

Common positioning errors in panoramic radiography: A review

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ABSTRACT

Professionals performing radiographic examinations are responsible for maintaining optimal image quality for accurate diagnoses. These professionals must competently execute techniques such as film manipulation and processing to minimize patient exposure to radiation. Improper performance by the professional and/or patient may result in a radiographic image of unsatisfactory quality that can also lead to a misdiagnosis and the development of an inadequate treatment plan. Currently, the most commonly performed extraoral examination is panoramic radiography. The invention of panoramic radiography has resulted in improvements in image quality with decreased exposure to radiation and at a low cost. However, this technique requires careful, accurate positioning of the patient's teeth and surrounding maxillofacial bone structure within the focal trough. Therefore, we reviewed the literature for the most common types of positioning errors in panoramic radiography to suggest the correct techniques. We would also discuss how to determine if the most common positioning errors occurred in panoramic radiography, such as in the positioning of the patient's head, tongue, chin, or body. (*Imaging Sci Dent* 2014; 44 : 1-6)

KEY WORDS: Panoramic Radiography; Patient Positioning; Quality Control; Review

Introduction

Radiographic examinations are important resources when diagnosing lesions of the complex jaw. This type of examination has been considered an important tool for diagnosis since its discovery. However, awareness of the risks of using ionizing radiation for diagnostic purposes emerged soon after its discovery. Therefore, methods that selectively expose a patient to X-rays have been proposed, such as a protection apparatus, faster films, and most appropriate technique.¹ In addition, using good quality images to acquire information is important in X-ray protection, and appropriate image quality is fundamental in the conservation of medical records as well as resolving legal issues.²

In dental radiology, quality control has been wrongly focused on only the control/development of equipment, such as the development of the X-ray apparatus and processors.³ However, another fundamental factor influencing the quality of dental radiology is the training that professionals who perform radiographs receive; this training must be maintained at a satisfactory level to ensure safety during examinations.⁴

Radiographic examination is commonly performed by dentists and is important in supplementing diagnoses of oral problems. In addition, a collection of dental radiographs can provide important technical, scientific, and legal data.²

Thus, dental professionals who perform radiographs are responsible for ensuring the level of quality for a proper diagnosis. These professionals must competently execute techniques and manage film processing while also supervising all steps of the examination to minimize unnecessary exposure to X-ray radiation. These efforts can prevent

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low quality images used to potentially misdiagnose a patient as well as errors in treatment allocation.⁵

Panoramic radiography is an extraoral examination. The development of this radiographic equipment improved the image quality using low radiation dose with low cost to the patient. However, in this radiographic technique, the patient's position is critical to ensure the acceptable final image focusing on the teeth and surrounding alveolar bone structure.⁶

Therefore, a successful panoramic radiograph requires careful positioning of the patient and proper technique.⁷ The appropriate technical procedure requires the patient's upright position with an elongated neck, shoulders down, straight back, and feet together. In addition, the Frankfort plane parallel to the ground and the median sagittal plane perpendicular to the ground should be established with chin support in the frontal chin cup with the tongue resting against the palate.⁸

Thus, proper positioning of the patient in the equipment is the most important factor in preventing a cascade of errors in diagnosis and treatment allocation. Given the importance of this type of error, we reviewed the current literature to evaluate common positioning errors associated with panoramic radiographs and suggest correct methods from these results to minimize these errors and patient exposure. Errors observed in radiography that negatively affected diagnostic quality were of specific interest.

Literature Review

The PUBMED database search (<http://www.ncbi.nlm.nih.gov/pubmed>) was performed to identify all literature reviews and case reports related to "radiographic positioning errors" and "panoramic radiographs."

