Distortion of digital panoramic radiographs used for implant site assessment

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ABSTRACT

Aims: This study is conducted to determine the amount of distortion of digital panoramic radiographs. Materials and Methods: Panoramic radiographs of all patients who received dental implants in the years 2012 and 2013 were selected from the records at the faculty of dentistry, King Abdulaziz University. Radiographs were analyzed using the R4 Kodak Software for linear measurements of implants length and width. The measurements were compared to the actual size of the implant, and the amount of distortion was calculated. Results: A total of 169 implants were analyzed. Horizontally, there was a statistically significant increase of 0.4 mm in width in the radiographic measurement compared to the actual size in the incisor region. Vertically, the sample overall exhibited a decrease by 0.4 mm compared to the actual size. Incisors had the highest difference with a decrease of 1.7 mm in the radiographic measurements compared to actual size. The highest distortion was found in the incisor region for both diameter and length (1.1 and 0.86), respectively. Conclusion: Digital panoramic radiographs show minimal to no distortion. The highest distortion is found in the anterior area.

Key words: Digital radiographs, distortion, implants, site preparation

INTRODUCTION

In dental practice, radiographs are considered an important tool for the assessment of bone architecture. Panoramic radiographs are widely used as standard radiographic examination tool when planning for implant therapy, especially for assessing vertical bone availability.[1-3] In recent years, advances in radiologic technology such as the introduction of digital radiographic imaging lead to increased efficiency of radiographic studies. They emit low-dose radiation and provide fairly accurate surveys.[4]

Distortion of radiographic images is one of the limitations that are well recognized in panoramic radiographs.[5-6] The amount of distortion depends on several factors including the distance between the patient and the film,[7] type of machine used,[8] and position of the object measured within the mandible.[9] This distortion must be considered during clinical application for proper diagnosis and treatment planning.

Determination of the available bone height is vital for choosing the appropriate implant length. Several studies indicate that this could be safely achieved using conventional and digital panoramic radiographs.[3,10-12] Moreover, digital panoramic radiography allows adjustment of magnification to get 1:1 image visualization and the use of software-based measurement tools for more accurate measurements.[13] On the other hand, measuring available bone width is not possible using panoramic radiographs. Bone width can be determined clinically using bone-mapping techniques or by cone-beam computerized tomography (CBCT) scan which has been shown to be more accurate than panoramic radiographs.[14] Hence, careful
radiographic and clinical measurements are essential to
determine the size of the implant for the intended site.

The objective of this study was to calculate the extent of distortion
de digital panoramic radiographs by measuring the dimension of
dental implants used as radio-opaque reference objects.

**MATERIALS AND METHODS**

Panoramic radiographs were selected from patients’ records
at the Faculty of Dentistry, King Abdulaziz University after
obtaining approval from the Research Ethics Committee. The records of patients who received dental implants in
the years 2012 and 2013 were examined. All records that
contained acceptable postoperative digital panoramic radiographs obtained with Kodak 8000 (Hemel Hempstead,
United Kingdom) digital panoramic unit were included in the
study. This excluded radiographs with any artifact that affects
the implant measurement.

The panoramic images were divided into three areas; molar
region, premolar and canine region, and anterior region. All
radiographs were analyzed by two trained dental interns
using the R4 Kodak Software (Carestream Dental, Herts, UK)
and were blinded to the actual size of the dental implants. Interexaminer reliability was conducted by comparing the
measurements of both examiners. The R4 Kodak Software was
used to perform linear measurements of the radiological implant
length from the implant platform to the apex of the implant and
from mesial surface to the distal surface at the neck of the
implant for the radiological implant width. The actual size of the
implant is determined from the digital file of the patient where
practitioners write the size of the implant used.

Student’s t-test was used to determine significant differences
between mean measurements and actual size. Furthermore,
the extent of distortion was calculated for each implant by
dividing the implant’s measured dimension (in mm) on the
postoperative panoramic radiograph by the implants’ actual
size.

**RESULTS**

A total of 169 implants from 92 radiographs were analyzed.
Of these, 96 were placed in the maxilla and 72 implants were
placed in the mandible. The number of implants placed in the
incisor, canine/premolar, and molar region were 13, 77, and
79 implants, respectively. Implant diameters were 3.5 mm
(36 implants), 4.1 mm (101 implants), and 5 mm (32 implants).
The lengths were 10 mm (35 implants), 11.5 mm (66 implants),
13 mm (67 implants), and 15 mm (1 implant). There was no
significant difference between measurements performed by
both observers.

The diameter and length of dental implants were measured
on digital panoramic radiographs and were compared to the
actual sizes of these implants. Examining implants placed
in all regions collectively revealed no statistically significant
difference between the actual diameter, which represents the
width, of the implant and the measured value [Table 1]. When
each region was examined separately, different results were
obtained. In the incisor region, the radiographic measurement
was statistically significantly greater than the actual size
by 0.4 mm (P < 0.05). When the length of the implant was
examined, the radiographic measurements of the sample
overall were decreased by 0.4 mm compared to the actual
size (P < 0.05) [Table 2]. Divided by regions, incisors had the
highest difference with a decrease of 1.7 mm in the radiographic
measurements compared to actual size (P < 0.05) [Table 2].
This is followed by the canine/premolar with decrease of
0.4 mm in the radiographic measurements (P < 0.05) [Table 2].
On the other hand, there was no significant difference in the
molar region.

