

Positional Errors in Orthopantomograph – A Comparative Systematic Review with analysis of 1014 additional cases

Short title: Positional Errors in Orthopantomograph

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Abstract

Objectives

The purpose of our systematic review was to investigate the most common errors in the panoramic radiography and their impacts on the resultant radiographic film. The knowledge about the common positioning errors and the ways to rectify the errors, will benefit in producing high quality radiograph.

Material and methods

PubMed, ProQuest, Google scholar, Science direct and Scopus were screened for studies. Article selection and data extraction was done by one investigator and other investigator confirmed its accuracy.

Results

Four hundred and seventy articles were initially identified from which eleven articles were full-text reviewed and included in the review. Additional 1014 radiographic cases were retrieved from the department of oral radiology and was assessed for various errors. Out of the eleven studies, the most common panoramic error encountered was, the tongue not placed on the palate and on the radiograph, it appeared as radiolucent band on the apex of the maxillary teeth.

Conclusion

To produce high quality radiograph, it is necessary for the operator to have a better communication with the patient and also to know about proper patient positioning.

Keywords: Positioning errors, Orthopantomograph, panoramic machine, errors and their impacts, patient position.

Introduction

The panoramic radiograph is also known as Orthopantomogram (OPG) is used in the investigation of facial and dental pain. The bones of the jaw, the teeth, the temporomandibular joints and maxillary sinuses can be seen in this radiograph.¹ It is most commonly used because of its broad demonstration of the oro-maxillofacial structures on a single image, with minimal patient discomfort and low radiation effective dose (14.2-24.3 mSv).² In panoramic radiographs the prevalence of incidental findings in young patients undergoing orthodontic treatment was found to be 8.7%, and these findings included idiopathic sclerosis, mucosal thickening, and periapical lesions.³ In this radiographic technique the patient's position is important for clear and acceptable final image, focusing on the teeth and alveolar bone structure. A successful panoramic radiograph requires careful positioning of the patient and proper technique.⁴ The poor diagnostic quality reduces the quality of the panoramic radiograph. This poor quality usually is not caused due to inherent limitation with the equipment, but due to the errors made by the operators during patient positioning and processing.⁵ Good-quality dental panoramic radiograph prevents misinterpretation causing incorrect diagnosis and treatment planning and it also maximizes the benefits to the patient by minimizing the radiation exposure and the financial cost. Radiation exposure due to the repetition of panoramic radiograph has been associated with an increased risk of inducing cancer.^{5, 6} Therefore we conducted systematic review of published journals to list out the common errors of panoramic radiographs and their prevalence. The main goal is to get a detailed view on the errors of panoramic radiography and their impacts on the radiographic film and to get a better understanding of causes of the errors and what could be done to avoid the errors in future. And the dentist at large is to understand the technical drawbacks and to understand the pitfalls in diagnosis in such faulty radiographs and not to over diagnose the lesions, and to know when to repeat the radiograph.

Materials and Methods

Ethical approval from the Institutional review board was obtained. Informed consent from the patients were obtained before the start of the study. The substructure of the systematic review is based on PRISMA Statement.⁷ The focused question is "what are the most common errors in the panoramic radiography and their impacts on the resultant radiographic film?"

Study design

This systematic review evaluated the various errors of the panoramic radiograph and its prevalence

Eligibility criteria

Inclusion criteria

Studies in which the primary objective was to evaluate the errors of panoramic radiograph was included. Both digitally or conventionally processed radiographic film were included. No language or time restriction were applied.

Exclusion criteria

Exclusion criteria included case reports less than 10 patients, reviews, letters, personal opinions, book chapters, conference abstracts and studies using animal models.

Information sources

The following databases were incorporated in the systematic search for relevant literature: PubMed, ProQuest, Google scholar, Science direct and Scopus. All searches were conducted from 1st September to 12th September 2020.

Search terms

Following search terms were used quality and panoramic radiograph, positioning errors and panoramic radiograph, common errors and panoramic radiograph, technical errors and panoramic radiograph, radiation and repeated panoramic radiograph.

