Evaluation of the Precision of Dimensional Measurements of the Mandible on Panoramic Radiographs

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ABSTRACT

Objectives: The purpose of this study was to assess the accuracy of panoramic radiography in measuring the linear dimensions.

Materials and methods: Various vertical, horizontal, oblique and angular parameters were denoted by metal markers and were measured on 30 dry mandibles with the use of calipers. The same mandibles were then positioned on panoramic machine, EC Proline and radiographic images of them were made. Measurements of the same distances were made on panoramic images and then compared with the measurements on the dry mandible. All the results were statistically analyzed.

Results: The measurements made on dry mandibles as well as on the panoramic images of the same revealed that they were statistically significant. The results of the measurements showed that the calculated magnification indices were lower than the manufacturer’s magnification index for the vertical, horizontal, oblique and angular measurements so long as the distance measured is on only one side of the mandible, whereas the calculated magnification Indices for the vertical, horizontal, oblique distances which traversed the midline of the mandible, were greatly enlarged than the manufacturer’s magnification index.

Conclusion: It was concluded that it is possible to use panoramic radiography for linear measurements of vertical, horizontal or oblique variables provided it is on only one side of the mandible.

Keywords: Panoramic radiography, Magnification index, Dimensional accuracy.

INTRODUCTION

Panoramic radiography, a simplified extraoral radiographic procedure, which visualizes the entire maxillofacial complex on a single film, has become a valuable adjunct to conventional extraoral radiographic procedures. The simplicity of the operation, the broadened scope of examination, the ability to project anatomic structures in their normal relationship with reduced superimposition of intervening parts and low radiation dosage are reasons for its widely growing popularity.1-3

Additionally, panoramic films are useful for making dimensional assessments of the bone, for the location of implants and determining relative angulations of the teeth with other structures.4 Panoramic radiography is frequently used to visualize root parallelism and mesiodistal tooth angulations, the relative position of the roots and restorative abutments.5 Panoramic radiographs are readily available and are cost effective.

The position of an object between the X-ray source and the film is responsible for magnification seen on radiograph and in the sharply depicted layer, the image is free of distortion, which means that magnification is same for both vertical and horizontal planes. Objects outside this layer will appear distorted in the image because of the difference between the velocity of the film and the velocity of the projection of the object, in relation to the tube and the film.

Magnification is the ratio of focus-to-film and focus-to-object distances. In the vertical dimension, the magnification would be calculated by dividing the distance from the X-ray source to the film by the distance from the X-ray source to the object. In the horizontal dimension, since the focus is different, it would be necessary to divide the distance from the intraoral rotation center to the film by the distance from the rotation center to the object.

MATERIALS AND METHODS

A study was undertaken to evaluate the accuracy of panoramic radiographs at The Oxford Dental College, Bengaluru, during the period of 2005 to 2006.

The following armamentarium was used to execute the research. These are as follows:
- 30 dry human mandibles
- 30 panoramic images of the dry human mandibles
- Metal marker lead wire
- Digital calipers
- Vernier calipers
• Protractor
• Marker pen
• OPG machine model EC Proline, made by Planmeca
• Dry printer (Dry Star 5302)
• Holder.

The entire procedure could be summarized as follows: Dry human mandibles were acquired from the department of anatomy. The dental status varied from fully dentate to completely edentulous. Lead wires were used as metal marker, in the form of 1 mm diameter as landmarks, to denote the points at which the distances were measured. The lead wire was cut into small pieces of 3 mm length with the help of a wire cutter and these metal markers were placed on the dry mandibles with the help of glue. Various vertical, horizontal, oblique distances and angles were measured on 30 dry mandibles. The measurements were made first on the dry mandibles by means of digital calipers (Fig. 1), Vernier calipers, to measure the distances between Co-Co, PM-PM, Go-Go and protractor for measuring the angular parameters. After the first step, a holder was fashioned so that the mandibles could be positioned in the cephalostat of the orthopantomographic machines so that placement of these could be standardized. Each mandible was exposed in the orthopantomographic machine with exposure parameters of 6 mA and 60 kvp. The vertical, horizontal, oblique distances and angles were measured on 30 panoramic radiographs of the same (Fig. 2).

The manufacturer lists the magnification factor for that OPG machine as 1.1×. The magnification index was calculated for each distance through the use of following formula:

$$\text{Magnification index} = \frac{\text{distance on the radiograph}}{\text{distance on the dry mandible}} \times \text{magnification} = \frac{x \text{ radiograph}}{x \text{ mandible}}.$$

The various vertical distances were measured on panoramic images and mandibles were as follows:

1. $UBM-LBM(S)$: Distance between upper and lower border of mandible in sagittal line.

2a. $R\ UBMM-LBM(FM)$: Distance between upper and lower border of mandible in line perpendicularly drawn at medial opening of right mental foramen.

2b. $L\ UBMM-LBM(FM)$: Distance between upper and lower border of mandible in line perpendicularly drawn at medial opening of left mental foramen.

3a. $R\ UBMM-LBM(8)$: Distance between the upper and lower borders of mandible in line perpendicularly drawn at the distal border of crown of right third molar or at the mesial border of trigonum retromolare in edentulous mandible.

3b. $L\ UBMM-LBM(8)$: Distance between the upper and lower borders of mandible in line perpendicularly drawn at the distal border of crown of left third molar or at the mesial border of trigonum retromolare in edentulous mandible.

4a. $R\ Co-Inc$: Right condylar height.

4b. $L\ Co-Inc$: Left condylar height.

The various horizontal distances were measured on panoramic images and mandibles were as follows:

A. Measurements that extend across the midline.

1. $Co-Co$: Distance between highest points of left and right condylar processes.

2. $PM-PM$: Distance between highest points of left and right coronoid processes.

