

Evaluation of Precision of Dimensional Measurements on Conventional and Digital Panoramic Radiograph Using Dry Mandibles

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ABSTRACT:

Background: Panoramic radiograph is a routinely used screening radiograph. Both conventional and digital panoramic radiographs are plagued with magnification errors and disproportional enlargement. To date no study has been conducted to compare the accuracy of dimensional measurements between conventional and digital panoramic image. Hence this study was undertaken to evaluate dimensional accuracy of two panoramic systems by comparing them with the anatomical dimensions.

Methods: 20 human mandibles were imaged using digital and conventional panoramic systems and their various horizontal and vertical measurements were compared with its actual anatomic dimensions.

Result: Among the nine specific sites selected for evaluation only 1 horizontal dimension of conventional panoramic radiograph and 2 vertical and 2 horizontal dimensions of digital panoramic radiograph were not significantly different from the actual dimension of dry mandible.

Conclusion: Dimensional measurements on panoramic radiographs cannot be reliably used for clinical application. However, when compared to conventional film based panoramic images digital images provided a better precision in dimensional measurements

Keywords: Digital Radiograph, Magnification, Panoramic Radiograph.

INTRODUCTION

Panoramic radiography conveniently provides the clinician with a comprehensive view of the maxillo-mandibular region, producing the image of both dental arches on a single film.¹ With the advances in electronics and computer science, digital imaging is becoming more popular and digital panoramic radiography may eventually replace film based conventional panoramic radiography.² The basic technique of digital panoramic radiography is same as that used in conventional machines.³ Image magnification and distortion are thus common for both conventional film based panoramic radiography and digital panoramic radiography.

In conventional panoramic radiography the dimensions can be determined easily using calipers. In contrast, a software measurement algorithm has to be used in digital panoramic radiography.³ The images are to be imported

into the software and after calibration of the measuring tool, measurements are to be made.

Laster et al in their study to assess the accuracy of measurements of mandibular anatomy in conventional panoramic radiographic images concluded that panoramic radiographs should be used with caution in making absolute measurements or relative comparisons.⁴ Scultze et al in their study to evaluate the precision and accuracy of measurements in digital panoramic radiography showed that digital measurements are sufficiently accurate for clinical use.³ To the best of our knowledge, no study has been conducted so far to compare the accuracy of dimensional measurements on conventional panoramic radiograph and digital panoramic images. Hence this study was undertaken to evaluate the accuracy of the dimensions measured on conventional panoramic images and digital panoramic images by comparing them with the anatomical dimensions.

MATERIALS AND METHODS

This study was conducted in the Department of Anatomy and Department of Oral Medicine and Radiology, MCOADS, Manipal. Twenty dry human mandibles of average size were selected from anatomy department. The mandibles were not identified by age, gender or ethnic group. Dental status of the mandibles varied from fully dentulous, partially edentulous to fully edentulous state. Institutional ethical committee approval was obtained prior to performing the study. (IEC 118/2009)

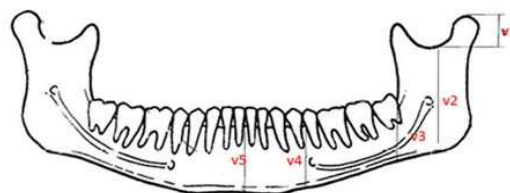
METHODS

Dry mandible

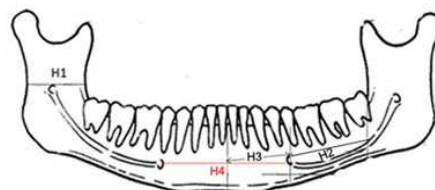
Metal markers (stainless steel balls of 3 mm diameter) were fixed at specific points on the mandible with the help of clear adhesive tape to denote the landmarks/points from which distances were measured (Figure 1). Once fixed, they were not removed until imaging by both modalities (conventional and digital) was completed. A metal wire of 1 cm length was also placed in the ramus region of the dry mandible in order to manually calibrate the length in the software for the digital measurement in ramus region and in other regions vertical diameter of metal ball was used as reference length. Divider and scale were used to make the measurements. Measurement of the nine vertical and seven horizontal distances on the dry mandible was done using a divider and scale.(Figure 2)



