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Research Article

Evaluation of Common Diagnostic Errors in Panoramic Radiographs and Interobserver Agreement in Error Identification

Yasin Yasa[1], Dilek Coban[2], Furkan Ozbey[3], Tunahan Tuna[1], Busra Nur Gokkurt Yilmaz[1], Zerrin Unal Erzurumlu[1], Elif Sadik[1]

[1]Ordu University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Ordu, Türkiye
[2]Kafkas University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Kars, Türkiye
[3]Afyonkarahisar Sağlık Bilimleri University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Afyonkarahisar, Türkiye

Abstract

Aim: Panoramic radiography is frequently used in dental practice as an imaging technique that provides an extensive view of facial anatomical structures. Achieving high-quality radiographic images requires precise positioning and technique. This study aims to evaluate the quality of panoramic radiographs, to identify common errors that compromise diagnostic adequacy, and to analyze interobserver agreement levels concerning these errors.

Material and Method: A study analyzed 947 panoramic radiographs from the archive of Ordu University based on nine specific error criteria. Four research assistants evaluated the diagnostic quality of each image, classifying them as "excellent," "diagnostically acceptable," or "unacceptable." Inter-observer agreement was measured with kappa statistics, and overall agreement was evaluated using the Fleiss κ test.

Results: The rate of incorrect radiographs was 66.1% to 78.8%, with the most common error criterion differing for each observer. The least common error was the chin tipped too low for observers 1 and 2, and the patient positioned forward for observers 3 and 4. The highest inter-observer agreement was observed regarding the presence of foreign objects on the radiographs, while the lowest agreement occurred in cases where the patient was positioned too far back. Overall, the diagnostic quality of the panoramic radiographs was rated as "acceptable," with scores ranging from 60.5% to 69.5%. The Fleiss Kappa analysis indicated fair agreement among the four observers in assessing radiographic quality (k=0.252).

Conclusion: This study demonstrates that errors in panoramic radiography significantly impact image quality and diagnostic accuracy, highlighting the need for standardization, the use of various imaging models, and enhanced training in radiographic education.

Keywords: Panoramic radiography, quality control, oral radiology, radiographic errors

INTRODUCTION

Panoramic radiography is widely utilized in dentistry. It provides a broad view of facial structures, including the maxillary and mandibular arches and their supporting anatomy. This technique has several advantages, such as a relatively low radiation dose, patient comfort, procedural simplicity, and short acquisition time, making it a valuable tool in clinical practice (1,2).

The diagnostic utility of panoramic radiography is diminished when image quality is suboptimal. Poor-quality radiographs increase the risk of misinterpretation, potentially leading to inaccurate diagnoses and suboptimal treatment planning (3,4).

Technical and processing errors are primary contributors to poor-quality images in panoramic radiography (5). Therefore, careful attention to patient positioning and each step of the imaging process is essential. According to the literature, the most frequently observed errors are positioning-related, followed by issues with exposure settings, artifacts, and other technical errors, in decreasing order of occurrence (3,6,7).

The quality of every X-ray depends on careful positioning of the patient and on the technique and processing of the image (2). Proper patient positioning in panoramic radiography requires alignment with four key anatomical planes: the median sagittal plane, the canine-meatus plane, the ala-tragus plane, and the orbital-meatus plane (Frankfort plane). The recommended positioning technique involves extending the neck, relaxing the shoulders, maintaining

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Corresponding Author: Yasin Yasa, Ordu University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Ordu, Türkiye
E-mail: yasayasin@outlook.com

an upright back, and keeping the feet together and slightly forward relative to the torso. Patients should be instructed to bite on the bite block, close their lips, and press their tongue against the roof of the mouth. Additionally, a lead apron should be placed over the areas of the patient's body below the head and neck to minimize radiation exposure, and care should be taken to ensure that no foreign objects are present in the head and neck region that might appear within the imaging field (5).

The primary objective of radiation protection is to produce high-quality radiographs suitable for diagnostic and treatment purposes while minimizing the patient's exposure to radiation (8). Consequently, reducing errors is essential to limit the number of suboptimal radiographs, prevent unnecessary radiation exposure, and reduce examination time (3,9-11).

This study aimed to assess the quality of panoramic radiography, identify specific errors contributing to diagnostically inadequate images, and analyze the interobserver agreement regarding these errors.

