

## ORIGINAL ARTICLE



# An audit of the quality of dental panoramic radiographs in the Orthodontic Unit, Klinik Pergigian Cahaya Suria

Juliza Md Lepi<sup>1\*</sup>, Mohd Zambri Mohamed Makhbul<sup>2</sup>

<sup>1</sup>Orthodontic Specialist Unit, Klinik Pergigian Tanjong Karang, Selangor, Ministry of Health, Malaysia.

<sup>2</sup>Orthodontic Specialist Unit, Klinik Pergigian Cahaya Suria, Kuala Lumpur, Ministry of Health, Malaysia.

## Abstract

This audit aimed to assess the quality of dental panoramic radiographs in the Orthodontic Unit at Klinik Pergigian (KP) Cahaya Suria by evaluating adherence to radiographic standards, the proportion of diagnostically acceptable images, and the parameters that frequently failed to meet established criteria. A total of 192 pre-treatment panoramic radiographs were analysed, and obtained from two radiology units: Hospital A (28.65%) and Hospital B (71.35%). Each radiograph was assessed using a standardized checklist covering patient identification, exposure parameters, artifact prevention, anatomical structure visibility, and overall diagnostic acceptability based on a two-point grading system. Intra-examiner reliability was ensured through repeated assessments. Data analysis identified trends and areas requiring quality improvement. The audit revealed that 98.96% of the panoramic radiographs were diagnostically acceptable, exceeding the 90% benchmark. Artifact removal compliance was 99.48%, ensuring minimal diagnostic interference. Right/left marking was consistently present in all images. Key anatomical structures such as condyles (93.75%), sinus floor (91.15%), crestal bone (95.83%), and teeth/developing follicles (100%) were highly visible. However, mental foramen visibility was low (42.71%), indicating potential limitations in exposure settings and positioning. Documentation gaps were noted, with 0% age recording and 36.98% missing exposure values, impacting record-keeping and retrospective analysis. The findings indicate that the radiograph quality assessed is highly satisfactory, with most images meeting diagnostic standards. However, improvements are needed in mental foramen visualization, exposure parameter documentation, and record-keeping. Regular audits, staff training, and a quality assurance checklist are recommended to further enhance diagnostic accuracy and compliance with radiographic standards.

## Received:

19 February 2026

## Revised:

9 July 2026

## Accepted:

9 July 2026

## Published Online:

31 July 2026

## How to cite this article:

Lepi, J., & Mohamed Makhbul, M. Z. (2026). An audit of the quality of dental panoramic radiographs in the Orthodontic Unit, Klinik Pergigian Cahaya Suria. *IIUM Journal of Orofacial and Health Sciences*, 7(2), 159–174.

<https://doi.org/10.31436/ijoh.s.v7i2.509>

## Article DOI:

<https://doi.org/10.31436/ijohs.v7i2.509>

## \*Corresponding author

## Address:

Klinik Pergigian Tanjong Karang, Selangor, Ministry of Health, Malaysia

## Telephone:

+603-32682700

## Email address:

[drjuliza@gmail.com](mailto:drjuliza@gmail.com)

**Keywords:** dental panoramic radiographs, clinical audit, orthodontic quality improvement

## Introduction

Dental panoramic radiographs are a crucial diagnostic tool in orthodontics, providing a comprehensive view of the dentition, maxillary and mandibular arches, and surrounding structures (Mallya & Lam,

2018). Panoramic radiography, also known as orthopantomography, is the most commonly requested screening test in dentistry (American Dental Association Council on Scientific Affairs, 2006). It is a crucial adjunct in diagnosis and treatment planning, enabling comprehensive imaging in a single exposure that includes dentition,

the mandible, portions of the maxilla such as the floor of the maxillary sinus, the hard palate, and the temporomandibular joints (TMJs). Nevertheless, the panoramic image presents a complex projection of the jaws, often involving multiple superimpositions and distortions, which can be further aggravated by technical errors during image acquisition (Kaffe *et al.*, 1977). Faculty of General Dental Practice (FGDP) or Public Health England (PHE) guidance recommends the use of a two-point grading scale, with images to be recorded as “diagnostically acceptable” (“A”) or “diagnostically not acceptable” (“NA”) (Public Health England & Faculty of General Dental Practice (UK), 2020). Successful interpretation of panoramic radiographs relies on a comprehensive understanding of the normal anatomy of the head and neck. This foundational knowledge is essential for identifying anatomical structures and variations, which can significantly influence the orthodontic diagnostic process and subsequent treatment planning.

The audit standard requires that at least 95% of digital radiographs are graded as “A” (diagnostically acceptable), ensuring they meet the necessary quality for accurate diagnosis without the need for retakes. For wet film radiographs, the standard is slightly lower, with a target of at least 90% being graded as “A” (diagnostically acceptable) (PHE & FGDP(UK), 2020). These benchmarks are set to maintain high radiographic quality, minimize diagnostic errors, and reduce the need for repeat exposures, thereby enhancing patient safety and care. From the literature review, the most commonly investigated radiograph quality criteria include contrast, sharpness, resolution, distortions, artifacts, and errors related to patient preparation and positioning (Aktuna Belgin & Serindere, 2019; Fux-Noy *et al.*, 2023; Marsha *et al.*, 2023; Lingam *et al.*, 2023; Suparno *et al.*, 2023). Common positioning errors include the patient being too far forward or backward, the chin being too high or too low, and the head being asymmetrical. In summary, six parameters determine whether a panoramic radiograph is correctly executed: symmetry between the two sides,

an occlusal plane exhibiting a slight upper concavity, the alignment of the two mandibular condyles at the same height, a clear depiction of the dental apexes of the upper teeth, a straight cervical spine, and appropriate exposure parameters (Izzetti *et al.*, 2021).