Panoramic radiography

In a single examination, panoramic radiograph allows good visualization of all dental elements and their anatomical structures in the maxillo-mandibular complex.^{9,10} In addition, the patient is exposed to a low dose of radiation.¹¹ For excellent visualizations of an anatomical structural, panoramic radiography should be performed with high technical standards and the image should be reviewed carefully.¹² Panoramic radiographs taken with high technical standards can provide good radiographic finding in diagnosing pathologies in the jaws.¹³

Panoramic radiography should be performed in accordance with the manufacturer's recommendations, and pati-

ents should remain perfectly positioned while the X-ray tube and image receptor (film or digital sensor) simultaneously revolve around the patient's head.¹⁴ The exposure time is set to allow for the image capture of one full rotation around the patient.⁵

During extraoral radiography, the image receptor is a combination of two intensifying screens surrounding a film. Each intensifying screen is coated with a layer of phosphor that fluoresces when activated by X-ray radiation that penetrates both the patient and the cassette. Cassette is the compartment accommodating a radiographic film during the radiography.¹⁵ This fluorescent glow sensitizes the film. The film used in panoramic radiography is 10-60 fold more sensitive than the film used in fluorescence X-ray radiation. Thus, these highly sensitive screens allow for a reduced amount of radiation exposure while also producing high quality images. As the X-ray tube and image receptor circle the patient, the image is recorded on the film and can be restricted by narrowing the X-ray tube or collimator.¹⁶

The quality of the final result is related to both the position of the patient during the exposure and the accuracy of the jaw position in the focal trough. Image quality can also be influenced by the proximity of the orofacial region to the desired focal trough, the mechanical area located between the radiation source, and the image receptor, which is designed for a medium-sized jaw.¹⁷

There are four basic anatomical planes used to properly position a patient: the ala-tragus plane, orbital/meatus plane (the Frankfort plane), canine/meatus plane, and median sagittal plane. Devices for positioning the head and supporting the chin are also important for precise positioning. The purpose and type of equipment being used with respect to proper positioning for image capture should be carefully explained to patients. Most importantly, patients should be instructed to bite on the bite block, close their lips, and push their tongue against the roof of their mouth.¹⁸ Moreover, a lead apron should be placed over the parts of the patient's body under the head and neck area.

Panoramic radiography is already a routine procedure for prosthetic planning, diagnosing pathologic changes in the maxilla, identifying the presence of root fragments and foreign bodies, and determining the height of the alveolar ridge. It can also be used to evaluate systemic conditions¹⁹ since a significant correlation exists between changes in the trabecular bone on panoramic radiographs and wrist radiographs (carpal) due to osteoporosis in the spine and femur as detected by bone densitometry.²⁰ This additional information may encourage early disease diagnosis, prior

to the onset of complications that could debilitate the patient's quality of life.²¹ Nonetheless, disadvantages in using this imaging modality exist, such as the limitations of a two-dimensional image and the incidence of image distortions that may interfere with surgical planning.²²

At present, panoramic radiography is not only widely available but also important to diagnose alterations in the oral condition. They provide evidence that can be used with clinical examination to improve the diagnostic process. Thus, panoramic radiography is a useful and practical complement during the clinical examination of teeth to diagnose caries, pulp origin diseases, and diseases of the facial bones.²³ In addition, panoramic radiograph allows a dentist to exam all of the teeth at once, including those still below the gum line; therefore, caries, tooth fractures, infections, or other diseases of the bones that support the teeth can be viewed and diagnosed.²⁴ Moreover, situations of bone resorption as well as radicular cysts, tumors, inflammation, post-accident fractures, temporomandibular joint disorders, and sinusitis can be identified. Panoramic radiography is commonly requested preoperatively; however, Ohman et al²⁵ stated that panoramic examination was not sufficient for pre-operative inspection.