MATERIAL AND METHOD

This study was approved by the Clinical Research Ethics Committee of Ordu University (Decision No: 2024/155) and was conducted in accordance with the Declaration of Helsinki.

This retrospective study analyzed panoramic radiographs obtained in the Department of Oral and Maxillofacial Radiology at Ordu University between November 2021 and February 2022.

Panoramic radiographs were obtained using Planmeca Promax 2D S3 device (Planmeca, Helsinki, Finland) with the following parameters: 66 kVp, 8 mA, and 15.8 s. In the study in which we evaluated positioning errors, 128 panoramic films with technical errors out of a total of 1075 panoramic radiographs were excluded from the study. The 947 panoramic radiographs were evaluated according to the following nine error criteria (6).

1. The chin tipped too low,
2. The chin tipped too high,
3. Absence of tongue and palate contact,
4. A slumped position,
5. The patient positioned forward,
6. The patient positioned backward,
7. The head tilted,
8. The head turned to one side,
9. Foreign bodies (metallic partial dentures, earrings, necklaces, piercings, glasses, hair clips, etc.).

All radiographs were evaluated by four dentomaxillofacial radiology research assistants with one year of experience. Finally, the observers rated the diagnostic acceptability of each radiograph as "excellent," "diagnostically acceptable," or "unacceptable." The term "excellent" was applicable when there were no errors. While radiographs with a maximum of two errors were recorded "diagnostic acceptable." In cases, it was categorized as "unacceptable" when there were three or more errors, and radiography was found to be non-diagnostic and needs to be repeated.

The data collected were entered into a computer and analyzed using Microsoft Excel and the Statistical Package for Social Sciences (SPSS®) software (version 20, SPSS®, Inc., Chicago, IL, USA). Inter-observer agreement was quantified using kappa statistics. Kappa values>0.75 were defined as "excellent" reproducibility, those between 0.40 and 0.75 as "fair to good" reproducibility and those <0.40 as "moderate to poor" reproducibility (12).

We used the Fleiss κ test to measure the overall agreement in the assessment of quality in panoramic radiography among the four observers.

RESULTS

The rate of radiographs considered incorrect by observers was between 66.1% and 78.8% (kappa values between 0.224 and 0.379).

The most common error criterion differed for each observer. The least common error was the chin tipped too low for observers 1 and 2, and the patient positioned forward for observers 3 and 4. The relative frequency of different errors as observed by the four observers is presented in Table 1 and illustrated in Figure 1 using a bar diagram.

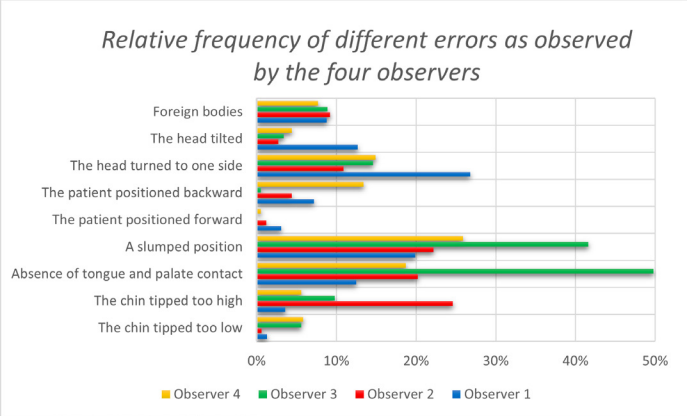

Figure 1. A bar diagram representing the frequency of errors as observed by four observers

The error criterion with the highest agreement between observers was the presence of foreign bodies on the panoramic radiography (kappa values between 0.577 and 0.852). The error criterion with the least agreement was that the patient positioned backward (kappa values between 0.020 and 0.232). Pairwise kappa values among the observers are presented in Table 2.

Based on the predefined criteria, the total counts of diagnostically acceptable, unacceptable, and excellent radiographs as assessed by the four observers are summarized in Table 3. According to the observers, the quality of the radiographs was "diagnostically acceptable," with a range of 60.5%-69.5%. Overall agreement among the four observers in assessing radiographic quality was classified as fair, with a Fleiss Kappa value of k=0.252.