Distortion was calculated and presented in Table 3. The highest
distortion was found in the incisor region for both
diameter and length. The diameter was 10.3% less on the
radiograph compared to actual size, whereas the length was

**Table 1: Comparison between the actual implants diameter
diameter and on the X-ray**

| Region       | n  | Mean actual diameter (mm±SD) | Mean measured diameter (mm±SD) | Difference (mm) |
|--------------|----|-----------------------------|-------------------------------|-----------------|
| All          | 169| 4.14±0.4                    | 4.02±0.6                     | 0.14            |
| Anterior     | 13 | 3.86±0.8                    | 4.27±0.8                     | −0.4*           |
| Canine/premolar | 77 | 3.88±0.3                    | 3.68±0.43                    | 0.2             |
| Molar        | 79 | 4.4±0.4                     | 4.43±0.4                     | 0.1             |

*Indicates P<0.05, SD – Standard deviation

**Table 2: Comparison between the actual implants length
and length on the X-ray**

| Region          | n  | Mean actual length (mm±SD) | Mean measured length (mm±SD) | Difference (mm) |
|-----------------|----|---------------------------|-------------------------------|-----------------|
| All             | 169| 11.8±1.1                  | 11.3±1.2                     | 0.5*            |
| Incisor         | 13 | 12±1.2                    | 10.5±1.0                     | 1.7*            |
| Canine/premolar | 77 | 11.8±1.2                  | 11.4±1.3                     | 0.4*            |
| Molar           | 79 | 11.6±1.0                  | 11.3±1.4                     | 0.3             |

*Indicates P<0.05, SD – Standard deviation

**Table 3: Amount of distortion**

| Region            | n  | Distortion (% ±SD) |
|-------------------|----|---------------------|
| Distortion in diameter |
| All               | 169| 10.3±1.3            |
| Anterior          | 13 | −10.3±16.0          |
| Canine + premolar | 77 | 4.8±9.7             |
| Molar             | 79 | −0.01±7.6           |
| Distortion in length |
| All               | 169| 3.7±6.7             |
| Anterior          | 13 | 13.7±7.9            |
| Canine + premolar | 77 | 3.7±6.0             |
| Molar             | 79 | 2.6±7.8             |
13.7% higher on the radiographs compared to actual size. To find out whether the maxilla or mandible is more affected with distortion, the maxilla and mandible were looked at separately [Table 4]. There was no difference between actual size and radiographic measurement when it comes to diameter in both mandible and maxilla. On the other hand, there was 0.4 and 0.5 mm decrease (P < 0.05) in the radiographic image length compared to actual implant length in both maxilla and mandible, respectively.

**DISCUSSION**

Digital panoramic radiographs are a valuable adjunct to implant dentistry as a preoperative diagnostic and treatment planning aid. In many cases, these radiographs along with proper clinical examination can be sufficient to determine the size and position of implants if distortion is accounted for. This study was conducted to help determine the amount of distortion associated with modern digital radiographs and the accuracy of the analysis software. As to be expected, there was a considerable amount of distortion in the radiographs with a mean difference of up to 1.7 mm. This is less than what was found in earlier reports which showed 2.3 mm of distortion in panoramic radiographs. These studies used cadaver skulls and measured the actual size of the alveolar process. When steel balls were used, the distortion was reduced to 0.2 mm.[15] This suggests that distortion of objects within the alveolar process is less than distortion in the ridge which is something to be considered when studying distortion.

The amount of distortion differed from one area to another. The most distortion was found in the anterior area. Other studies also found that the anterior region had the most distortion. Kim et al. measured implant sizes in the mandible and found that the magnification is higher in the anterior region in comparison to other areas.[11] The difference in diameter might be due to the curvature in the premaxilla which cannot be represented by the X-ray machine. On the other hand, the difference in length, which was higher, is probably due to the angulations of the implants measured, which follows the apico-coronal accesses of the premaxilla and anterior mandible, in relation the floor when the occlusal plane is parallel to the floor. This could be attributed to the inclination of the premaxilla which has usually some degree of hyperdivergency and it is almost never perpendicular to the Frankfort horizontal while on the other hand the panoramic X-ray film is always perpendicular to the Frankfort horizontal. This difference in angulation causes the image to be shorter. This means that more caution should be applied when placing an implant in the anterior area to minimize the risk of injuring the floor of the nose.

In the posterior region, the amount of distortion is usually examined in the third molar region.[15,16] These studies found minimal to nonsignificant distortion in this region. In this study, minimal to no distortion was found in the posterior area. Nevertheless, the vertical dimension should be assessed very carefully, and adequate safety margin should be established, especially when working in proximity of vital structures such as the inferior alveolar canal and the maxillary sinus.

**CONCLUSION**

The results of this and other studies show that digital panoramic radiographs are reliable tools of preimplant assessment and treatment planning. Nevertheless, distortion should be accounted for, especially in anterior region. It has been shown that there is a difference in measurements between panoramic radiographs and CBCT, and CBCT is more accurate than both periapical and panoramic radiographs. Although the radiation exposure of standard digital panoramic radiography was found to be much less compared to CBCT, some cases require CBCT scan for more accurate measurements.[14] It is the clinician’s responsibility to determine the need for a more extensive radiographic study for the best outcome with the least possible risk.

**Acknowledgment**

I would like to thank the intern office and the team of dental interns who helped in data gathering.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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