Original Research

The Effect of Changing Focal Trough in a Panoramic Device on the Accuracy of Distance Measurements

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Abstract

Introduction: Magnification and distortion are the most important limitations of panoramic radiography. The aim of this study was to determine the effects of changing focal trough option of Planmeca SCARA 3 on the accuracy of linear distance measurements. **Materials and Methods:** In this *in-vitro* study, 28 pieces of gutta-percha were attached to the assumptive place of each lost root of an adult dry skull with average size and normal shape. The actual measurements were obtained by a digital caliper. The panoramic images of the skull were taken in six different sizes and shapes of focal trough. This procedure was repeated ten times with new gutta-percha. Paired *t*-test was used to compare the values of different actual and radiographic images of gutta-percha dimensions. **Results:** The mean difference [standard deviation (SD)] between actual measurement and panoramic radiography in the different groups was from 0.37 (1.1) to 0.58 (2.87) mm. The mean (SD) difference of linear measurements between real and radiographic images was 0.52 (0.43) mm in average size, V-shaped group, which was statistically and clinically significant ($P = 0.00$). **Conclusion:** Changing the focal trough option of Planmeca SCARA 3 has minimal effects on the accuracy of linear measurements in panoramic radiographs.

Keywords: Image distortion, magnification, panoramic

Introduction

Panoramic radiography has become popular in the past decade[1] owing to its low radiation dose, ease of examination, and short time required to take the radiograph.[2] It also facilitates the overall assessment of the quantity and quality of the bone, dentition, temporomandibular joint and dentomaxillofacial trauma.[3-5] However, there are two main disadvantages in panoramic imaging, namely, distortion and magnification.[6,7] Unequal magnification and geometric distortion are important limitations associated with panoramic radiography. There are vertical and horizontal dimensional distortions in panoramic images, and the combination of these distortions causes angular distortion.[8]

A previous study showed that participant position plays a critical role in panoramic radiography in preventing distortion, making the image too wide or too narrow.[9] Researchers have demonstrated that corrected participant position is necessary for providing an accurate measurement of structures in panoramic radiographs.[10]

Image sharpness in panoramic radiographic images is related to the image layer, which varies from one panoramic X-ray device to another.[11] Accurate images can be obtained when the object is placed in the focal trough. In this layer, the X-ray tube and sensor have similar speed.[12,13] The focal trough layer is a three-dimensional curved layer. This layer consists of three different positions: middle, inner, and outer. In the middle portion, magnification factors are balanced, and images have less distortion; however, in the inner and outer portions, they are dissimilar, and in most cases, magnification of the horizontal axis causes the distortion of the images.[14]

The shape and location of focal trough layer have changed in more recent dental panoramic devices. This layer is changed by the different movements of device around the

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object.[15] While the formation of a radiographic image in the different positions of the participant has shown different magnifications in both horizontal and vertical axes,[16,17] there is not enough evidence on the effects of changing focal trough in panoramic devices on longitudinal measurements. The aim of this study was to determine the effects of changing the shape and size of focal trough on linear distance measurements in panoramic radiography.

Materials and Methods

This *in-vitro* study was conducted in Isfahan University of Medical Sciences on one adult human dry skull with average size and normal shape. This research was approved by the ethical committee of Isfahan Dental School Research Center (#192013).

To determine the linear measurement (horizontal and vertical), 28 pieces of opaque gutta-percha were attached on the assumptive place of each root in the one quadrant of mandible and maxilla with glum (Super Glue, Razi, Iran). By a digital caliper (Guanglu, Tahizeu, China) with 0.01 mm accuracy, the actual linear measurements were determined.

For reconstruction of temporomandibular joint in the skull, one piece of the base plate wax with 1.5 mm thickness between condyle and glenoid fossa was used. The jaw was fixed in the centric relation position with adhesive tape. Then, the skull was fixed by a polyvinyl plastic pipe, which is attached to the video tripod (Zeiss Universal Tripod FT6302, Oberkochen, Germany). Then, the skull was placed in the optimal position in the panoramic unit: the Frankfurt plane was set parallel to horizon and the midline of skull was match to the device midline. The panoramic digital images of the skull were obtained by Planmeca SCARA 3 Helsinki – Finland, with coupled charge device detector at 54 kVp, 8 mA and 16 s imaging time, based on pilot study [Figure 1].

Panoramic program of this panoramic device provided nine focal trough options including the shape of skull (square, normal, and V) and the size (small, normal, and wide). In this study, six types of images were obtained based on focal troughs: (1) average size, V shaped; (2) average size, normal shape; (3) average size, square shape; (4) wide size, V shaped; (5) wide size, normal shape; and (6) wide size, square shape. It should be noted that because the skull belonged to an adult human, the small size option of focal trough was not considered. Then, the gutta-percha was removed from the skull and new gutta-percha with a different size was replaced. The process of replacing gutta-percha with a new one and taking the images was repeated ten times. The images were obtained by Romexis software and a 22-inch screen monitor (LG, Seoul, Korea) with 1440 × 900 pixels resolution. The linear measurements were observed by two researchers separately.