Figure 1: Metal markers in place



V1= condylar height
 V2=distance between sigmoid notch and gonial point
 V3= distance from the junction of anterior border of ramus and upper border of mandible to the lower border of mandible
 V4= distance between upper and lower border of mandible in mental foramen region
 V5= distance between upper and lower border of mandible in mid sagittal plane



H1=Width of ramus from the superior portion of mandibular foramen
 H2=width of the line joining midpoint of mental foramen to the midpoint of line (drawn from the junction of anterior border of ramus and upper border of mandible to inferior border)
 H3=width from midpoint of mental foramen to pt at midsagittal line
 H4=width from midpoint of right mental foramen to midpoint of left mental foramen

Figure 2: Landmarks for horizontal and vertical measurements

Conventional Panoramic image

Conventional panoramic image of dry mandible with the attached metal markers was obtained with PLANMECA 2002 Panoramic machine.(Figure 3)



Figure 3: Positioning of mandible in conventional panoramic machine

The mandible was stabilized in the panoramic machine with a custom made thermocol stand with a thermocol rod raising the posterior aspect of the mandible to simulate normal patient positioning. Anterior, posterior and sagittal positions were marked with laser beam positioning indicators and thermocol stand was also marked with pencil so as to maintain the same position for digital panoramic machine. Exposure parameters selected were 60 kVp, 4

mA current, and exposure time was 18 seconds. 21 aluminum sheets each of 0.5 mm thickness were fixed over the x-ray tube head with the help of plaster tape in order to reduce the exposure.(Figure 3) Kodak T-Mat Ektavision film was used and the film was processed in Promax automatic processor.

Digital radiographic image

The digital panoramic image was obtained using Kodak 8000c panoramic machine that used a fiber optic charged couple device (CCD) sensor as the image receptor. The mandible was positioned in the machine using the laser beam guides to exactly the same points as positioned when in the conventional machine. Exposure parameters used for the digital panoramic machine were 60 kVp, 2 mA current, exposure time 13.2 seconds

Measurements on the conventional and digital radiographic images

The measurements on the conventional panoramic radiograph were performed by placing it on a view box and tracing the required points with pencil. Measurements of all the vertical and horizontal distances were made with the help of ruler, considering the center of the ball as a reference point. The Kodak dental imaging 6.6 software provided along with the digital panoramic machine was used to measure the various dimensions on the digital images. The linear measurement tool of the software was first manually calibrated in each area based on the known dimension of wire and metal ball.(Figure 4)

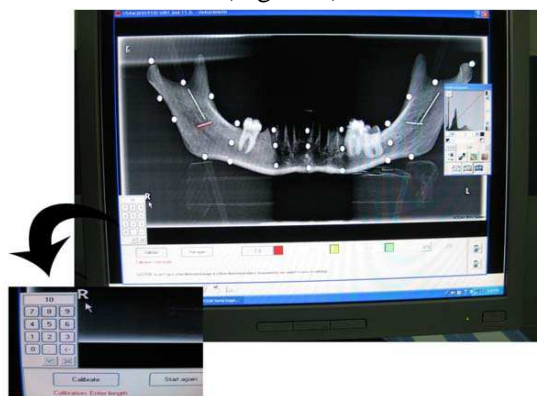


Figure 4: Measurement being done using Kodak software

The right and left measurements for the bilateral linear dimensions were averaged. The dimensional measurements were then compared with each other. An intraclass correlation test was designed to assess reproducibility. Another examiner measured the same distances on 8 images to assess inter-examiner reliability and same person who conducted the study repeated the measurements again after one month to assess intra-examiner reliability.

