A Study for Determination of Various Positioning Errors in Digital Panoramic Radiography for Evaluation of Diagnostic Image Quality

Abstract
Faulty radiographs have poor diagnostic quality, and repetition of such poor-quality radiographs leads to increased patient exposure to radiation. Since digital panoramic radiography has replaced manual radiography, the only hindrance in producing good-quality radiographs is the positioning errors. Objectives: Our study aims to determine the various positioning errors and their relative frequency and to identify those errors directly responsible for diagnostically inadequate images. Materials and Methods: Five hundred panoramic radiographs taken serially (from the year 2007) were retrospectively assessed for the positioning errors by three oral and maxillofacial radiology specialists using a performa enlisting the errors. The three specialists had different duration of clinical experience and they evaluated the orthopantograms as diagnostically acceptable or unacceptable. They also observed the relative frequency of all the positioning errors. Statistical Analysis: The kappa value for intraobserver agreement was calculated, which suggested that the agreement among the observers was fair. Results: Of the 500 panoramic radiographs viewed by the three observers, 25 (5%) had no errors, while 475 (95%) showed one or more positioning errors. The most common error in our study was found to be head turned to one side (33.8%) and the least common error was patient movement during exposure (1.8%). Conclusion: Positioning errors are very common in digital panoramic radiography, and they lead to production of poor-quality radiographs. The operator should take this fact into consideration and spend more time in patient positioning, thereby reducing the repetition of radiographs and unwanted patient exposure.

Keywords: Panoramic radiography, patient exposure, positioning errors

Introduction
A considerable number of radiographs exposed in dentistry are of marginal or nondiagnostic quality. The value of a panoramic radiograph is reduced when it is of poor diagnostic quality, due to various positioning and processing errors. Among the various types of image quality evaluations, clinical imaging evaluation is the most important inspection that enables actual and comprehensive evaluation since it reflects the entire quality-assurance process and it must be performed continuously.[1]

Low-quality radiographs can lead to repetition of radiographs and misinterpretation, which in turn may result in incorrect diagnosis and treatment planning. The repetition of panoramic radiography carries an associated risk of inducing cancer which has been estimated as 0.21 or 1.9 cases/million examinations.[2]

Inaccuracies in patient positioning lead to discrepancies between horizontal and vertical magnification, with consequent distortion of the image. Since a principal objective of the quality assessment program is to ensure the production of good diagnostic quality radiographs, it is vital to monitor image quality on a regular basis. It is recommended that a simple, subjective image quality rating system should be used for dental radiographs.[3]

The principal aim of this study was to assess the quality of panoramic radiographs. The subsidiary aims were to determine the relative frequency of errors and to identify those errors directly responsible for diagnostically inadequate images.

Materials and Methods
This study was carried out in the Department of Oral Medicine and Radiology, VSPM’s Dental College and Research Centre, Nagpur, Maharashtra, India. Five hundred panoramic radiographs

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taken serially (from October 2007 to October 2014) were retrospectively assessed for the positioning errors by three oral and maxillofacial radiology specialists using a pro forma enlisting the errors [Figure 1].

All projections were made with the same radiographic equipment (Kodak 8000C Digital Panoramic and Cephalometric system) operating at 80 kVp and 12 mA according to the manufacturer’s instructions. The exposure time was 12 s. Radiographs were taken by the postgraduate students of our department and a radiology technician with more than 10 years of experience. The radiographs were viewed under identical conditions without any modifications, on a 15-inch computer monitor (HPv 185 w, Intel Pentium 4 inside) with a screen resolution of 640 × 480, 32-bit color mode in a room with subdued lighting. All the 500 panoramic radiographs were assessed by three observers, a postgraduate student, a lecturer, and a professor. The panoramic radiographs were assessed for the following positioning errors: chin tipped high, chin tipped low, slumped position, patient positioned forward, patient positioned backward, failure to position the tongue against the palate, patient movement during exposure, head tilted, and head turned to one side [Figures 2-10].

The panoramic radiographs were assessed and judged as being diagnostically acceptable or diagnostically unacceptable by the three observers who were a postgraduate student, a lecturer, and a professor and no particular sequence was followed, but the observations recorded by one observer were not disclosed to the other.

Radiographs with ≤2 errors were considered diagnostically acceptable and >2 errors were considered diagnostically unacceptable, which was a self-designed criterion.

Data analysis was performed using SPSS software, version 15.0 (SPSS Inc., Chicago, IL, USA), and intraobserver agreement was calculated using kappa analysis.

**Results**

Of the 500 panoramic radiographs viewed by the three observers, 25 (5%) had no errors and 475 (95%) showed one or more positioning errors. The most common error in our study was found to be head turned to one side (33.8%) and the least common error according to observer 2 and observer 3 was patient movement during exposure. Although observer 1 found chin tipped low as the least common error, the average value of the three observers favored patient movement as the least common error (1.8%). The relative frequency of different positioning errors as observed by the three observers is shown in Table 1 and is represented by a bar diagram [Figure 11].