Figure 1: Panoramic digital images of the skull were obtained by Planmeca SCARA 3

To analyze, Statistical Package for the Social Sciences version 20.0 software (IBM Corp., Released 2011, IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY: IBM Corp.) was used. Intraclass correlation coefficient (ICC) was used to analyze the interobserver reliability of measurement ($\alpha = 0.05$). Paired *t*-test was used to compare the linear measurements of actual and radiographic images ($\alpha = 0.05$). The differences of more than 0.5 mm were considered as clinically significant.[18]

Results

According to ICC values, interobserver correlation was 0.994 (*P*-value <0.001).

The mean [standard deviation (SD)] difference between actual measurement and panoramic radiography in the different groups was from 0.37 (1.1) to 0.58 (2.87). The mean (SD) difference of linear measurements between real and radiographic was 0.52 (0.43) mm in average size, V-shaped group, which was statistically and clinically significant. The other groups were not significantly different either clinically or statistically [Table 1].

The confounding factors including the jaws (upper and lower), direction of linear measurement (vertical and horizontal), and region of measurements (molar, premolar, canine and incisors) were evaluated. The upper and lower jaws ($P = 0.03$) and the direction of linear measurements ($P = 0.00$) showed may influence the linear measurement between actual and images measurements. However; the region of measurements may not influence the linear measurements ($P = 0.2$).

Discussion

To date, there has been limited research on the effects of changing focal troughs on the accuracy of vertical and horizontal measurements. The aim of this study was to

Table 1: The mean (SD) difference of linear measurements between actual and radiographic

Group	Mean difference (SD)	*P*-value†
Average size – V shaped	0.52 (0.43)	0.00
Average size – normal shape	0.43 (0.46)	0.00
Average size – square shape	0.44 (1.29)	0.00
Wide size – V shaped	0.41 (0.44)	0.00
Wide size – normal shape	0.37 (1.1)	0.00
Wide size – square shape	0.58 (2.87)	0.01

Data are presented by mm. †Pair *t*-test.

compare different focal troughs options of panoramic machine on linear measurements. The dimensions of focal trough have been determined by the measurements of the machines on the basis of mathematical formulations.[12,18] In the new brand panoramic machine, the focal trough area could be changed with options on the panoramic machine.[2]

The mean difference between actual measurement and panoramic radiography in the different groups was from 0.37 to 0.58 mm. This finding was consistent with those of Sonick *et al*.,[19] showing the difference between panoramic radiography and actual measurement on normal head position, from 0.5 to 7.5 mm (mean: 3 mm). This result suggests that the focal troughs have a minimal effect on the accuracy of linear measurement in panoramic radiographs. Furthermore, Peker *et al*.[20] studied three different imaging techniques including panoramic radiography, conventional tomography, and computed radiography scan to localize the mandible canal location before placing an implant. In their study, six dry human mandibles were used to measure the vertical distances for different posterior locations. They concluded that there were no overestimations more than 1 mm.

This study showed that magnifications varied among different focal troughs, although most of them were not clinically important. Only the average size V-shaped group showed both clinically and statistically significant difference. This finding was in line with that of Lund and Manson-Hing,[12,18] who studied different focal troughs in different panoramic machines. They demonstrated that magnification varied among machines, but their difference was very minimal. However, previous studies have revealed that the accuracy of linear measurement on panoramic image can be affected by the size, form, and position of the jaws in panoramic devices,[21] changing the focal trough area with options on panoramic device that could not improve the accuracy of image.

It was shown that the position of the participant (anterior or posterior to the middle of focal trough) affected the horizontal dimensions more than vertical dimensions. Because of the horizontal rotation of the X-ray source, vertical dimensions were more reliable than the horizontal dimensions.[11,22,23] In addition, the present study demonstrated that the region of interest in the jaws may not affect the accuracy. These findings did not support the previous research conducted by Hoseini Zarch *et al*.[24] They calculated the highest differences between actual measurements and radiographic measurements for anterior location. This contrast might be due to different panoramic machines and different study designs. They used 3-mm diameter lead balls. The lead balls were placed on the crest edge in different distances on the buccal and lingual surfaces, midline and inferior border.

The main limitation of this study and also this option in the new brand of panoramic devise was that they were not a particular definition for the size and the shape of skull. Therefore, the option for selection of the focal trough is subjective and not objective. The other limitation of this study was the low number of samples. Further research is needed to investigate the effects of changing focal troughs on the different types of skulls.

Conclusion

Changing the focal trough option of Planmeca SCARA 3 has minimal effects on the accuracy of linear measurements in panoramic radiographs.

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Conflicts of interest

There are no conflicts of interest.

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