Statistical Analysis

Statistical analysis was done using SPSS version 16.0. Repeated measures were taken for Statistical significance. The p-value was set at 0.05. One sample t-test was used to compare the difference in the measurements. Statistical reliability analysis was done using intra class correlation test

RESULTS AND OBSERVATIONS

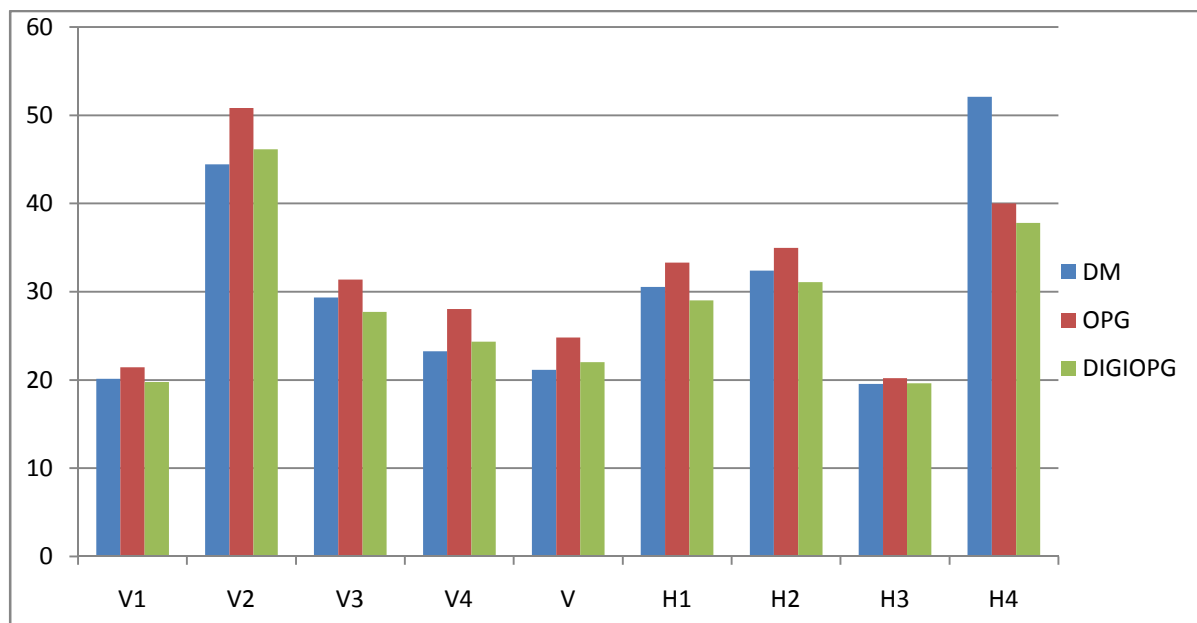
Five vertical dimensions and four horizontal dimensions were measured on each of the dry mandibles and on their corresponding panoramic film images & digital panoramic images and were compared.. The results of the study were as follows:

Table 1 shows the mean value of measurement in all three groups (dry mandible, conventional radiograph and digital radiograph). It shows that the mean values of the dimensions on conventional panoramic images were greater in all regions except H4 region, where it was smaller than dry mandible but still greater than digital OPG. It also shows mean values of dimensions on digital OPG to be lesser than dry mandible in V1, V3, H1, H2, H4 region and greater in V2, V4 and V region. In H3 region the dimension in digital OPG was closer to dry mandible measurement. **Intra-observer reliability** in conventional panoramic radiograph for vertical measurements ranged from 0.908 to 0.976 and for horizontal measurements it ranged from 0.927 to 0.991. In digital panoramic radiograph intra-observer reliability for

Table 1: Comparison of measurements in digital panoramic radiograph and conventional panoramic radiograph

