements with a digital caliper.

There was no statistically significant difference in error values found between Romexis and ondemand (p=value>0.05) for most of the measurements.

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