Ministry of Health (MOH) Malaysia licensing requirements specify that the minimum information displayed on a radiograph should include the patient’s name, identification number, date of examination, and right or left marker. Healthcare institutions also conduct Quality Assurance Programme (QAP) reject analyses to calculate radiographic rejection rates, identify the causes of rejection, and report the findings to MOH. However, at present time, a dentistry-specific national QAP guideline has not been published by MOH. Therefore, the present audit used established international radiographic quality benchmarks together with a locally developed checklist tailored to the diagnostic requirements of orthodontic practice. While general radiographic quality assessment frameworks, such as those from the Faculty of General Dental Practice (FGDP) or Public Health England (PHE), provided recommendations, these do not cater specifically to the unique diagnostic needs of orthodontics. This gap emphasizes the need to audit and develop tailored standards for orthodontic panoramic radiograph quality, ensuring that radiographs adequately support orthodontic diagnosis and treatment planning. This work aimed to conduct an audit on the quality of dental panoramic radiographs in the Orthodontic Unit, Klinik Pergigian (KP) Cahaya Suria. The goals were to assess adherence to developed radiographic standards, to examine the proportion of radiographs that met the criteria for diagnostically acceptable dental panoramic imaging, and to ascertain the parameters that frequently failed to conform to the established standards.

## Materials and Methods

This audit was conducted at the Orthodontic Unit, KP Cahaya Suria in Kuala Lumpur. It was registered with the National Medical Research Registration (NMRR), with research ID: RSCH ID-25-00601-WTL. Ethical approval for this study was obtained from the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia. Pre-treatment dental panoramic radiographs were selected from the first 200 patients registered in 2024, with registration numbers coded from 1/24 to 200/24. The dental panoramic radiographs were printed on X-ray film and were viewed with a light box and magnifier in a darkened room. Each radiograph was assessed once by an orthodontist utilizing a locally developed structured audit checklist to evaluate essential quality parameters specific to orthodontic practice. Data analysis was performed to assess the quality of the radiographs by systematically evaluating the extent to which each radiograph met the established criteria. For each radiograph, the number of criteria fulfilled was calculated and subsequently expressed as a percentage. This approach allowed for a comprehensive description of the radiographic quality across the sample, providing a quantitative representation of how well the radiographs adhered to the defined standards. The results were then analysed to identify trends and patterns in the data, facilitating an objective evaluation of the overall radiographic quality and highlighting areas that may require improvement.

To assess intra-examiner reliability, 30 dental panoramic radiographs were randomly selected and reassessed by the same examiner two weeks after the initial assessment using the same checklist. For each radiograph, an overall quality score was calculated as the percentage of applicable checklist criteria fulfilled. The

repeatability of this continuous overall score was evaluated using a two-way mixed-effects, absolute-agreement, single-measure Intraclass Correlation Coefficient, ICC (3,1), with a 95% confidence interval. ICC values of less than 0.40 were interpreted as poor, 0.40–0.59 as fair, 0.60–0.74 as good, and 0.75–1.00 as excellent agreement.

### Inclusion criteria

- Pre-treatment dental panoramic radiograph.
- Radiographs taken from Radiology Unit of Hospital A or Hospital B.

### Exclusion criteria

- The patient underwent growth modification, fixed appliance treatment, and orthognathic surgery.
- Radiographs that were not taken from Hospital A or B

### Analysis of image quality

In addition to the mandatory KKM radiograph-labelling requirements of patient name, identification number, date of examination, and right or left marker, the selected radiographs were analysed using supplementary variables such as sex, age or date of birth, acquisition time, and exposure parameters for internal quality-assurance purposes. Patient-preparation errors were assessed based on the presence of unremoved metallic objects. Positioning-related errors were considered when grading the overall diagnostic acceptability and anatomical visibility of the radiographs; however, specific positioning errors, such as chin-up, chin-down, excessive forward or backward positioning, head tilt, and head rotation, were not individually categorized. The parameters assessed and recorded for the dental panoramic radiographs are listed in Table 1.

Table 1. Parameters and criteria observed from panoramic radiographs.

| Parameters                                                                                                                                                                                                           | Criteria                                                                                                                                                                                                                                                                                                                                                                    | Interpretation                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <b>Identification:</b> <ul style="list-style-type: none"> <li>Name of patient</li> <li>Sex</li> <li>Age</li> <li>Registration number</li> <li>Date of taking</li> <li>Time of taking</li> </ul>                      | <ul style="list-style-type: none"> <li>Present</li> <li>Not present</li> </ul>                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>Yes</li> <li>No</li> </ul>                                                                   |
| <b>Mark for left or right</b>                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>Right marking</li> <li>Left marking</li> </ul>                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>Right</li> <li>Left</li> </ul>                                                               |
| <b>Two-point grading scale of overall quality assessment.</b>                                                                                                                                                        | <ul style="list-style-type: none"> <li>No errors or minimal errors in either patient preparation, exposure, positioning, image reconstruction, and of sufficient image quality to answer the clinical question</li> <li>Errors in either patient preparation, exposure, positioning, or image reconstruction which renders the image diagnostically unacceptable</li> </ul> | <ul style="list-style-type: none"> <li>“Diagnostically acceptable” (“A”)</li> <li>“Diagnostically not acceptable” (“NA”)</li> </ul> |
| <b>Density and contrast.</b>                                                                                                                                                                                         | <ul style="list-style-type: none"> <li>Unsatisfactory density with adequate contrast between the enamel and the dentine.</li> <li>Satisfactory density and contrast between the enamel and the dentine.</li> <li>Excellent density and contrast between the enamel and the dentine.</li> </ul>                                                                              | <ul style="list-style-type: none"> <li>Unsatisfactory</li> <li>Satisfactory</li> <li>Excellent</li> </ul>                           |
| <b>Removal of all metallic objects including removable orthodontic appliances, removable prostheses, piercings, glasses, necklaces, hearing aids, and hair pins to prevent artifacts from the radiographed site.</b> | <ul style="list-style-type: none"> <li>Removed</li> <li>Not removed</li> </ul>                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>Removed</li> <li>Not removed</li> </ul>                                                      |
| <b>Condyles and condylar necks</b>                                                                                                                                                                                   | This criterion assesses whether the condyles and their corresponding necks are visible and well-defined on the panoramic radiograph. The presence of these anatomical structures is essential for evaluating the full extent of the temporomandibular joint (TMJ) region,                                                                                                   |                                                                                                                                     |