According to the predefined criteria, the total number of diagnostically acceptable, unacceptable, and error-free
The kappa value for intraobserver agreement between observers 1 and 2 was 0.234, observers 1 and 3 was 0.252, and observers 2 and 3 was 0.539. The overall kappa statistic for intraobserver reliability was 0.341.

It was seen that the observations made by observers 2 and 3 were somewhat similar. It can therefore be said that the duration of radiological experience influences the judging of errors. Despite the variability, the overall kappa statistic for intraobserver reliability was 0.341, and the overall intraobserver agreement was found to be fair.

Discussion

The images evaluated in the study were gathered from the Department of Oral and Maxillofacial Radiology of VSPM’s Dental College. Since the images were assessed in the serial order when the departmental specialists were unaware of the study, the sample may be regarded as representative of everyday radiograph quality.

The guidelines on radiology standards for primary dental care set quality standards for dental radiography, defining the terms “excellent,” “diagnostically acceptable,” and “unacceptable.” It was proposed that the rate of

Table 1: Relative frequency of different positioning errors as observed by the three observers

| Errors                        | Observer 1 (%) | Observer 2 (%) | Observer 3 (%) |
|-------------------------------|----------------|----------------|----------------|
| Chin tipped high              | 23.2           | 12.4           | 11.6           |
| Chin tipped low               | 10.6           | 9              | 11.2           |
| Patient positioned forward    | 14.6           | 21.4           | 19.6           |
| Patient positioned backward   | 20.6           | 8.6            | 9.2            |
| Failure to position the tongue against the palate | 28.4 | 6 | 4.8 |
| Patient movement during exposure | 12 | 1.6 | 2.0 |
| Head tilted                   | 10.8           | 12.4           | 11.6           |
| Head turned to one side       | 52             | 25.8           | 23.8           |
| A slumped position            | 18.2           | 23.4           | 21.8           |

Table 2: Observations made by the three observers regarding the quality of radiographs

| Quality                | Observer 1 (%) | Observer 2 (%) | Observer 3 (%) |
|------------------------|----------------|----------------|----------------|
| Acceptable             | 406 (81.2)     | 463 (92.6)     | 469 (93.8)     |
| Unacceptable           | 94 (18.8)      | 37 (7.4)       | 31 (6.2)       |
| Error-free radiographs | 21 (4.2)       | 28 (5.6)       | 26 (5.2)       |

Figure 5: The central incisors are in front of the bite groove, causing them to appear thin and fuzzy. The cervical spine is in the focal zone, causing it to be superimposed on the mandible

Figure 6: The anterior teeth are positioned behind the bite groove, causing them to appear wider than normal

Figure 7: Panoramic radiograph shows the patient failure to position the tongue against the palate, leading to a dark shadow over the maxillary teeth between the palate and dorsum of the tongue

Figure 8: Radiograph shows image distortion due to patient movement during exposure
In our study, head turned to one side was the most common error identified (33.8%), which is not in accordance with the studies performed by Dhillon et al. and Rushton et al.[3] The probable reason for head turned to one side being the most common error could be improper head stabilizer or lack of communication between the operator and the patient. The operator should spend some time in proper patient positioning and ensure that the patient’s head must be centered in three different planes which are mid-sagittal (perpendicular to the floor), occlusal (parallel to the floor), and the anteroposterior plane to uniformly record the maxillofacial complex.

On the other hand, the least common error in our study, i.e., patient movement during exposure, is in accordance with the results of the study performed by Dhillon et al. (1.6%) and Rushton et al. (0.8%).

In our study, only 10.8% of the radiographs were unacceptable which is less than the results of the studies conducted by Brezden and Brooks (18.2%), Rushton et al. (33%), and Dhillon et al. (24.9%), which suggests that good-quality panoramic radiographs are predominantly produced in our department.

Although there was variability in assessing the frequency of each particular error among the three observers, the intraobserver reliability was found to be fair and statistically significant.

On the whole, it can be said that the positioning errors have the capacity to make a radiograph diagnostically unacceptable which will eventually lead to repetition of radiographs. The repetition of panoramic radiography due to low diagnostic quality carries an associated risk of inducing cancer which has been estimated as 0.21 or 1.9 cases/million examinations.[3] It seems that operator skill, better communication with the patient, and spending time in patient positioning could decrease the number of errors and help produce high-quality radiographs, thereby reducing unwanted patient exposure.

**Conclusion**

Since manual panoramic radiography is a long-lost method and digital radiography has become routine, positioning errors are the only hindrance in the production of good diagnostic quality radiographs. The operator should realize the vitality of this and spend enough time in patient positioning.

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**Conflicts of interest**

There are no conflicts of interest.

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