Study selection

In 1st phase of selection- the titles and abstracts were screened and evaluated.

In the 2nd phase of selection- Full text were screened and study which have the inclusion and exclusion criteria were selected

Collection process

For all the included studies, following descriptive characteristics were recorded: Author, year of study, country of research, study type, sample size, most common error in the panoramic radiography and its impact, least common error in panoramic radiography, type of panoramic machine used and results of the included study. One reviewer collected the required information from included studies and the other reviewer confirmed its accuracy.

Additional cases

The 1014 radiographic cases were retrieved from the department of oral radiology. Cases were reviewed retrospectively by oral radiologists for radiographic findings. Patient with adequate history and relevant radiographic data were included in the study. In each case, age, gender and radiographic data were collected from the records. The panoramic radiographs were assessed and judged by two independent Oral Radiologists who were double-blinded to the study categorization and clinical records.

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (IBM SPSS Version 20) and intraobserver agreement was calculated using kappa analysis.

The various types of panoramic errors encountered in these cases are listed out.

Error	Type of error	Impacts on the radiograph
Error 1	Patient positioned too forward	Anterior teeth in both arches are out of focus, blurred, and narrow, and spine superimposed
Error 2	Patient positioned too far back	Anterior teeth in both arches are out of focus, blurred, and wide, in appearance and excessive ghosting of mandibular spine.
Error 3	Patient head tilted downwards, chin backward and forehead in front	Blurring of lower root apices, shadow of hyoid bone on anterior mandible, condyles are cut off, v shaped mandible, and spine forms arch or gazebo effect

Error 4	Patient head tilted upwards, chin placed forward, and forehead tilted toward the back	Blurring of upper incisors, hard palate superimposed on the roots, flat occlusal plane, mandible is broad and flat, condyles at edge of film
Error 5	Patient head is twisted	The teeth and ramus of one side of the mandible appears wide and larger than that the other side.
Error 6	Patients head is tilted or tipped in the machine	Image tilted, one angle of mandible higher than other, condyles not equal in height
Error 7	Ghost of spinal column due to slumping	White tapered opacity in middle of image
Error 8	Patients tongue is not fully placed against the roof of the mouth	Dark shadow in the maxilla below the palate
Error 9	Patient movement during exposure	Blurred image with step effect
Error 10	Artefacts	Ghost images, reflected images
Error 11	Multiple errors (Multiple errors more than 6)	
Error 12	Errors rendering the radiographic film as non-diagnostic	
Error 13	Ghosting of other structures (e.g.) hyoid bone	

Results of the additional cases

Out of 1014 cases viewed, 130 (12.8%) had no errors, while 884 (87.1%) radiographs showed one or more positioning errors. The most common error observed in the radiographs were ghost of the spine column due to slumping (31%) and due to which white opacity line is seen in the middle of the image, followed by patients tongue is not fully placed in the roof of the mouth (25.9%) and due to which it caused dark shadow in the maxilla below the palate. The least common error which was observed is patient movement during exposure (0.29%). The other common errors in the study were patient positioned too forward (0.7%), patient positioned too far back (0.7%), patient head tilted downwards (17.9%) and patient head is twisted (17.9%). The level of significance used in the statistical tests was 95 % (0.05). Therefore, p value of 0.05 were considered to indicate statistical significance. The inter-examiner reliability was 84 %. Overall, the intra-examiner agreement was found to be good.

Discussion

Panoramic radiographs evaluated in this study, was obtained from the Department of Oral radiology and retrospectively assessed for their positioning errors. The radiographs of all the patients, taken for diagnostic purpose were included in the study.