In pediatric patients, panoramic radiography can be used to monitor teeth before they emerge and analyze their location, shape, and angles as well as the presence of a supernumerary tooth or the absence of a tooth germ, thus preventing or preparing for future esthetic problems.²⁶

Overall, panoramic radiography can be used in the following situations; for general surveys of oral health, to determine the best radiographic supplements for surgical procedures, for initial and progressive evaluations of orthodontic treatment, for information about pediatric growth and development, to review chronological dental eruptions and the axes of permanent tooth eruptions, to evaluate cystic or or neoplastic lesions, to measure the dimensions for implantology, for historical documentation, to evaluate the temporomandibular joint, and to detect the presence of foreign bodies.²⁷

Professionals should perform radiography in an environment conducive to the interpretation of the results beginning with radiographic film storage followed by a proper examination and adequate interpretation of the results. Failure to perform any of these steps properly during the examination may lead to erroneous conclusions and unnecessary patient exposure to repetitive radiographs.²⁸

The interpretation of panoramic radiographs requires prior knowledge of the human anatomy. Moreover, a number of variations that fall within the normal range can be

noted and should be examined carefully to avoid erroneous conclusions.²⁹ To this end, radiographic images should be carefully evaluated by a trained professional.

Radiographic errors of positioning

Radiographs that are sharp or detailed and have minimal distortion, correct film framing in the region, a lack of artifacts, good density, and adequate contrast are considered to be of good quality.³⁰ Radiographs that do not meet these criteria indicate that a mistake occurred during radiographic imaging and/or processing.

Technical or processing errors are the main errors that occur during panoramic radiographs. Therefore, care must be taken while positioning the patient and during the execution of the entire process. Studies from oral radiology institutes have indicated that positioning,⁷ exposure factors, artifact appearance, and technical performance are the most commonly observed errors in decreasing order.

The most common error, patient positioning, is dependent on the operator communicating and controlling the patient's position.⁶ Thus, positioning errors should be reduced to minimize the number of unsatisfactory radiographs and avoid unnecessary exposure of the patient to X-ray radiation.

Another common error occurs when the patient's head is positioned in front of the focus, which leads to an image with dental arches, particularly the front teeth, with a blurred, shortened, and narrowed appearance. Furthermore, the proximal area around the premolars and the column of the ramus can overlap.³¹

In this context, the cause of most repeated examinations was found to be due to incorrect positioning of the patient's head. In 21.15%, 24.84%, 21.21%, and 20.30% of cases requiring re-examination, the reason for re-examination was that the patient's head was in front of the focal trough, turned to the right or left, tilted forward, or positioned behind the focal trough, respectively. When the patient's head is positioned behind the plane of focus, the dental arches, especially in the anterior teeth, appear blurred and expanded in the horizontal direction. In addition, the condyles appear at the lateral edges of the film.^{6,7} When the patient's head is tilted back, the occlusal plane becomes flattened or reversely curved as the apexes of the upper incisors appear out of focus. In addition, the condyles were projected out of the imaged area due to an increase in the intercondylar distance.

When the patient's head is tilted forward, the occlusal plane becomes excessively curved in panoramic radiogra-

phs. In this scenario, the apexes of the lower incisors also appear out of focus. In addition, overlapping images of the hyoid bone in the anterior mandible can be apparent. However, this may be because the upper regions of the condyles may not be visible and the intercondylar distance could be narrowing.^{6,7}

During radiographic examination, patients commonly tilt or turn their head to the right or left.⁶ When patients tilt their head, the structures imaged become asymmetrical (the side toward the slope appears reduced in size compared with the opposite side), and the proximal surfaces become substantially overlapped. When patients turn their head to one side, the teeth appear to be extended on one side of the midline and the sharp proximal surfaces appear overlapped, whereas the teeth on the opposite side appear shortened. Furthermore, the ascending mandible on one side appears much larger than that of the other, and the condyles appear to be different sizes.

The patient's chin and the occlusal plane must be positioned correctly to avoid distortions.⁶ The occlusal plane should be angled at -20° to -30° from the horizontal plane. One way to position the chin is to set as the line connecting the tragus of the ear to the outer corner of the eye is parallel to the ground. If the chin was elevated, the occlusal plane on the radiograph will appear flat or inverted, and the image would be distorted. Furthermore, the shadow of the radiopaque palate bone can overlap the roots of the maxillary teeth. Conversely, if the chin is tilted down, the teeth will overlap and the symphysis of the jaw may not be visible. In addition, both mandibular condyles may appear to be projecting out of the upper edge of the image.⁶