Dimensions	DM	OPG	DIGI	OPG	t value	p value	DIGI	t value	p value
	mean	mean	mean	diff 1			diff 2		
V1	20.12	21.42	19.76	1.30	2.50	0.022	-0.359	-0.91	0.375
V2	44.45	50.82	46.15	6.37	13.53	<0.001	1.700	2.12	0.048
V3	29.36	31.37	27.73	2.01	5.74	<0.001	-1.627	-4.07	0.001
V4	23.25	28.03	24.33	4.78	12.46	<0.001	1.082	1.97	0.064
V	21.13	24.80	22.02	3.66	11.97	<0.001	0.885	2.49	0.022
H1	30.55	33.30	29.03	2.75	6.70	<0.001	-1.515	-2.69	0.014
H2	32.40	34.99	31.08	2.58	3.25	0.004	-1.329	-1.68	0.109
H3	19.57	20.20	19.61	0.63	0.43	0.672	0.052	0.04	0.966
H4	52.07	40.02	37.81	-12.05	-10.63	<0.001	-14.26	-15.37	<0.001

DM=dry mandible, OPG=conventional panoramic radiograph, DIGIOPG=digital panoramic radiograph



DM=dry mandible, OPG=conventional panoramic radiograph, DIGIOPG=digital panoramic radiograph

Figure 5: Comparison of mean value in three groups

vertical measurements ranged from 0.908 to 0.979 and for horizontal measurements it ranged from 0.927 to 0.991

Inter-observer reliability in conventional panoramic radiograph for vertical measurements ranged from 0.881 to 0.981 and for horizontal measurement it ranged from 0.927 to 0.991. In digital panoramic radiograph inter-observer reliability for vertical measurements ranged from 0.881 to 0.981 and for horizontal measurements it ranged from 0.91 to 0.981.

DISCUSSION

In the study it was found that only the horizontal distance (H3) on conventional image correlated with actual distance. In digital images, out of nine dimensions, four were closer to the actual measurements i.e. V1, V4, H2 & H3. A thorough search of literature was done to find out if there are any studies like this to compare the precision of dimensional measurements in different regions of conventional and digital panoramic images but no such study was found.

Maximum difference in measurement was observed in symphyseal region i.e. horizontal measurement crossing the midline. This result was in agreement with the observations made in the study by Amir et al⁵ who also found the same. However in their study, measurements were magnified as they had taken the dimension from right condylar head to left condylar head and right coronoid process to left coronoid process. In contrast, in our study measurements were minified because the dimensions were considered from midpoint of right mental foramen to midpoint of left mental foramen. Our result can be explained by the fact that panoramic image is two dimensional like other radiographs while the mandible is a three dimensional structure with its curves and contours. Moreover, the film cassette is flat and not curved. This can be interpreted as the measurements in a curved plane may be more than measurement in a straight plane.

An attempt was also made in this study to evaluate the reproducibility of dimensional measurements by determining intra and inter observer variability. Digital measurements were done by manually calibrating the linear measurement tool of the software in each area based on the known dimension of wire and metal ball. The calibration had to be done repeatedly for the measurements in various areas because the calibration done for the particular area holds good for only a one inch strip in that area. Based upon the findings of the study, the intra and inter-observer reliability were high.

CONCLUSION

The following conclusions were drawn from the study.

- Among the five vertical and four horizontal dimensions measured on conventional panoramic radiographs, only the horizontal distance between the midsagittal line and midpoint of mental foramen (H3) was not significantly different from the anatomical dimensions measured on the dry mandible.

Hence dimensional measurements on conventional panoramic radiographs cannot be reliably used for clinical applications.

- Among the five vertical and four horizontal distances measured on digital panoramic images, two vertical (V1&V4) and two horizontal dimensions (H2&H3) were not significantly different from the actual (anatomic) dimensions measured on the dry mandible. The digital images thus provided greater precision in dimensional measurements compared to conventional panoramic radiographs.

The conclusions drawn from this study may provide a guideline in choosing the panoramic imaging modality and in predicting the reliability of the dimensional measurements in various areas of the image. However, this study used dry mandibles; a similar study using human subjects is recommended to determine the precision of dimensional measurements in real life situations

CONFLICT OF INTEREST

The authors declare no conflict of interest

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