ORIGINAL PAPER

COMPARISON OF POSITIONING ERRORS ON PANORAMIC RADIOGRAPHS IN INDONESIAN CHILDREN, ADULTS, AND ELDERLY PATIENTS

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ABSTRACT

Introduction: Panoramic radiography is one of the most frequently used extraoral radiography techniques. Different anatomical structures and levels of understanding of instructions may differ in different age groups.

Objectives: To investigate the distribution of positioning errors on panoramic radiographs and their correlation between the age groups of children, adults, and the elderly.

Material and methods: This descriptive cross-sectional study used 495 panoramic radiographs from oral radiology medical records at a dental hospital. The inclusion criteria were 3 age categories; children (≤ 14 years), adults (15-59 years), and the elderly (≥ 60 years) selected by a consecutive sampling method. Pearson's χ^2 categorical comparative statistical tests were performed for data analysis from more than 2 unpaired samples.

Results: Among the 3 age groups, the radiographs that had the most errors were the children's age group, with 321 errors (37%), while the radiographs of adults and the elderly had 255 (29.4%) and 292 errors (33.6%), respectively. It was recorded that the spine not being in the upright position, improper positioning of the tongue, and moving during exposure were statistically significantly different between the children, adults, and the elderly ($p < 0.05$, Pearson's χ^2 test).

Conclusions: The results of this study showed that the most common error in the 3 age groups was incorrect tongue position. In elderly patients, the position of the spine was the second most common error, while in children, it was moving during exposure.

Key words: children, adults, positioning errors, elderly, panoramic radiographs.

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INTRODUCTION

Panoramic radiography is one of the most frequently used extraoral radiographic techniques to obtain radiographic images of the facial structure, including the maxilla and mandible, with all their supporting structures. At present, panoramic radiography has wide applications in dentistry. It is often used as a preliminary evaluation before a treatment plan [1]. However, panoramic radiography has some limitations because the duration of a radiographic examination is relatively long; thus, patient positioning and their ability to stand or sit still are of utmost importance [2].

Research has shown that most panoramic radiographs have poor diagnostic quality, thereby reducing the reliability of their radiographic interpretations [3, 4]. Low-quality radiographs can also cause dentists to have difficulty interpreting a disease or disorder; therefore, radiodiagnosis and treatment planning errors occur [5]. In addition, failure to produce panoramic radiographs may indicate repeated exposure, so that patients receive unnecessary radiation [5, 6]. The quality of the radio-

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graphic image depends on the proper technique and image-making. Correct patient positioning is essential for obtaining sharp, accurate, undistorted, and ghost-free images. To achieve this, the patient's head should be positioned so that the midsagittal plane is perpendicular to the floor, and the Frankfurt plane is parallel to the floor. The patient's teeth should be positioned in the focal trough, and the tongue should be on the roof of the mouth (against the palate) during the entire exposure and to keep their lips together to prevent it from obscuring the image.

While panoramic images provide a broad view of the entire dental arch, they may not show fine details or structures in the anterior or posterior regions. Furthermore, dental restorations and orthodontic appliances can create superimposition to the dental structures on panoramic images, making it difficult to interpret if there are caries lesions on the panoramic image so that intraoral imaging is indicated. Ghost images in radiography occur when a metallic object, such as a jewellery, is positioned close to the X-ray film or digital sensor. Structures within the focal trough in a panoramic image will be sharp, well defined, and overall lacking in distortion. Objects outside the focal trough that are dense enough to attenuate X-rays will occasionally present twice as the X-ray tube rotates around the patient's head; this is known as a ghost image. This can result in a secondary image being produced on the radiograph, which is often located in a different position than the primary image due to the rotational radiography technique. The ghost image is distorted and larger than the actual object projected and often not at the same height. Metal objects can produce ghost images; however, anatomical structures such as the mandibular angle and the cervical spine can also produce this type of image. In addition to the limitations described above, panoramic images can also be impacted by technical and patient errors. Technical errors can occur during the image acquisition process, such as incorrect exposure settings, faulty equipment, or improper image processing. Patient errors, on the other hand, can occur during the preparation and positioning of the patient for the panoramic image. It is important to keep these limitations in mind when interpreting panoramic images, and to consider other imaging modalities when necessary, to obtain a complete and accurate diagnosis.