This study revealed that out of 1014 panoramic radiographs, 87% of radiographs examined had one or more positioning errors, thus reducing the diagnostic yield of the resultant radiographic images. The most common error was slumped position and it was in correlation with Ceren Aktuna Belgin et al., who sampled 500 radiographs in his study.¹¹ The second most common error in this study was failure to position the tongue against the palate which was in accordance with Nithin Kumar retrospective study with 1000 radiographic samples. The least common error in this study was patient movement during exposure (0.29%), is in accordance with the results of the study performed by Swetha Kattimani et al.,¹⁰ and Benjamin Peretz et al.,¹³

Result of the Systemic review

A summary of the results of the included studies are shown in the Table-1. A total of 8765 articles were found in the various scientific database with search expressions relevant to this study, of these, 470 articles were selected for initial screening and from those 470 articles duplicates were excluded and the remaining was 140 articles. After abstract and text screening a total of 11 articles were finally selected for the study with the inclusion and exclusion criteria of the systematic review.⁸⁻¹¹ The selection process of the include study is shown in Fig –1.

Out of 11 studies which were included in the systematic review 10 were retrospective and one was randomized control clinical trial. The sample size of each study ranged from 500 radiographs to 2000 radiographs. The films were processed digitally or by conventional method. Out of 11 studies, 10 studies were processed digitally. The list of studies and various characteristic of the studies are tabulated in table 1.

The most common panoramic error encountered in the studies included, the tongue not placed on the palate and on the radiograph it appeared as radiolucent band on the apex of the maxillary teeth.^{8, 11,12,14,15,16,17,18.} The second most common error in this systematic review was head turned towards one side and on the radiograph it was seen as asymmetrical condyle and the ramus appeared one side larger than the other.^{9, 10, 12, 15.} The least common error in all most all studies was patient movement and it caused blurring effects on the radiograph and also step defects on the inferior border of the mandible.^{8,10,13,15,16,17,18.}

Discussion

The primary findings of this systematic review is that the tongue not placed on the palate was the most common error in the studies included in this review. This error could be due to the lack of communication of the radiographic technician to instruct the patient, to swallow and place the tongue on the roof of the mouth. Another possibility could be misunderstanding the instructions and placing only the tip of the tongue on the palate or the patients were given no instructions regarding this.¹⁷

The second most common error in the included studies was head turned towards one side. This error might be due to improper head stabilizer or due to lack of communication between the technician and the patient. The technician should spend some time in proper patient positioning and ensure that the patient's head is centered in three different planes which are midsagittal (perpendicular to the floor), occlusal (parallel to the floor), and the anteroposterior plane to uniformly record the maxillofacial complex.¹⁵

On the other hand, the least common error in this systematic review is the patient movement during exposure, it in correlation with the results of the study performed by Dhillon et al., Rushton et al. and many others.

In additional studies, the most common error was slumped position, a ghost shadow on the symphysis may be attributed to patient slumping; there is a natural tendency for patients, when holding the handles of the machine, to slump. The dental technician needs to be certain before taking the radiograph that the patient's back and spine are erect with the neck extended.¹⁷

The magnification of the panoramic radiographs ranges between 10% and 30%. The errors in the positioning of the patients cause these magnification more prominent. This might lead to incorrect diagnosis, hence patient positioning is very crucial. For the correct position, the patient's head should be positioned on the Frankfort horizontal plane, the canine-meatus line and the midsagittal line. If this is not observed, the patient might tilt his head to the right, left, front or back. When the patient tilts his head towards one side, the teeth near the tube head will appear to be wider and longer on the image.

The patient must be informed about the "ski position" in order to prevent superposition of the spina in the anterior region. The focal trough in the panoramic radiographs, is the area where the curvature dental arch image is viewed at its clearest and highest quality. The patient's jaw should be in the focal trough and the patient must bite the bite bar to prevent the overlap of the teeth.¹¹

Blurred images of the incisor teeth appears, when the patient is seated too forward in the focal trough. The positioning error of only 3 to 4 mm in the horizontal plane can make a drastic change in the width of the images. In those cases, interproximal caries may not appear or appears smaller in size. The appearance of periapical pathology may also be affected. To avoid this problem, the correct patient position is assured by the vertical indication laser beams positioned on anterior teeth.¹⁹

The most common three positioning errors and the protocols to be followed to avoid the errors are listed out in the Table 2.