3. $Go-Go$: Distance between left and right gonion points.

B. Measurements that do not extend across the midline.

4a. $R\ LBM(S)-GO$: Distance between the lower border of mandible in sagittal line and gonion point of right side of mandible.

4b. $L\ LBM(S)-GO$: Distance between the lower border of mandible in sagittal line and gonion point of right side of mandible.

5a. $RW$: Width of right ramus.

5b. $LW$: Width of left ramus.

6a. $R\ Co-PM$: Distance between highest points of right condylar process and highest point of right coronoid process.

6b. $L\ Co-PM$: Distance between highest points of left condylar process and highest point of left coronoid process.

The various oblique distances which were measured on panoramic images and mandibles were as follows:

1a. $R\ Wp-CM$: Distance between the point of posterior ramus width on the right side and point of upper entrance in mandibular canal.
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1b. \( L \ Wp-CM \): Distance between the point of posterior ramus width on left side and point of upper entrance in mandibular canal.

2a. \( R \ Co-S \): Distance between highest point of right condylar process and lower border of mandible in sagittal line.

2b. \( L \ Co-S \): Distance between highest point of left condylar process and lower border of mandible in sagittal line.

The various angular measurements which were made on panoramic images and mandibles were as follows:

1a. \( R \ Go-angle \): Angle between tangents of right corpus and right ramus of mandible.

1b. \( L \ Go-angle \): Angle between tangents of left corpus and left ramus of mandible.

All the vertical, horizontal, oblique and angular parameters were measured on the dry mandibles and panoramic images of the same. All the measurements were statistically analyzed.

METHOD OF STATISTICAL ANALYSIS

The following methods of statistical analysis have been used in this study.

The results for each parameter averaged (mean ± standard deviation) measured on the mandibles and their radiographic, as well as their calculated magnification indices with 95% confidence intervals are presented in Tables 1 and 2 Figures 1 and 2.

The Student’s t-test was used to determine whether there was a statistical difference between calculated magnification indices and manufacturer magnification indices in the parameters measured.

Student’s t-test is as follows:

\[

t = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}},
\]

where \( s_1 \) and \( s_2 \) are the standard deviations of the two samples, \( n_1 \) and \( n_2 \) are the sample sizes.

In the above test the p-value of less than 0.05 was accepted as indicating statistical significance. Data analysis was carried out using statistical package for social science (SPSS, V 10.5) package.

RESULTS

Descriptive statistics (x, standard deviation, standard error) for all vertical, horizontal, oblique and angular measurements were calculated as well as their calculated magnification indices.

Table 1 shows the mean and standard deviation of vertical measurements of the panoramic radiographs and the mandibles and the calculated magnification indices and it was observed that all the calculated magnification indices were less than the index listed by the manufacturer (1.1×). The results are graphically represented in Graphs 1 and 2.

Table 2 shows the mean and standard deviation of horizontal measurements on the panoramic radiographs and the mandibles and the calculated magnification indices and it was observed that the calculated magnification indices for Co-Co, PM-PM and Go-Go were greatly enlarged than the manufacturer’s magnification index (1.1×), whereas calculated horizontal measurements with respect to others were less than the magnification index given by the manufacturer of panoramic machine (1.1×) (Graphs 3 and 4).

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<th>Table 1: Significance of difference between calculated magnification indices for vertical variables and magnification index (1.1×) listed by manufacture of device used</th>
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Table 2 shows that the calculated magnification indices and the manufacturer’s magnification index and it was observed that the measurements between Co-Co, PM-PM and Go-Go were statistically significant and these calculated magnification indices were more than the manufacturer’s magnification index. This indicates that these horizontal measurements which cross the midline should not be considered. The other horizontal measurements that is the ones which do not cross the midline, even though they were statistically significant, it was observed that the calculated magnification indices were less than the manufacturer’s magnification index (1.1×) and these measurements could be used (Graphs 3 and 4).

DISCUSSION
Panoramic radiography by far is a very popular and widely accepted technique. Apart from the routine uses, it is also used for dimensional and angular measurements which helps to determine the inclinations of impacted teeth, relative position of the roots and for implant site assessment.

However, one of the shortcomings of panoramic radiographs is image distortion. Magnification or distortion is an inherent property of panoramic machine. Taking this into account, the present study was conducted with an aim of evaluating the precision of dimensional measurements made from panoramic radiographs.

The calculated magnification indices of vertical measurements on the panoramic radiographs ranges from 0.99 to 1.06 and shows that it is lower than the manufacturer’s magnification index (1.1×) (Table 1 and Graphs 1 and 2). The differences between calculated magnification indices and the manufacturer’s magnification indices were statistically significant (p < 0.05), indicating that these vertical measurements could be used in panoramic radiography with precision.

This was observed so because the mandibles were encompassed in the central plane of the image layer that is in the focal trough where the distortion is least and the vertical dimensions of the beam depend on projection factor with X-ray as its functional focus. The vertical dimension of the beam allows a large area of an object to be sharply projected. Shape and size distortions of radiographic images in the vertical plane are a function of projection factors of alignment of the film,
Panoramic radiography is an effective method for measuring the linear measurements of vertical, horizontal, oblique and angular variables if it is on only one side of the mandible by knowing the magnification factor. Dimensions of the structures on the orthopantomographic images are similar to the actual dimensions of the filmed structures as long as the parameters measured do not traverse the midline of the mandible.

CONCLUSION

Panoramic radiography is an effective method for measuring the linear measurements of vertical, horizontal, oblique and angular variables if it is on only one side of the mandible by knowing the magnification factor. Dimensions of the structures on the orthopantomographic images are similar to the actual dimensions of the filmed structures as long as the parameters measured do not traverse the midline of the mandible.

REFERENCES