|                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                              |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
|                                       | <p>which may be relevant in orthodontic diagnosis and treatment planning.</p> <ul style="list-style-type: none"> <li>• Identified: The condyles and condylar necks are fully visible without any significant distortion, cropping, or obstructions.</li> <li>• Not Identified: The condyles and/or condylar necks are either not visible, partially visible, obscured, or excluded from the image field, potentially limiting the diagnostic value of the radiograph.</li> </ul>                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>• Identifiable</li> <li>• Not identifiable</li> </ul> |
| <b>Sinus floor</b>                    | <p>This criterion evaluates the visibility of the maxillary sinus floor on the radiograph, a key landmark in orthodontic assessment for posterior teeth positioning, root proximity, and sinus pathology.</p> <ul style="list-style-type: none"> <li>• Identified: The sinus floor is clearly visible with well-defined borders, without significant distortion or obstruction. The anatomical structure is adequately captured for diagnostic purposes.</li> <li>• Not Identified: The sinus floor is not visible, partially visible, or obscured due to image cropping, positioning errors, poor exposure, or radiographic artifacts. This may limit the diagnostic value of the radiograph.</li> </ul> | <ul style="list-style-type: none"> <li>• Identifiable</li> <li>• Not identifiable</li> </ul> |
| <b>Inferior alveolar nerve canals</b> | <p>This criterion evaluates the visibility of the inferior alveolar nerve canal (IANC) on the dental panoramic radiograph. Clear identification of the IANC is essential for assessing nerve proximity to the mandibular teeth, particularly for orthodontic treatment planning and surgical considerations.</p> <ul style="list-style-type: none"> <li>• Identified: The inferior alveolar nerve canal is clearly visible with well-defined borders, allowing for accurate assessment.</li> <li>• Not Identified: The canal is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic accuracy.</li> </ul>  | <ul style="list-style-type: none"> <li>• Identifiable</li> <li>• Not identifiable</li> </ul> |
| <b>Mental foramen</b>                 | <p>This criterion evaluates the mental foramen's visibility, a key landmark for assessing nerve position in orthodontics and surgical procedures.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                              |

|                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                          |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
|                                                        | <ul style="list-style-type: none"> <li>Identified: The mental foramen is clearly visible with well-defined borders, allowing for accurate assessment.</li> <li>Not Identified: The foramen is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic accuracy.</li> </ul>                                                                                                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Identifiable</li> <li>Not identifiable</li> </ul> |
| <b>Crestal bone position of the alveolar processes</b> | <p>This criterion evaluates the visibility of the crestal alveolar bone in the alveolar process on the dental panoramic radiograph. Clear identification is essential for assessing bone levels, supporting orthodontic treatment planning, and detecting potential bone loss.</p> <ul style="list-style-type: none"> <li>Identified: The crestal alveolar bone is clearly visible with well-defined margins</li> <li>Not Identified: The bone is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic interpretation.</li> </ul>                                                                                      | <ul style="list-style-type: none"> <li>Identifiable</li> <li>Not identifiable</li> </ul> |
| <b>Periodontal ligament spaces and laminae durae</b>   | <p>This criterion evaluates the visibility of the periodontal ligament (PDL) space and lamina dura on the dental panoramic radiograph. Clear identification of these structures is important for assessing periodontal health, root integrity, and potential pathology.</p> <ul style="list-style-type: none"> <li>Identified: The PDL space appears as a uniform radiolucent line surrounding the tooth root, and the lamina dura is visible as a continuous radiopaque outline.</li> <li>Not Identified: The PDL space and/or lamina dura are unclear, discontinuous, or obscured due to image quality issues, positioning errors, or radiographic artifacts, potentially affecting diagnostic accuracy.</li> </ul> | <ul style="list-style-type: none"> <li>Identifiable</li> <li>Not identifiable</li> </ul> |
| <b>Teeth and developing follicles</b>                  | <p>This criterion evaluates the visibility of teeth and developing follicles on the dental panoramic radiograph. Clear identification is essential for assessing tooth development, eruption patterns, and any abnormalities.</p> <ul style="list-style-type: none"> <li>Identified: Teeth and developing follicles are clearly visible with</li> </ul>                                                                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>Identifiable</li> </ul>                           |

|  |                                                                                                                                                                                                                                                                                                                                                                      |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>well-defined margins, allowing for accurate assessment.</p> <ul style="list-style-type: none"> <li>• Not Identified: Teeth and/or developing follicles are unclear, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic interpretation.</li> <li>• Not identifiable</li> </ul> |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Results

The findings were based on a systematic analysis of radiographs to assess compliance with diagnostic standards and identify areas for improvement in radiographic practice. The following sections present the results of the evaluation and highlight patterns observed in the sample

Table 2 presented the prevalence of parameters that met the required criteria as well as those that did not conform to the established standards. Of the 200 dental panoramic radiographs assessed in this audit, eight were excluded as they were not from either Hospital A or B, resulting in a final sample of 192 radiographs for analysis. Among these, 28.65% were obtained from Hospital A, while 71.35% were from Hospital B. The assessment of patient and image identification demonstrated full compliance in recording patient ID and birthdate, as both were documented in 100% of the images. Similarly, the date of acquisition was recorded in all cases. However, the patient's age was absent in all images (0%), the time of acquisition was only documented in 37.50% of cases, and the sex was recorded in 28.65% of images. Additionally, the exposure value was recorded in 63.02% of the images. Regarding orientation markers, all radiographs included either a right or left

marking, with 28.65% displaying a right-side marking and 71.35% a left-side marking.