Quality control is very important for interpretation [7]. A study conducted in Europe by Fairozekhan *et al.* [6] used 1014 panoramic radiographs. Only 130 radiographs had no errors, while 884 radiographs had one or more positional errors. Another study by Pandey *et al.* [8] mentions that panoramic radiographic errors can occur due to technical and position errors. Of the 1010 panoramic radiographs, 11.3% had technical errors and 16.2% had positional errors. In a study by Pandey *et al.* [8], the patient's position was the most common error. Technical errors, such as poor contrast and sharpness, can be reduced using digital radiography [6]. Digital radiography allows for better control of exposure and image processing, resulting in higher-resolution images. The rapid advancement of technology in the field of radiography has led to the creation of software and hardware options that reduce technical errors in panoramic radiography. These options include S-Pan technology, cameras that assist with patient positioning and display the location of the Frankfurt plane in red and green on the control panel, and algorithms that correct for some motion artifacts (e.g. tremors). These algorithms use motion correction techniques to reduce image blurring and distortion caused by patient movement. Furthermore, digital radiography enables real-time image adjustment, which allows for immediate identification and correction of technical errors. Although digital radiography has several advantages compared to conventional radiography, potential errors in digital panoramic radiography can occur from the possibility of overexposure or underexposure due to incorrect settings or calibration of the digital imaging system. This can result in images that are too bright or too dark, making it difficult to see the details of the dental structures, and potentially leading to inaccurate diagnoses.

Position errors can occur in both conventional and digital techniques [5, 8]. This has been explained by Salemi *et al.* [9], who stated that there was no statistically significant difference in positional errors between conventional and digital radiographs. According to Kumar *et al.* [10], the most significant proportion of radiographic errors is due to the position of the tongue not being in contact with the roof of the mouth (69.5%), followed by the patient's neck not being erect (52.1%), the patient being too far back (35.6%), the patient being too far forward (28.9%), the chin facing upwards too much (27.1%), and the chin facing downwards too much (15.6%). This makes the patient's position, which includes the tongue, neck, and head position, critical to producing a suitable radiographic image. Incorrect patient positioning can result in various types of radiographic errors, including both horizontal and vertical enlargement [5]. Whereas, if the anterior teeth are anteriorly displaced in the focal trough, it can result in overlapping, magnification, or distortion of the teeth, making it difficult to assess their condition accurately. Therefore, it is important to ensure that the patient is properly positioned in the focal trough to obtain the best possible radiograph for accurate diagnosis and treatment planning.

According to Bagherpour *et al.* [11], lack of cooperation in paediatric patients causes panoramic radiographic errors more frequently than in adult patients. Children also have smaller and less-developed dental structures than adults, which can make it more challenging to obtain an accurate panoramic radiograph. The quality of the image can be affected by the number and placement of the teeth. Despite being less dense than permanent teeth, deciduous teeth can still be readily inserted into the focal trough. In contrast, the teeth

in mixed dentitions may not be well-positioned in the arches and frequently lie outside the focal trough. In addition, studies have shown that with increasing age, body posture and anatomical structures undergo changes that can affect panoramic radiographic images [12, 13]. From the description above, the researchers were interested in conducting research to investigate the distribution positioning errors on panoramic radiographs and their correlation between the age groups of children, adults, and the elderly.

OBJECTIVES

The present study aimed to investigate the distribution of positioning errors on panoramic radiographs and their correlation between the age groups of children, adults, and the elderly.

MATERIAL AND METHODS

A descriptive cross-sectional study was performed in mid-2021 using 495 panoramic radiographs from oral radiology medical records at the Universitas Indonesia dental hospital. The inclusion criteria were 3 age categories: children (≤ 14 years), adults (15-59 years), and the elderly (≥ 60 years). A total of 165 panoramic radiographs in each category were selected by the consecutive sampling method. Samples were taken from mid-2021 to early 2020, until the sample number in each category was met.

All digital radiographs were taken with a Veraviewepocs panoramic and cephalometric model (J. Morita Corp., Kyoto, Japan) with a high-resolution charge-coupled device (CCD) sensor (32-bit microprocessor). Panoramic exposure was carried out at 10 milliampere seconds (mAs) for 12-15 seconds at 70-80 kVp. The process of sampling digital data was completed using I-Dixel imaging software (J. Morita Corp., Kyoto, Japan). Panoramic radiographic examinations were carried out alternately by 4 operators based on a rotation schedule (morning/evening shift) at the hospital. All operators had more than 5 years' working experience. This research was conducted by a dental student under the guidance of teaching staff of the Department of Dentomaxillofacial Radiology. All panoramic images were individually measured by a 4th year dental student who had been previously calibrated by a supervisor. To evaluate the consistency and reliability of the dental student's measurement, intra- and inter-observer agreements were carried out.