The positioning errors have the capacity to make a radiograph diagnostically unacceptable and leads 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.²⁰ When there is two or more radiographic errors on the radiographic film, the radiography has to be repeated, which in turn increases risk of radiation. The patient movement causes blurring effects on the radiograph and reduces the quality of the radiograph.^{15]}

Conclusion

On the whole, for the interpretation purpose, it is important for the dentist to be aware of the common errors and also to know how they affect the quality of the image. The dentist must monitor the quality of panoramic radiograph and also must ensure that they are free of positioning errors. The operator's skill, better communication with the patient, and the time spent in patient positioning decreases the number of errors and helps in producing high quality radiographs.

Reference

1. Constantine S, Clark B, Kiermeier A, Anderson P. Panoramic radiography is of limited value in the evaluation of maxillary sinus disease. *Oral surgery, oral medicine, oral pathology and oral radiology*. 2019 Mar 1; 127(3):237-46.
2. Boeddinghaus R, Whyte A. Dental panoramic tomography: an approach for the general radiologist. *Australasian radiology*. 2006 Dec; 50(6):526-33.
3. Abdalla-Aslan R, Yeshua T, Kabla D, Leichter I, Nadler C. An artificial intelligence system using machine-learning for automatic detection and classification of dental restorations in panoramic radiography: Automated detection and classification of panoramic dental restoration. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*. 2020 Jun 3.

4. Rondon RH, Pereira YC, do Nascimento GC. Common positioning errors in panoramic radiography: A review. *Imaging science in dentistry*. 2014 Mar 1; 44(1):1-6.
5. Kratz RJ, Nguyen CT, Walton JN, MacDonald D. Dental students' interpretations of digital panoramic radiographs on completely edentate patients. *Journal of dental education*. 2018 Mar;82(3):313-21.
6. Kaviani F, Johari M, Esmaeili F. Evaluation of common errors of panoramic radiographs in Tabriz Faculty of Dentistry. *Journal of dental research, dental clinics, dental prospects*. 2008;2(3):99.
7. Shea BJ, Grimshaw JM, Wells GA, Boers M, Andersson N, Hamel C, Porter AC, Tugwell P, Moher D, Bouter LM. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC medical research methodology*. 2007 Dec 1;7(1):10.
8. Kumar N. Assessment of common errors and subjective quality of digital panoramic radiographs in a dental institution. *Dentistry and Medical Research*. 2020 Jan 1;8(1):23.
9. Choi BR, Choi DH, Huh KH, Yi WJ, Heo MS, Choi SC, Bae KH, Lee SS. Clinical image quality evaluation for panoramic radiography in Korean dental clinics. *Imaging science in dentistry*. 2012 Sep 1;42(3):183-90.
10. Kattimani S, Kempwade P, Ramesh DN, Byatnal A, Nasreen S, Subashani T. Determination of different positioning errors in digital panoramic radiography: A retrospective study. *Journal of Medicine, Radiology, Pathology and Surgery*. 2019 Mar 1;6(2):5-8.
11. Belgin CA, Serindere G. Evaluation of error types and quality on panoramic radiography. *International Dental Research*. 2019 Dec 31;9(3):99-104.
12. Loughlin A, Drage N, Greenall C, Farnell DJ. An investigation in to the impact of acquisition location on error type and rate when undertaking panoramic radiography. *Radiography*. 2017 Nov 1;23(4):305-9.
13. Peretz B, Gotler M, Kaffe I. Common errors in digital panoramic radiographs of patients with mixed dentition and patients with permanent dentition. *International journal of dentistry*. 2012 Oct;2012.
14. Newadkar UR, Chaudhari L, Khalekar YK. Common errors on panoramic radiograph: A time to reflect and review and not to sweep them under the carpet!. *SRM Journal of Research in Dental Sciences*. 2016 Jul 1;7(3):146.
15. Khator AM, Motwani MB, Choudhary AB. A study for determination of various positioning errors in digital panoramic radiography for evaluation of diagnostic image quality. *Indian Journal of Dental Research*. 2017 Nov 1;28(6):666.
16. Rushton MN, Rushton VE, Worthington HV. The value of a quality improvement programme for panoramic radiography: A cluster randomised controlled trial. *Journal of Dentistry*. 2013 Apr 1;41(4):328-35.
17. Dhillon M, Raju SM, Verma S, Tomar D, Mohan RS, Lakhanpal M, Krishnamoorthy B. Positioning errors and quality assessment in panoramic radiography. *Imaging science in dentistry*. 2012 Dec 1;42(4):207-12.
18. Pandey S, Pai KM, Dhakal A. Common positioning and technical errors in panoramic radiography. *Journal of Chitwan Medical College*. 2014 Jul 30;4(1):26-9.
19. Serman N, Horrell BM, Singer S. High-quality panoramic radiographs: Tips and tricks. *Dentistry today*. 2003 Jan 1;22(1):70-3.
20. Praveen BN, Shubhasini AR, Bhanushree R, Sumsun PS, Sushma CN. Radiation in Dental Practice: Awareness, Protection and Recommendations. *JContemp Dent Pract* 2013;14(1):143-148.