In terms of overall image quality, the two-point grading system classified 98.96% of the images as diagnostically acceptable ("A"), while only 1.04% were deemed diagnostically unacceptable ("NA"). These findings indicate that nearly all DPRs met the necessary quality standards for clinical use. Figure 1 shows a diagnostically acceptable ("A") radiograph with clear anatomical structures, proper contrast, and sharpness, meeting the required diagnostic standards for clinical assessment, while Figure 2 illustrates a diagnostically unacceptable ("NA") radiograph, which fails to meet the required diagnostic standards due to factors such as poor image quality, improper angulation, and excessive ghost images. Artifact prevention was assessed based on the removal of metallic objects that could interfere with image clarity. The majority of images (99.48%) were free from artifacts, as all removable orthodontic appliances, prostheses, piercings, and other metallic objects had been appropriately removed before image acquisition. Only one case (0.52%) exhibited unremoved artifacts, suggesting strong adherence to pre-radiographic preparation protocols.



Table 2. Prevalence of the parameters that were fulfilled or did not meet the requirements.

| Parameters                                                                                                                                                                                                                                           | Criteria         | Prevalence   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------|
| <b>Place taken</b>                                                                                                                                                                                                                                   | Hospital A       | 55 (28.65%)  |
|                                                                                                                                                                                                                                                      | Hospital B       | 137 (71.35%) |
| <b>Id</b>                                                                                                                                                                                                                                            | Yes              | 192 (100%)   |
|                                                                                                                                                                                                                                                      | No               | 0 (0%)       |
| <b>Sex</b>                                                                                                                                                                                                                                           | Yes              | 55 (28.65%)  |
|                                                                                                                                                                                                                                                      | No               | 137 (71.35%) |
| <b>Birthday</b>                                                                                                                                                                                                                                      | Yes              | 192 (100%)   |
|                                                                                                                                                                                                                                                      | No               | 0 (0%)       |
| <b>Age</b>                                                                                                                                                                                                                                           | Yes              | 0 (0%)       |
|                                                                                                                                                                                                                                                      | No               | 192 (100%)   |
| <b>Date of taking</b>                                                                                                                                                                                                                                | Yes              | 192 (100%)   |
|                                                                                                                                                                                                                                                      | No               | 0 (0%)       |
| <b>Time of taking</b>                                                                                                                                                                                                                                | Yes              | 72 (37.50%)  |
|                                                                                                                                                                                                                                                      | No               | 120 (62.50%) |
| <b>Exposure value</b>                                                                                                                                                                                                                                | Yes              | 121 (63.02%) |
|                                                                                                                                                                                                                                                      | No               | 71 (36.98%)  |
| <b>Right or left marking</b>                                                                                                                                                                                                                         | Right marking    | 55 (28.65%)  |
|                                                                                                                                                                                                                                                      | Left marking     | 137 (71.35%) |
| <b>Two-point grading scale</b><br><i>("Diagnostically acceptable" ("A")</i><br><i>Or "Diagnostically not acceptable" ("NA"))</i>                                                                                                                     | ("A")            | 190 (98.96%) |
|                                                                                                                                                                                                                                                      | ("NA")           | 2 (1.04%)    |
| <b>Removal of all metallic objects including removable orthodontic appliances, removable prostheses, piercings, glasses, necklaces, hearing aids, and hair pins to prevent artifacts from the radiographed site</b><br><i>(Removed/ not removed)</i> | Removed          | 191 (99.48%) |
|                                                                                                                                                                                                                                                      | Not removed      | 1 (0.52%)    |
| <b>Condyles and condylar necks</b><br><i>(Identifiable/Not identifiable)</i>                                                                                                                                                                         | Identifiable     | 180 (93.75%) |
|                                                                                                                                                                                                                                                      | Not identifiable | 12 (6.25%)   |
| <b>Sinus floor</b><br><i>(Identifiable/Not identifiable)</i>                                                                                                                                                                                         | Identifiable     | 175 (91.15%) |
|                                                                                                                                                                                                                                                      | Not identifiable | 17 (8.85%)   |
| <b>Inferior alveolar nerve canals</b><br><i>(Identifiable/Not identifiable)</i>                                                                                                                                                                      | Identifiable     | 157 (81.77%) |
|                                                                                                                                                                                                                                                      | Not identifiable | 35 (18.23%)  |
| <b>Mental foramen</b><br><i>(Identifiable/Not identifiable)</i>                                                                                                                                                                                      | Identifiable     | 82 (42.71%)  |
|                                                                                                                                                                                                                                                      | Not identifiable | 110 (57.29%) |
| <b>Crestal bone position of the alveolar processes</b><br><i>(Identifiable/Not identifiable)</i>                                                                                                                                                     | Identifiable     | 184 (95.83%) |
|                                                                                                                                                                                                                                                      | Not identifiable | 8 (4.17%)    |
| <b>Periodontal ligament spaces and laminae durae</b><br><i>(Identifiable/ Not identifiable)</i>                                                                                                                                                      | Identifiable     | 136 (70.83%) |
|                                                                                                                                                                                                                                                      | Not identifiable | 56 (29.17%)  |
| <b>Teeth and developing follicles</b><br><i>(Identifiable/ Not identifiable)</i>                                                                                                                                                                     | Identifiable     | 100%         |
|                                                                                                                                                                                                                                                      | Not identifiable | 0 (0%)       |



Table 3. Statistical treatment of the audit variables and intra-examiner reliability of the overall radiographic quality score.