The positional errors of panoramic radiography included in this study were as follows:

1. Spinal position error (ghosting shadow error): the patient bends when standing or sitting, the spine will create a triangular radiopaque image that overlaps the anterior teeth.
2. Anteroposterior error: the patient is positioned forward or backward. The error occurs because the position of the patient's head or the anterior teeth are not placed according to the bite block. A position of the patient that is too far forward from the focal trough can cause the anterior teeth to appear blurred and narrow. In addition, the vertebrae appear to overlap with the mandibular ramus and premolars overlapping one another. On the other hand, if the patient is too far back towards the head of the X-ray tube, the anterior teeth will appear blurred and widened, and a ghost image of the spine may be seen.
3. Horizontal errors: the head turned to the right or the left. The error occurs because the midsagittal plane is not vertical and the head rotates. If the patient's head is not properly centred, the mandibular ramus and posterior teeth will appear unilaterally widened. The side that is farther away from the receptor will appear larger, and the side that is closer to the receptor will appear smaller. One condyle and one side of the neck will appear asymmetrical and larger than the other side. The mandibular angle looks higher than the other side.
4. Vertical errors: chin tipped low or high. The error occurs because the Frankfurt plane is not horizontal. In a patient with the chin facing too high and the forehead too far back, the hard palate and the floor of the nasal cavity appear to coincide with the roots of the maxillary teeth. The occlusal plane is in the form of a 'reverse smile line', or it looks flat. In patients with a chin that is too downward and the forehead too forward, the mandibular incisors appear blurred, the condyle may not be visible, the shadow of the hyoid bone coincides with the anterior aspect of the mandible, the premolars overlap one another, and the occlusal plane is shaped exaggerated smile line.
5. Improper tongue position (air shadow error): a tongue that is not placed on the palate will produce a dark shadow on the maxilla under the palate, so that the maxillary incisors appear blurred. Lifting and placing parts dorsal tongue to the palate provides an image of the soft tissue of the tongue to fill in the cavity resulting in density in the image.
6. Patient movement during exposure: the patient movement may result in only minor blurring or distortion, while in other cases it may lead to significant image artifacts, including ghost images or double images.

STATISTICAL ANALYSIS

Intra- and inter-observer reliability tests were performed using the Kappa method, and as many as 10% (50) of the 495 panoramic radiograph samples were randomly selected. Intra- and inter-observer measurements were taken with a time difference of one week after the first measurement. The same dental student performed an intra-observer test, while the inter-observers were clinical supervisors with 15 years of experience in oral radiology. The independent variable was the age

TABLE 1. Percentage of panoramic radiographs with one or more errors

	Frequency			Percentage
	Children, *n* (%)	Adult, *n* (%)	Elderly, *n* (%)	
Panoramic with 1 error	44 (8.9)	64 (12.9)	58 (11.7)	33.5
Panoramic with 2 errors	72 (14.5)	45 (9.1)	65 (13.1)	36.8
Panoramic with 3 errors	28 (5.7)	23 (4.6)	29 (5.9)	16.2
Panoramic with 4 errors	11 (2.2)	8 (1.6)	3 (0.6)	4.4
Panoramic with 5 errors	1 (0.2)	0 (0)	1 (0.2)	0.4
Panoramic with no error	9 (1.8)	25 (5.1)	9 (1.8)	8.7
Total	495 (100)			

TABLE 2. Percentage of different radiographic errors in each age group

	Frequency			Percentage
	Children, *n* (%)	Adult, *n* (%)	Elderly, *n* (%)	
Panoramic preparation errors	20 (2.3)	16 (1.8)	7 (0.8)	5
Patient preparation errors	15 (1.7)	0	0	1.7
Patient positioning errors	286 (33)	239 (27.5)	285 (32.8)	93.3
Total	868 (100)			

listed in the medical records. The dependent variable included the number of positional errors (spine not upright, anteroposterior error, horizontal error, vertical error, improper tongue position, and patient moving). The scale used was categorical. The data obtained were further processed using Pearson's χ^2 categorical comparative statistical tests for data from more than 2 unpaired samples. Statistical significance was set at $p < 0.05$. The data were analysed with SPSS, Version 17.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The κ measurements of the intra- and inter-observer agreement were 0.833 and 0.735, respectively. The intra- and inter-observer reliability tests showed that the interpretations made by the researchers had almost perfect agreement and substantial agreement, respectively.