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Table 1. Relative frequency of different errors as observed by the four observers

Errors	Observer 1		Observer 2		Observer 3		Observer 4	
	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)	Absence N (%)	Presence N (%)
Presence of error	292 (30.8)	655 (69.2)	267 (28.2)	680 (71.8)	201 (28.2)	746 (78.8)	321 (33.9)	626 (66.1)
The chin tipped too low	935 (98.7)	12 (1.3)	941 (99.4)	6 (0.6)	894 (94.4)	53 (5.6)	892 (94.2)	55 (5.8)
The chin tipped too high	913 (96.4)	34 (3.6)	714 (75.4)	233 (24.6)	853 (90.1)	93 (9.8)	894 (94.4)	53 (5.6)
Absence of tongue and palate contact	829 (87.5)	118 (12.5)	756 (79.8)	191 (20.2)	475 (50.2)	472 (49.8)	770 (81.3)	177 (18.7)
A slumped position	759 (80.1)	188 (19.9)	737 (77.8)	210 (22.2)	553 (58.4)	394 (41.6)	702 (74.1)	245 (25.9)
The patient positioned forward	918 (96.9)	29 (3.1)	936 (98.8)	11 (1.2)	947 (100)	(0)	942 (99.5)	5 (0.5)
The patient positioned backward	879 (92.8)	68 (7.2)	905 (95.6)	42 (4.4)	942 (99.5)	5 (0.5)	820 (86.6)	127 (13.4)
The head turned to one side	693 (73.2)	254 (26.8)	844 (89.1)	103 (10.9)	809 (85.4)	138 (14.6)	806 (85.1)	141 (14.9)
The head tilted	827 (87.3)	120 (12.7)	921 (97.3)	26 (2.7)	915 (96.6)	32 (3.4)	905 (95.6)	42 (4.4)
Foreign bodies	864 (91.2)	83 (8.8)	860 (90.8)	87 (9.2)	863 (91.1)	84 (8.9)	874 (92.3)	74 (7.7)

Table 2. Interobserver reproducibility expressed by kappa values for observers pairwise

Errors	Observer 1 vs 2	Observer 1 vs 3	Observer 1 vs 4	Observer 2 vs 3	Observer 2 vs 4	Observer 3 vs 4
Fault-free	0.379	0.309	0.246	0.346	0.224	0.352
The chin tipped too low	0.328	0.262	0.101	0.160	0.088	0.175
The chin tipped too high	0.133	0.176	0.171	0.263	0.030	0.143
Absence of tongue and palate contact	0.384	0.200	0.127	0.257	0.137	0.164
A slumped position	**0.511**	**0.413**	0.306	**0.408**	0.304	0.336
The patient positioned forward	0.339	-	0.110	-	0.245	-
The patient positioned backward	0.231	0.101	0.112	0.076	0.055	0.020
The head turned to one side	0.181	0.233	0.164	**0.417**	0.166	0.147
The head tilted	0.225	0.222	0.088	0.289	0.178	0.129
Foreign bodies	**0.819**	**0.796**	**0.595**	**0.852**	**0.577**	**0.632**

Table 3. Observations made by the four observers regarding the quality of radiographs

Quality	Observer 1 N (%)	Observer 2 N (%)	Observer 3 N (%)	Observer 4 N (%)
Excellent	291 (30.7)	263 (27.8)	193 (20.4)	320 (33.8)
Diagnostically acceptable	631 (66.6)	658 (69.5)	647 (68.4)	573 (60.5)
Unacceptable	25 (2.6)	26 (2.7)	107 (11.3)	54 (5.7)

DISCUSSION

The focal trough in a panoramic X-ray unit is a three-dimensional curved zone where anatomical structures are most clearly visualized. Due to the limited dimensions of the focal trough, even minor positioning errors can lead to distortions. Structures positioned outside this zone may appear blurred, magnified, reduced in size, or otherwise distorted. Thus, proper patient preparation and precise head positioning within the focal trough are critical for obtaining diagnostically valuable panoramic radiographs (13).

Dental radiography quality standards are established by recommendations on radiology standards, which also define the phrases “excellent”, “diagnostically acceptable”, and “unacceptable”. Guidelines recommend that the rate of “unacceptable” radiographs should not exceed 10%, while at least 70% of radiographs should be classified as “excellent” or fault-free (14). However, achieving these quality standards can be challenging in practice. In previous studies, the error rate of radiographs was reported to range from 62.4% to 93% (6,9,13,15-17). In the current study, the rate of erroneous radiographs was observed between 66.1% and 78.8% according to the observers.