| Variable                                        | Response Format                   | Included in overall percentage score | Item-level ICC reported |
|-------------------------------------------------|-----------------------------------|--------------------------------------|-------------------------|
| Place taken                                     | Hospital A/ Hospital B            | No*                                  | No                      |
| Id                                              | Yes/<br>No                        | Yes                                  | No                      |
| Sex                                             | Yes/<br>No                        | Yes                                  | No                      |
| Birthday                                        | Yes/<br>No                        | Yes                                  | No                      |
| Age                                             | Yes/<br>No                        | Yes                                  | No                      |
| Date of taking                                  | Yes/<br>No                        | Yes                                  | No                      |
| Time of taking                                  | Yes/<br>No                        | Yes                                  | No                      |
| Exposure value                                  | Yes/<br>No                        | Yes                                  | No                      |
| Right or left marking                           | Present/<br>Not Present           | Yes                                  | No                      |
| Two-point grading scale                         | Acceptable/<br>Not Acceptable     | Yes                                  | No                      |
| Removal of metallic objects                     | Removed/<br>Not Removed           | Yes                                  | No                      |
| Condyles and condylar necks                     | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Sinus floor                                     | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Inferior alveolar nerve canals                  | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Mental foramen                                  | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Crestal bone position of the alveolar processes | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Periodontal ligament spaces and laminae durae   | Identifiable/<br>Not identifiable | Yes                                  | No                      |
| Overall percentage quality score                | Continuous percentage             | Not applicable                       | Yes: ICC(3,1)           |

\*The place where the radiograph was taken identifies the source of the image and should not normally contribute to the radiographic quality score.

Table 4. Intra-examiner reliability of the overall percentage quality score using intraclass correlation coefficient (ICC).

| Reliability Outcome                                       | Number Reassessed | ICC model                                                            | ICC Value | 95% CI      | Interpretation      |
|-----------------------------------------------------------|-------------------|----------------------------------------------------------------------|-----------|-------------|---------------------|
| Overall percentage of applicable audit criteria fulfilled | 30                | Two-way mixed-effects, absolute agreement, single measure, ICC (3,1) | 0.998     | 0.995–0.999 | Excellent agreement |

ICC was calculated only for the continuous overall percentage quality score. Item-level ICC values were not reported because the individual checklist variables were categorical.



Figure 1. Diagnostically acceptable (“A”) radiograph, demonstrating optimal image quality with appropriate contrast, sharpness, and clarity of anatomical structures.



Figure 2. Diagnostically unacceptable (“NA”) radiograph characterized by poor image quality, insufficient diagnostic detail, and technical errors that hinder accurate clinical assessment.

The visibility of key anatomical structures was also evaluated. The condyles and condylar necks were identifiable in 93.75% of images, while the sinus floor was visible in 91.15% of cases. The inferior alveolar nerve canals were distinguishable in 81.77% of images, whereas the mental foramen was only identifiable in 42.71%, indicating a limitation in visualization for more than half of the cases. The crestal bone position of the alveolar processes was discernible in 95.83% of images, and the periodontal ligament spaces along with laminae durae were visible in 70.83% of cases. Notably, teeth and developing follicles were clearly identifiable in 100% of the images, ensuring their diagnostic reliability in orthodontic assessments. Table 3 summarises the audit variables, corresponding response formats, and the statistical approach applied to each variable in relation to the overall radiographic quality score and intra-examiner reliability analysis. The audit checklist comprised predominantly categorical variables, including binary responses such as Yes/No, Present/Not Present, Removed/Not Removed, Acceptable/Not Acceptable, and Identifiable/Not Identifiable. These variables were incorporated into the computation of the overall percentage radiographic quality score, as they reflected compliance with predefined radiographic quality criteria. In contrast, the place where the radiograph was taken was excluded from the overall score because this variable served solely to identify the source of image acquisition and was not considered an intrinsic indicator of radiographic quality. Given the categorical nature of the individual checklist items, item-level intraclass correlation coefficients were not calculated. Instead, intra-examiner reliability was assessed using the continuous overall percentage quality score, with agreement evaluated using the intraclass correlation coefficient model ICC (3,1). As shown in Table 4, the intra-examiner reliability of the overall radiographic quality score was assessed using paired percentage scores from 30 randomly selected radiographs evaluated on two occasions. The analysis demonstrated excellent intra-examiner

reliability, with an ICC of 0.998 (95% CI: 0.995–0.999).

Compliance with the mandatory radiograph labelling requirements was assessed based on the presence of patient identification, date of examination, and right or left marking. Additional information, including sex, age, acquisition time, and exposure values, was variably displayed. However, these variables were evaluated as supplementary quality-assurance indicators rather than mandatory MOH labelling requirements. Overall, the findings from this audit suggest that the quality of radiographs received in the Orthodontic Unit at KP Cahaya Suria is largely satisfactory, with the vast majority of radiographs being diagnostically acceptable. However, specific areas for improvement include the documentation of patient age and acquisition time, as well as the optimisation of techniques to enhance the visualization of the mental foramen. Addressing these aspects could further improve the diagnostic utility of panoramic radiographs and ensure higher compliance with established imaging standards.

## Discussion

The high percentage of diagnostically acceptable images (98.96%) observed in this audit indicates that the current radiographic protocols are highly effective. This finding aligns with established quality standards in dental radiography, such as the guidelines set by the Faculty of General Dental Practice (FGDP), which recommend that no more than 10% of radiographs should be diagnostically unacceptable (PHE & FGDP(UK), 2020). The audit results, with only 1.04% of images deemed unacceptable, fall well within this, demonstrating strong adherence to best practices in image acquisition, patient positioning, and exposure settings. Comparatively, previous studies evaluating the quality of dental panoramic radiographs in general dental practices have reported lower rates of diagnostically acceptable images, often citing issues such as patient movement, improper head positioning, and inconsistent

exposure settings (Fux-Noy *et al.*, 2023; Suparno *et al.*, 2023; Lingam *et al.*, 2023). In contrast, the findings from this audit suggest that these common challenges are effectively managed, likely due to strict adherence to standard operating procedures (SOPs) and adequate radiographic training among staff (Khan *et al.*, 2015; Dhillon *et al.*, 2012). The presence of a structured quality assurance process may also contribute to minimizing errors that could compromise diagnostic quality. Despite these positive findings, continuous monitoring remains essential to maintain the high quality of radiographs and further reduce the occurrence of unacceptable images (American Dental Association, 2012).