The position of the tongue also greatly influences the radiographic image quality.³² In the radiograph, the presence of a radiolucent band at the apex of the upper teeth is an indication that tongue contact with the upper palate was not sufficient. In addition, if the tongue is not placed on the palate or the lips remain open, the incisal area on the crowns may become obscured by the air space. A dark air space between the dorsum of the tongue and the hard and soft palates (palatoglossal air spaces) obscure the apical region of the maxillary teeth. To avoid this error-prone situation, which would cause the central incisor apex to be misdiagnosed, the patient should be asked to position their tongue so that it adheres to the palate (roof of the mouth) and to not swallow saliva to prevent tongue movement during radiography.³³

Incorrect patient posture and movement during radiography can produce a "ghost image" that appears as blurred areas in the image and forms large step defects in the in-

ferior border of the mandible.⁶

Radiographic image distortions due to the presence of anatomical structures or objects positioned outside the focal trough are known by several names including reverse shadows or shadows, secondary images, attached pictures, double images, triple pictures, ghost earrings (cysts), and contralateral and ghosting images.³⁴ These images, which are found on rotational panoramic radiographs only, are usually anatomical structures such as the vertebrae, rami, or hyoid bone, but can also be artificial objects such as metallic materials, dental crowns, wires, containment plates, earrings, necklaces, or machine parts. The presence of anatomical objects or artificial structures can create multiple images and ghost images.

Discussion

Radiographic examinations complement the diagnoses of soft and hard tissue lesions and sometimes become the sole method for the detection of possible residual changes. However, radiographic interpretations may be impaired if errors are introduced during radiographic imaging or film processing.³⁵ To avoid unnecessary radiation exposure, the repetitive use radiography should be avoided in practice. Moreover, unnecessary exposure can be eliminated by protecting the other areas of the body from X-ray radiation.³⁶

Positioning errors commonly occur in panoramic radiography. The focal plane (image layer) in panoramic radiography has limited dimensions; therefore, minor positioning errors can cause image distortions such as unequal vertical and horizontal magnification, the appearance of overlapping of teeth, and the loss of image sharpness.

Despite added efforts to avoid errors, some errors are inevitable due to the patient's physical stature, facial asymmetry, or inability to adhere to the instructions.³⁷ According to Ono et al,³⁷ anatomical variations might produce different radiographic images. Additionally, Gianni et al³⁸ stated that professionals who would use this radiography for treatment planning should understand those errors and account for these changes to the best of their ability, using their expertise and experience to ensure treatment success.

Image discrepancies can be recognized by comparing the image sharpness and distortion of anatomical structures between the images. Considering the specific anatomical relationships in radiography, the horizontal and vertical positioning errors can be recognized.

Regarding the positioning errors, focal point positioning posterior to the maxilla is easily recognizable. With vertical positioning errors, it is possible to observe blurring

and a widening of structures posterior to the stern, while the structures anterior to the sternum appears shortened and slightly blurred. Errors in horizontal placement introduce more distortion of the maxilla than mandible. The positions of lifting and lowering the chin respectively widen and shorten the mandible. Moreover, the maxilla and the upper part of the ascending branch of the mandible are distorted more than the mandible. This distortional discrepancy between maxilla and mandible became larger when the chin is elevated than lowered. This reflects the differences in the anatomical arrangement to the focal plan and the direction of X-rays to the maxilla and mandible. Thus, the relation between anatomical position of maxillofacial structure and the distortional ratio on radiographs provide a guide for differentiating between horizontal and vertical positioning errors.³²

In conclusion, panoramic radiography is a routine examination in dental clinics. Therefore, the image taking and processing procedure should be performed appropriately in order to acquire the acceptable image quality for diagnosis. In addition, repetitive examinations and consequent patient exposure to unnecessary radiation should be minimized with technical care. Patient positioning errors are the most frequent type of error in panoramic radiography; thus, an understanding of these errors and their consequence is required to minimize unnecessary X-ray exposure.

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