Figure and Tables

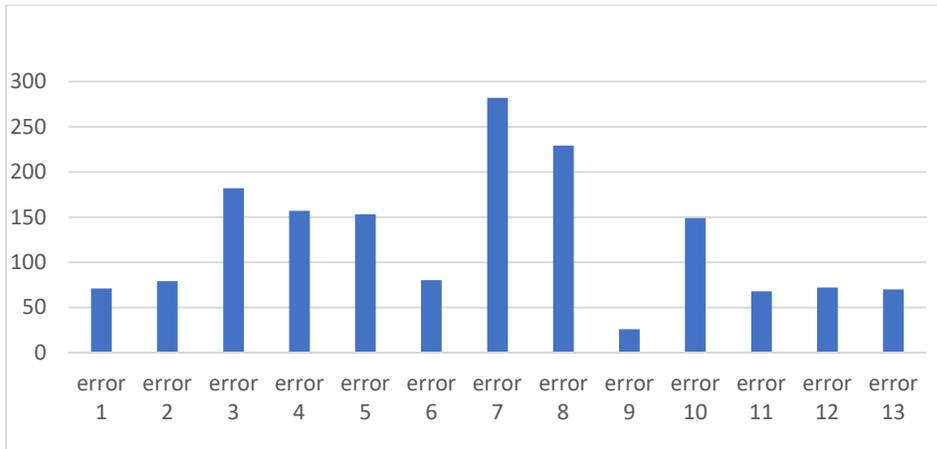


Figure 1. Bar graph showing frequency of positioning errors in the additional cases

Table 1. List of included studies and its main characteristics

No	Author	Year of study	Study type	Country of research	Sample size	Most common error in panoramic radiography	Its impact on the radiograph	Least common error	Type of panoramic machine used	Result
1	Nithin Kumar	2019	Retrospective	Iraq	1000	Failure to position the tongue against the palate	Root apices of the teeth are obscured	Patient movement	NewTom Giano, CEFLA s.c., Imola, Italy	Out of 1000 224- no error 776- one or more positioning error. ⁸
2	Bo-Ram Choi et al.,	2012	Retrospective	Korea	297	Positioning and image taking	Sharpness and contrast	Anatomic abnormality	-	Overall image quality Out of 297 17- optimal for diagnosis 153-adequate for diagnosis 109-poor but diagnosable 9- too poor for diagnosis. ⁹
3	Swetha Kattimani et al.,	2019	Retrospective	India	500	i. Head turned towards one side ii. Patient positioning forward	Asymmetry of condyles , ramus is wider on one side than the other, uneven pattern of blurring throughout arch, nasal structures not clear	Patient movement	PLANMEC A 2006, 75 kVp, and 10 mA	Out of 500, 86- no errors 412- showed one or more positioning errors. ¹⁰