The audit findings demonstrate full compliance in recording essential patient identification details, including patient ID, birthdate, and the date of radiographic acquisition. This is a critical strength, as proper documentation of these details ensures accurate patient tracking, facilitates long-term treatment planning, and minimizes the risk of misidentification (Aakre *et al.*, 2006). Maintaining these records aligns with best practices in radiographic quality assurance, contributing to efficient data management and improved patient safety (Tridandapani *et al.*, 2013). The audit findings indicate that all dental panoramic radiographs contained right or left markers, ensuring proper image orientation during diagnosis. This is a positive finding, as consistent use of orientation markers is essential for accurate interpretation of dental and skeletal asymmetries in orthodontic cases (Barry *et al.*, 2016). Misinterpretation of the left and right sides can lead to diagnostic errors, incorrect treatment planning, and potential complications in orthodontic or surgical interventions (Titley & Cosson, 2014). Ensuring consistent placement of markers prevents confusion in cases of unilateral pathology, asymmetrical growth patterns, or skeletal discrepancies.

However, notable weaknesses were identified in the documentation of patient age and time of image acquisition. The complete absence of age documentation

(0%) and the low compliance in recording the sex (28.65%) and time of acquisition (37.50%) highlight gaps in record-keeping that may impact clinical decision-making. Age and sex are crucial factors in orthodontic diagnosis and treatment planning, as they influence tooth development, eruption timing, skeletal growth prediction, and the selection of appropriate orthodontic interventions (Wang *et al.*, 2024; Alikhani *et al.*, 2018). Similarly, documenting the time of radiographic acquisition is important for exposure tracking and quality control (American Dental Association, 2012). Time-based data can help monitor radiation dosage patterns, assess operator consistency, and identify trends that may influence image quality.

The audit findings revealed that exposure values were documented in 63.02% of dental panoramic radiographs, leaving a significant proportion (36.98%) without recorded exposure settings. This shortfall in documentation raises concerns regarding consistency in image quality and radiation dose optimisation. Proper documentation of exposure parameters, including kilovoltage (kV), milliamperage (mA), and exposure time, is essential for maintaining standardized radiographic quality and ensuring that patient radiation exposure is kept within optimal limits (Benavides *et al.*, 2024). Additionally, exposure settings influence contrast, sharpness, and overall diagnostic utility, particularly in orthodontics, where accurate visualization of dental and skeletal structures is crucial for treatment planning. The absence of exposure values limits the ability to analyze potential causes of suboptimal images and makes it difficult to replicate successful settings for future imaging (Granlund *et al.*, 2016; Ludlow *et al.*, 2008). Moreover, tracking exposure parameters is important for dose optimisation, helping to balance sufficient image quality with minimal radiation exposure in line with the As Low As Reasonably Achievable (ALARA) principle (European ALARA Network, 2019). Although age, sex, acquisition time, and exposure parameters were not consistently displayed, their absence should not be interpreted as non-compliance with MOH radiograph

labelling requirements. These variables were included as supplementary audit indicators because they may facilitate retrospective quality assessment, exposure optimisation, and investigation of technically suboptimal images.

In addition, the audit results demonstrated near-perfect compliance (99.48%) in the removal of metallic objects before radiographic exposure, indicating strong adherence to pre-radiographic preparation protocols, while only 0.52% of cases exhibited unremoved artifacts. This high level of compliance significantly contributes to improved diagnostic accuracy by minimizing superimpositions, distortions, and beam-hardening effects that could obscure critical anatomical structures (Ramos *et al.*, 2016). In contrast, studies assessing the quality of dental panoramic radiographs in general dental practices have reported a higher prevalence of artifacts due to inconsistent adherence to pre-radiographic preparation guidelines (Mohtavipour *et al.*, 2013). Images with metallic artifacts impact the visibility of the maxillary sinus, mandibular ramus, and adjacent structures (Aktuna Belgin & Serindere, 2019).

The audit findings yielded high visibility rates for several critical anatomical structures in dental panoramic radiographs, indicating that the images provide reliable diagnostic information for orthodontic assessment. Notably, the condyles (93.75%), sinus floor (91.15%), crestal bone (95.83%), and teeth and developing follicles (100%) were consistently well-visualised. These results suggest that the current radiographic protocols effectively capture essential maxillofacial structures, supporting accurate orthodontic diagnosis, treatment planning, and growth assessment. The excellent visualization of developing follicles, in particular, is crucial in pediatric and adolescent patients (American Academy of Pediatric Dentistry, 2018), as it enables precise evaluation of tooth eruption patterns, impaction risks, and potential space discrepancies.

However, a significant area of concern was identified in the visualization of the mental foramen, which was identifiable in only 42.71% of images. This low detection rate suggests potential limitations in exposure settings, patient positioning, or image processing techniques. Visibility of the mental foramen on panoramic radiographs may also be affected by anatomical variation in its position, shape, and relationship to the mandibular premolar roots, as well as differences in surrounding bone density. Superimposition of adjacent anatomical structures and the inherent projection and magnification characteristics of panoramic imaging may further reduce its visibility. Patient-related factors, including age and movement during image acquisition, may also contribute. Therefore, the observed low visibility rate likely resulted from a combination of anatomical, patient-related, and technical factors. The mental foramen is a critical reference point in both orthodontic and surgical procedures, as it marks the exit of the mental nerve, which provides sensory innervation to the lower lip, chin, and adjacent mucosa (Gupta *et al.*, 2015). Poor visualization of the mental foramen can have clinical implications, particularly in cases involving extractions, dental implant placement, and orthognathic surgery, where inadvertent nerve damage can result in temporary or permanent paresthesia (Gupta *et al.*, 2015; Jasim, 2020). Additionally, in orthodontics, clear identification of the mental foramen is essential for growth and development assessment and for evaluating mandibular asymmetry (Abdullah Bahamid *et al.*, 2023).