Of the 495 panoramic radiographs observed, 43 (8.7%) had no errors, while 452 (91.3%) showed one or more errors. The distribution of radiographic errors can be seen in Table 1. Panoramic radiographic errors can be divided into three categories. Tool preparation errors (orbital base or mandibular bone cortical not completely covered), patient preparation errors (visible ghost images in the form of earrings and necklaces), and patient positioning errors (patient position does not match the guidelines). The prevalence of these errors on panoramic radiographs is shown in Table 2. The most common panoramic radiographic errors were patient positioning errors, comprising as many as 810 (93.3%) of the 868 total errors. Among the 3 age groups, the radiographs that had the most errors were in the children's age group, with 321 errors (37%), while the radiographs of adults and the elderly had 255 (29.4%) and 292 errors (33.6%), respectively. There were no panoramic radiographic patient preparation errors in the adult and elderly age groups.

Common errors in positioning patients include the spine position not upright, anteroposterior errors, horizontal errors, vertical errors, tongue position incorrect, and patient movement. The frequency distribution of the radiographic position errors is shown in Table 3. The highest error found in the 3 age groups was the incorrect tongue position error, with 233 radiographs (28.8%). Errors in the position of the spine not upright and anteroposterior errors were most common in the elderly. Meanwhile, horizontal errors, vertical errors, failure in tongue position, and moving patients mainly occured in the children's age group.

DISCUSSION

The results of this study showed that of the 495 radiographs included in the inclusion criteria, 452 radiographs (91.31%) had one or more errors, and only 43 radiographs (8.69%) had no errors. Of the 3 age groups, children and the elderly had a greater prevalence of errors, amounting to 94.5%. Meanwhile, the prevalence of errors in the adult age group was 84.9%. This could be because children tend to be restless and move during light exposure, and there may be difficulties in positioning children correctly due to their small head size and different body proportions compared to adults. As a result, there may be difficulties in positioning the child correctly to ensure that the desired structures are captured in the image. For example, the child's chin may not be positioned correctly, leading to incomplete or distorted images of the mandible. Additionally, children's teeth may not be completely erupted or in their final positions, due to their developing dentition, which will affect how they bite and how their teeth are positioned in the focal trough. Proper positioning and co-operation of the child is essential to avoid errors on the panoramic radiographic examination. Because the elderly tend to be unable to perform complex movements and have altered anatomical structures, it may pose difficulties in positioning elderly patients, especially those with Parkinson's disease with motor disorders [7, 9].

Panoramic radiography is one of the most frequently used extraoral radiography techniques because it is con-

TABLE 3. Positioning errors on panoramic radiographs

Error position	Frequency			Percentage
	Children, *n* (%)	Adult, *n* (%)	Elderly, *n* (%)	
Spinal position error (slumped position)	5 (0.6)	26 (3.2)	82 (10.1)	13.9
Anteroposterior error	48 (5.9)	57 (7.0)	62 (7.7)	20.6
Patient positioned forward	25 (3.1)	32 (4.0)	44 (5.4)	
Patient positioned backward	23 (2.8)	25 (3.1)	18 (2.2)	
Horizontal error	32 (4.0)	31 (3.8)	27 (3.3)	11.1
Head turned to the right	19 (2.3)	21 (2.6)	13 (1.6)	
Head turned to the left	13 (1.6)	10 (1.2)	14 (1.7)	
Vertical error	51 (6.3)	36 (4.4)	33 (4.1)	14.8
Chin tipped low	51 (6.3)	36 (4.4)	32 (4.0)	
Chin tipped high	0	0	1 (0.1)	
Failure to position tongue on the palate	91 (11.2)	75 (9.3)	67 (8.3)	28.8
Patient movement during exposure	59 (7.3)	14 (1.7)	14 (1.7)	10.7
Total position errors	810 (100)			

TABLE 4. Results of categorical comparison analysis of positioning errors between children, adults, and the elderly

	Children, *n* (%)	Adults, *n* (%)	Elderly, *n* (%)	*p*-value*
Spinal position error				
A slumped position	5 (3.0)	26 (15.8)	82 (49.7)	0.000
Correct position	160 (97.0)	139 (84.2)	83 (50.3)	
Anteroposterior error				
Patient positioned forward or backward	48 (29.1)	57 (34.6)	62 (37.6)	0.108
Correct position	117 (70.9)	108 (65.4)	103 (62.4)	
Horizontal error				
Head turned to the left or right side	32 (19.4)	31 (18.8)	27 (16.4)	0.597
Correct position	133 (80.6)	134 (81.2)	138 (83.6)	
Vertical error				
Chin tipped low or high	51 (30.9)	36 (21.8)	33 (20.0)	0.063
Correct position	114 (69.1)	129 (78.2)	132 (80.0)	
Tongue position				
Failure to position tongue on the palate	91 (55.2)	75 (45.5)	67 (40.6)	0.026
Correct position	74 (44.8)	90 (54.4)	98 (59.4)	
Patient movement				
Patient movement during exposure	59 (35.8)	14 (8.5)	14 (8.5)	0.000
Correct position	106 (64.2)	151 (91.5)	151 (91.5)	