In a study by Dhillon et al. evaluating 1,782 radiographs, 24.9% were classified as “diagnostically unacceptable” (9). Similar studies by Brezden et al. and Kumar et al. reported rates of 18.2% and 13.2%, respectively (4,18). In the present study, the rate of diagnostic unacceptable radiographs ranged from 2.6% to 11.3% according to the observers. The variation in this rate compared to similar studies may stem from differences in the observers' undergraduate education across countries as well as variations in their levels of experience.

All observers in this study were research assistants of dentomaxillofacial radiology with one year of experience. Kappa statistics indicated low interobserver reproducibility for most parameters, with the exception of foreign body detection, which showed excellent agreement among all observer pairs. This variability may be attributable to differences in the observers’ educational backgrounds, as they completed their undergraduate studies at different dental faculties, and their limited experience in this specialty. Overall agreement on panoramic radiograph quality, as measured by Fleiss Kappa, was fair, suggesting that while observers were consistent in their overall quality ratings, their assessments of specific error types varied. In a comparable study by Khator et al., 500 radiographs were assessed by three observers—a postgraduate student, a lecturer, and a professor, showing that observations from the lecturer and professor were more closely aligned. This finding underscores the potential impact of radiological experience on error evaluation (19).

Observer 1 identified the most frequent error as the patient’s head being turned to one side. Similarly, studies by Bissoon et al. and Kaviani et al. reported head rotation as the most common error (20,21) When patients turn their heads, it results in overlapping of proximal surfaces, the teeth on one side appear wider and the teeth on the other side appear narrower. This misalignment also causes inconsistencies in the horizontal magnification of anatomical structures, complicating diagnostic interpretation (5).

Observer 2 noted that the most frequent error was the patient’s chin positioned too high. Recognized indicators for identifying an excessively elevated chin position include the flattening of the occlusal plane and distortion of the maxillary anterior tooth apices. This type of positioning error can lead to significant distortion of the maxillary anterior residual ridge, potentially compromising diagnostic interpretation of this area to such an extent that accurate evaluation may no longer be feasible (22).

According to Observer 3, the most common error observed was absence of tongue and palate contact. This has also been found to be the most common error in many other studies (6,7,9,10,13,16,23,24). This error results in a radiolucent shadow over the apices of the maxillary teeth, which complicates interpretation of the periapical region. Consequently, it can lead to missed diagnoses of periapical pathology, root resorption, and both odontogenic and non-odontogenic lesions around the maxillary tooth apices (6). Ensuring patient cooperation is essential to minimize this error.

Observer 4 reported that the most common error was a slumped posture, which was also observed as the most frequent error in studies by Belgin et al. and Fairozekhan et al. (15,25). This positioning issue results in a ghost image of the cervical spine being superimposed on the anterior region (20). Factors contributing to this error may include advanced age, postural abnormalities, or obesity, which can make optimal positioning challenging. To prevent this, the operator should ensure that the patient’s spine is straight, and the neck properly extended.

The occurrence of errors can be significantly minimized by double-checking patient positioning and providing clear, concise instructions (26). However, errors may still occur in patients with facial asymmetry, short or heavy necks, severe obesity, extreme height, or those unable to follow directions, which may be beyond the operator's control (13). In such cases, the operator must exercise caution during positioning. Additionally, to enhance radiographic quality, periodic random audits should be conducted.

Education for technicians, dentists, and dental students is crucial in minimizing errors in panoramic radiography. In a study by Wenzel et al., it was found that computer-assisted learning and training with a phantom in a simulated clinical environment enhanced dental students' ability to identify panoramic errors and improve their patient positioning skills (27).

In recent years, various artificial intelligence-based software programs have been developed to enhance image quality by correcting errors in panoramic radiography. Du et al. utilized a convolutional neural network (CNN)-based architecture designed to eliminate image blurring caused

by patient positioning errors. The results demonstrated that the CNN effectively estimated the positioning error of the patient's dental arch, followed by the reconstruction of the corrected panoramic image, which successfully reduced the blur (28).

CONCLUSION

In conclusion, the evaluation of panoramic radiographic errors in this study, which had a substantial impact on image quality and diagnostic value, varied across observers. Standardization of radiography education is essential, along with the implementation of diverse educational models and the support of both theoretical and practical periodic training. Looking ahead, the widespread adoption of artificial intelligence-supported programs has the potential to automatically correct panoramic errors, thereby ensuring the production of high-quality images.

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