A limitation of this audit was that individual patient-positioning errors, including chin-up, chin-down, excessive forward or backward positioning, head tilt, and head rotation, were not separately recorded. Future audit cycles should categorize these errors individually to identify the most frequent technical causes of diagnostically unacceptable radiographs. Next, the audit checklist was locally developed from published guidance and literature and was not subjected to formal content validation or pilot testing. Therefore, its applicability and validity in other clinical settings require

further evaluation. Overall, while panoramic radiographs in this audit demonstrated strong diagnostic reliability, targeted improvements in mental foramen visibility are necessary to further enhance their clinical utility. By refining exposure settings, ensuring optimal patient positioning, and incorporating cone beam computed tomography (CBCT) imaging when required, the orthodontic unit can continue to improve radiographic accuracy and minimize the risk of diagnostic errors.

## Recommendations

To maintain the high quality of dental panoramic radiographs and address any deviations from standards, it is essential to implement a continuous quality improvement framework. Regular radiographic audits should be conducted to monitor compliance with imaging protocols, assess the consistency of exposure settings, and ensure that all essential anatomical structures are adequately visualised. These audits will help identify recurring issues and provide data-driven insights for refining imaging practices.

Staff training is another critical aspect of quality improvement. Training programs should focus on documentation practices, patient positioning techniques, and exposure parameter optimisation to enhance diagnostic reliability. Ensuring that radiographers consistently record key patient details, such as age and time of acquisition, will improve record-keeping and facilitate retrospective analysis of radiographic quality. Additionally, refining positioning techniques can help address visibility challenges, particularly for structures such as the mental foramen, which had a lower detection rate in this audit.

To further strengthen quality control, implementing a pre-radiographic quality assurance checklist is recommended. This checklist should include verification of patient identification, exposure settings, artifact removal, and proper marker placement before finalizing the radiograph. By ensuring that all essential details are

recorded and that imaging protocols are strictly followed, the orthodontic unit can minimize errors, improve diagnostic consistency, and enhance patient safety. Regular review of this checklist, along with periodic refresher training for staff, will help maintain high standards in panoramic radiographs acquisition and interpretation.

## Acknowledgement

Authors would like to thank all staff at the Orthodontic Specialist Unit for assistance and contribution to this audit. Special gratitude to the Director General of Health Malaysia and the Principal Director of the Oral Health Division, Ministry of Health Malaysia, for permission to have this audit published.

## References

- Aakre, K. T., & Johnson, C. D. (2006). Plain-radiographic image labeling: a process to improve clinical outcomes. *Journal of the American College of Radiology*, 3(12), 949-953. <https://doi.org/10.1016/j.jacr.2006.07.005>
- Aktuna Belgin, C., & Serindere, G. (2019). Evaluation of error types and quality on panoramic radiography. *International Dental Research*, 9(3), 99-104. <https://doi.org/10.5577/intdentres.2019.vol9.no.3.2>
- Alikhani, M., Chou, M. Y., Khoo, E., Alansari, S., Kwal, R., Elfersi, T., Almansour, A., Sangsuwon, C., Al Jearah, M., Nervina, J. M., & Teixeira, C. C. (2018). Age-dependent biologic response to orthodontic forces. *American Journal of Orthodontics and Dentofacial Orthopedics*, 153(5), 632-644. <https://doi.org/10.1016/j.ajodo.2017.09.016>
- American Academy of Pediatric Dentistry (2018). Prescribing dental radiographs for infants, children, adolescents, and individuals with special health care needs. *Pediatric Dentistry*, 40(6), 213-215.
- American Dental Association Council on Scientific Affairs (2006). The use of dental radiographs: update and recommendations. *The Journal of the American Dental Association*, 137(9), 1304-1312. <https://doi.org/10.14219/jada.archive.2006.0393>
- American Dental Association Council on Scientific Affairs & U.S. Food and Drug Administration (2012). *Dental radiographic examinations: Recommendations for patient selection and limiting radiation exposure*. American Dental Association. <https://www.ada.org/-/media/project/ada-organization/ada/ada-org/files/resources/library/oral-health->