4	Ceren Aktuna Belgin et al.,	2019	Retrospective	Turkey	500	i. Slumped position ii. Tongue not in contact with the palate	i) Radiopaque area in the anterior teeth due to superposition of the spina. ii) Radiolucent area in the apex of the maxillary teeth due to palatoglossal airspace.	Chin tipped high	Digital Panoramic device Planmeca, Helsinki, Finland 70 kVp and 10 mA.	Out of 500 317- one or more errors 183- no errors. ¹¹
5	A. Loughlin et al.,	2015	Retrospective	UK	315	i) Positioning error- rotation of the patient ii) Preparation error-tongue not placed in the palate	i) Magnification of the posterior teeth on the side that is rotated away from the image receptor ii) Radiolucent band overlying the apices of maxillary teeth.	Patient chin down	Instrumentarium OC100 Proline XC Instrumentarium OC200 Instrumentarium OP100 Orthopantom agraph	Out of 315 221- Diagnostically acceptable 64- excellent 30- unacceptable. ¹²
6	Benjamin Peretz et al.,	2009	Retrospective	Israel	289	Tongue not placed on palate	Radiolucent band projected on the apices of maxillary teeth.	Patient movement	Kodak 8000c Digital Panoramic and Cephalometric System 70Kv and 10mA 13 seconds	Out of 289 168-diagnostic radiograph 121- non diagnostic radiograph. ¹³
7	Ujwala Rohan Newadkar et al.,	2016	Retrospective	India	2000	i) Tongue not placed on the palate	i) Radiolucent band projected on the apices	Failure to remove patient	Advanced medical system 70	Out Of 2000 1780- with one or more errors

						ii)chin tipped too low or too high	of maxillary teeth ii) Excessive curving of occlusal plane. Flattening or reverse curvature of occlusal plane	jewels, prostheses and use of lead apron during exposure	kVp and 10 mA	220- no errors. ¹⁴
8	Apurva Mohite Khato et al.,	2014	Retrospective	India	500	Head turned towards one side	Causing an asymmetry of the condyles, and wider teeth and ramus on one side than the other	Patient movement	Kodak 8000c Digital Panoramic and Cephalometric System 70Kv and 10m	Out of 500 475- one or more errors 25- error free. ¹⁵
9	Michael N. Rushton et al.,	2012	Clustered randomized control clinical trail	UK	800	i)tongue not positioned in the palate ii)lips not closed	Radiolucent band projected on the apices of maxillary teeth.	Patient movement	-	In this cluster randomized controlled trial the distance feedback is an effective method in instructing dental practitioners to correct technical and processing errors experienced in producing

										panoramic radiographs. ¹⁶
10	Manu Dhillon et al.,	2012	Retrospective	India	1782	Tongue not placed on the palate	Radiolucent band projected on the apices of maxillary teeth.	Patient movement	Strato 2000D, Villa Sistemi Medicali, Milan, Italy 50-80 kVp 4-10 mA	Out of 1782 1586- positioning errors 196- error free. ¹⁷
11	S Pandey et al.,	2010	Retrospective	India	1010	Most common technical error was density/dark radiograph Most common positioning error- Tongue not placed on the palate	Radiolucent band projected on the apices of maxillary teeth	Patient movement	Planmeca 2002cc panoramic machine	Out of 1010 278- technical and positioning error 732- error free ¹⁸

Table 2. Protocols to avoid the positioning errors

Error	Impacts on the radiographic film	Protocols to avoid the positioning error
The tongue not placed on the palate	Radiolucent band overlying the apices of maxillary teeth	Instruct the patient to swallow and place the tongue on the roof of the mouth.
Head turned towards one side	Causing an asymmetry of the condyles, and wider teeth and ramus on one side than the other	The patient's head must be centered in three different planes which are midsagittal (perpendicular to the floor), occlusal (parallel to the floor), and the anteroposterior plane to uniformly record the maxillofacial complex
Slumped position	Radiopaque area in the anterior teeth due to superposition of the spina	The patient's back and spine to be erect with the neck extended. (With older patients who are unable to straighten the neck, an occlusal projection of the mandibular region may be needed for a greater diagnostic yield)