**Pearson's χ^2 categorical comparative test*

sidered simple, easy, fast, and has little radiation exposure compared to full-mouth intraoral surveys [14, 15]. Patient positioning errors were more common than equipment preparation errors and patient preparation errors in the 3 age groups. The frequency of patient positioning errors was found to be 810 errors from 495 radiographs. This is in accordance with the results of a previous study by Fairozekhan *et al.* [6], who evaluated 1014 panoramic radiographs, with a result that 884 radiographs (87.2%) had one or more errors in positioning the patient. Several factors that occur are beyond the operator's control, such as patients who are obese, too tall, or unable to follow instructions. Although errors can occur beyond the control of the operator, most of the errors can be prevented

by the operator and can be reduced by paying greater attention during the radiographic process [16, 17].

The most common patient positioning error on panoramic radiographs was improper tongue position. As many as 233 of the 495 panoramic radiographs had this error (47.07%). The results of this study are similar to most research results that have stated that the most common error found was improper tongue position [18, 19]. A categorical comparative analysis test was conducted using Pearson's χ^2 to see if there was a significant difference between the errors in incorrect tongue position in children, adults, and the elderly. The results showed a significant difference in incorrect tongue position errors between the age groups of children, adults, and the elderly ($p = 0.026$). The frequency of occurrence of this error is higher in the child age-group and then decreases with age. This error can occur because of the operator's lack of communication in instructing the patient to swallow and place the tongue on the palate. Another explanation is that the patient sometimes misunderstands the instructions and only puts the tip of the tongue on the palate, or the patient does not pay much attention to the instructions given by the operator [17, 20].

The unpaired categorical comparative Pearson's χ^2 test showed a significant difference in spinal position errors between the age groups of children, adults, and the elderly ($p = 0.000$). The percentage of these errors that occur increases with age. These results are similar to the study of Belgin *et al.* [20], which stated that the incorrect position of the spine (not being upright) occurred more often in patients over 56 years of age (37.7%). Research by Roghani *et al.* [21] explains that elderly patients have a high prevalence of cervical kyphosis, which amounts to 20-40%. One of the causes of cervical kyphosis is a weakened extensor muscle, which causes the patient to be unable to lift the head high. However, Khan *et al.* [22] stated that patients naturally tend to bend over when asked to hold the provided support.

Similar to the research by Kumar [10], the results of this study showed that the error of the patient moving during exposure was the error with the lowest prevalence. The prevalence of this error was much higher in children than in adults and the elderly. Using Pearson's χ^2 test, it was found that there was a significant difference in patients moving during exposure between children, adults, and the elderly ($p = 0.000$). Researchers explained that a higher prevalence in children occurs because children tend to find it more difficult to stand still during light exposure (13-20 seconds). This can also explain why vertical and horizontal errors are more common in children than in adults and the elderly [7, 23, 24].

Errors in panoramic radiographs can affect interpretation and diagnosis. In general, panoramic radiographs show magnifications of about 10-30%. Therefore, errors in patient positioning can cause this magnification to become more disproportionate; hence, the patient's position when taking radiographs is crucial [20]. In this study, it was found that the number of position errors was higher in children than in adults and the elderly. This can happen because children do not understand the importance of following the instructions of the operator, which is not the case for adult and elderly patients. In addition, children tend to experience anxiety, which results from pain, fear of unfamiliar surroundings, and a lack of assistance from parents or operators when the exposure is ongoing. Excessive anxiety can interfere with the child's understanding of following instructions from the operator [25].

Errors in panoramic radiographs caused by patient position errors are still common at the dental hospital in Universitas Indonesia. However, most errors are patient related (incorrect tongue position). Errors can be minimized by providing clearer, more applicable instructions and increasing operator attention during patient positioning. In addition, the operator can be given access to view the patient's position through the control room to ensure that the patient remains in the correct position and does not move during exposure. These efforts are expected to reduce the prevalence of errors and to help produce high-quality panoramic radiographs.

CONCLUSIONS

The results of this study showed that the most common error in the 3 age groups was incorrect tongue position error. In elderly patients, the position of the spine is the second most common error, while in children it is moving during exposure.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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