- [topics/dental radiographic examinations 2012.pdf](#)
- Bahamid, A. A., Alsaif, S. Y., Almansouri, A. S. M., Alshammri, S. M., Alshahrani, F. A., & Alhusayni, H. A. (2023). Mental foramen position, shape, continuity, and symmetry among malocclusion patients: A radiographic study. *Cureus*, 15(12), e51056. <https://doi.org/10.7759/cureus.51056>
- Barry, K., Kumar, S., Linke, R., & Dawes, E. (2016). A clinical audit of anatomical side marker use in a paediatric medical imaging department. *Journal of Medical Radiation Sciences*, 63(3), 148–154. <https://doi.org/10.1002/jmrs.176>
- Benavides, E., Krecioch, J. R., Connolly, R. T., Allareddy, T., Buchanan, A., Spelic, D., et al. (2024). Optimizing radiation safety in dentistry: clinical recommendations and regulatory considerations. *The Journal of the American Dental Association*, 155(4), 280–293.e4. <https://doi.org/10.1016/j.adaj.2023.12.002>
- Dhillon, M., Raju, S. M., Verma, S., Tomar, D., Mohan, R. S., Lakhanpal, M., et al. (2012). Positioning errors and quality assessment in panoramic radiography. *Imaging Science in Dentistry*, 42(4), 207–212. <https://doi.org/10.5624/isd.2012.42.4.207>
- European ALARA Network (2019). *Optimization of radiation protection—ALARA: A practical guidebook*. [https://www.eu-alara.net/images/stories/EANdocuments/Publications/EAN\\_ALARA\\_Book oct 2019V2.pdf](https://www.eu-alara.net/images/stories/EANdocuments/Publications/EAN_ALARA_Book_oct_2019V2.pdf)
- Fux-Noy, A., Rohana, R., Rettman, A., Moskovitz, M., & Nadler, C. (2023). Panoramic errors in pediatric patients with special needs. *Scientific Reports*, 13(1), 11757. <https://doi.org/10.1038/s41598-023-38823-1>
- Granlund, C., Thilander-Klang, A., Ylhan, B., Lofthag-Hansen, S., & Ekestubbe, A. (2016). Absorbed organ and effective doses from digital intra-oral and panoramic radiography applying the ICRP 103 recommendations for effective dose estimations. *The British Journal of Radiology*, 89(1066), 20151052. <https://doi.org/10.1259/bjr.20151052>
- Gupta, V., Pitti, P., & Sholapurkar, A. (2015). Panoramic radiographic study of mental foramen in selected Dravidians of South Indian population: A hospital-based study. *Journal of Clinical and Experimental Dentistry*, 7(4), e451–e456. <https://doi.org/10.4317/jced.52174>
- Izzetti, R., Nisi, M., Aringhieri, G., Crocetti, L., Graziani, F., & Nardi, C. (2021). Basic knowledge and new advances in panoramic radiography imaging techniques: A narrative review on what dentists and radiologists should know. *Applied Sciences*, 11(17), 7858. <https://doi.org/10.3390/app11177858>
- Jasim, H. H. (2020). Evaluation of mental foramen location: a review article. *Journal of Medical Care Research and Review*, 3(7), 379–385. <https://doi.org/10.15520/mcrr.v3i7.107>
- Kaffe, I., Fishel, D., & Gorsky, M. (1977). Panoramic radiography in dentistry. *Refu'at Hapeh Vehashinayim*, 26(2), 25–30.
- Khan, S. Q., Ashraf, B., & Mehdi, H. (2015). Evaluation of patient preparation and positioning errors on digital panoramic radiographs. *Pakistan Oral & Dental Journal*, 35(1), 65–69.
- Lingam, A. S., Koppolu, P., Abdulsalam, R., Reddy, R. L., Anwarullah, A., & Koppolu, D. (2023). Assessment of common errors and subjective quality of digital panoramic radiographs in a dental institution, Riyadh. *Annals of African Medicine*, 22(1), 49–54. <https://doi.org/10.4103/aam.aam.213.21>
- Ludlow, J. B., Davies-Ludlow, L. E., & White, S. C. (2008). Patient risk related to common dental radiographic examinations: The impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation. *The Journal of the American Dental Association*, 139(9), 1237–1243. <https://doi.org/10.14219/jada.archive.2008.0339>
- Mallya, S. M., & Lam, E. W. N. (2018). *White and Pharoah's oral radiology: Principles and interpretation* (8th ed.). Elsevier.
- Marsha, E. A., Kiswanjaya, B., & Bachtar-Iskandar, H. H. (2023). Comparison of positioning errors on panoramic radiographs in Indonesian children, adults, and elderly patients. *Journal of Stomatology*, 76(3), 175–181. <https://doi.org/10.5114/jos.2023.131200>
- Mohtavipour, S. T., Javadzadeh Haghighat, A. S., Dalili, Z., Nemati, S., Mohtavipour, S. S., Narenjisani, M., et al. (2013). Common errors in digital panoramic radiographs taken in Rasht Dental School. *Journal of Dentomaxillofacial Radiology, Pathology and Surgery*, 2(2), 32–36. <https://doi.org/10.18869/acadpub.3dj.2.2.32>
- Public Health England & Faculty of General Dental Practice (UK) (2020). *Guidance notes for dental practitioners on the safe use of X-ray equipment* (2nd ed.). <https://cgdent.uk/wp-content/uploads/securepdfs/Guidance-notes-for-dental-practitioners-on-the-safe-use-of-x-ray-equipment-2020-online-version.pdf>
- Ramos, B. C., da Silva Izar, B. R., Costa Pereira, J. L., Souza, P. S., Valerio, C. S., Tuji, F. M., et al. (2016). Formation of ghost images due to metal objects on the surface of the patient's face: a pictorial essay. *Imaging Science in Dentistry*, 46(1), 63–68. <https://doi.org/10.5624/isd.2016.46.1.63>
- Suparno, N. R., Faizah, A., & Nafisah, A. N. (2023). Assessment of panoramic radiograph errors: An evaluation of patient preparation and positioning quality at Soelastri Dental and Oral Hospital. *The Open Dentistry Journal*, 17, e187421062309120. <https://doi.org/10.2174/0118742106261974230925073155>
- Titley, A. G., & Cosson, P. (2014). Radiographer use of anatomical side markers and the latent conditions affecting their use in practice. *Radiography*, 20(1), 42–47. <https://doi.org/10.1016/j.radi.2013.10.004>
- Tridandapani, S., Ramamurthy, S., Galgano, S. J., & Provenzale, J. M. (2013). Increasing rate of detection of wrong-patient radiographs: use of photographs obtained at time of radiography. *American Journal of Roentgenology*, 200(4), W345–W352. <https://doi.org/10.2214/AJR.12.9521>
- Wang, J., Huang, Y., Chen, F., & Li, W. (2024). The age-related effects on orthodontic tooth movement and



the surrounding periodontal environment.  
*Frontiers in Physiology*, 15, 1460168.  
<https://doi.org/10.3389/fphys.2024.1460168>