

# The Diagnostic Accuracy of Periapical Radiolucency Using Intraoral Periapical Radiograph and Orthopantomogram: The Impact of Observer Experience - A Retrospective Study

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## KEYWORDS

Periapical abscess, Infection, Radiographic Imaging, Periapical radiography.

## ABSTRACT

**Background:** Periapical diseases involve inflammation and tissue destruction around the tooth's root, often due to bacterial infections from caries, trauma, or poor endodontic treatment. Accurate diagnosis is crucial, with Intraoral Periapical Radiograph (IOPA) and Orthopantomogram (OPG) as primary imaging tools. IOPA offers high-resolution images for small lesions, while OPG provides a panoramic view for multiple pathologies. Their diagnostic accuracy in detecting periapical radiolucency (PRLs) varies, influenced by the observer's experience.

**Aim:** The study aimed to evaluate the diagnostic accuracy of Periapical Radiolucency Using an Intraoral Periapical Radiograph and Orthopantomogram and the Impact of Observer Experience.

**Material and methodology:** A Retrospective study was conducted at a private institution of the Oral and Maxillofacial Radiology Department, involving 105 previously diagnosed cases of periapical pathology. Patients were evaluated using IOPA followed by an OPG. The diagnostic accuracy of OPG compared to IOPA was analyzed using sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV). Interobserver variability was also assessed using kappa statistics to determine the consistency of radiographic interpretations.

**Results:** The results indicated that periapical radiographs (IOPA) demonstrated higher accuracy than orthopantomograms (OPG) in detecting periapical radiolucencies. The sensitivity of IOPA was 83%, surpassing that of OPG at 52.5%. IOPA also exhibited a specificity of 55% while OPG had a specificity of 66.5%. Furthermore, the positive predictive value (PPV) of IOPA was 78.5%, compared to 68.5% for OPG, and the negative predictive value (NPV) of IOPA was 52%, slightly higher than the 50% NPV of OPG. Interobserver agreement was high at 92.2% among certain observers; however, kappa statistics revealed no significant differences in agreement levels.

**Conclusion:** Overall, IOPA demonstrated superior diagnostic accuracy compared to OPG, highlighting its importance for accurate diagnosis and treatment planning in periapical conditions, IOPA is less expensive and has less radiation exposure compared to OPG

## 1. Introduction

Periapical diseases are inflammatory or infectious conditions that affect the root apex of a tooth. These conditions are commonly caused by bacterial infections resulting from dental caries, and failed dental

procedures, leading to periapical abscesses, granulomas, and cysts. Accurate diagnosis is essential for effective treatment and management of these conditions. Radiology is crucial in diagnosing periapical diseases especially two-dimensional imaging modalities like Intraoral periapical radiographs (IOPA), and Orthopantomogram (OPG). The Intraoral periapical radiographs (IOPA) provide high-resolution images of specific teeth and their surrounding structures allowing for the detection of small lesions, crown-root fractures, and a detailed assessment of root canal anatomy [1,2]. Orthopantomogram (OPG) offers a panoramic view of the entire jaw, including both maxillary and mandibular arches, which is useful for identifying widespread pathologies, and multiple lesions and assessing overall dental and bony structures [3]. Periapical radiolucency (PRL) is a critical indicator of periapical pathology in dental radiology, often signalling infection or other degenerative processes associated with the dental pulp [4]. Accurate identification and diagnosis of these radiolucent areas are essential in determining appropriate treatment strategies. Periapical radiographs (PRs) and orthopantomograms (OPGs) are commonly used in diagnosing periapical diseases [5]. While PRs provide a detailed view of specific teeth and their surrounding structures, OPGs offer a broader view of the entire dentition, including the maxilla and mandible, which may be beneficial in certain clinical scenarios [6,7]. The previous research showing the efficacy of each imaging technique has been extensive, with studies demonstrating significant differences in diagnostic performance [8]. Specifically, prior research has indicated that periapical radiographs may exhibit higher sensitivity in detecting small periapical lesions than OPGs, which may overlook these subtler abnormalities due to their inherently lower detail. However, OPGs possess advantages in providing contextual information about the dental arch as a whole, which can be invaluable in complex cases involving multiple teeth [9,10]. In addition to the type of radiographic imaging, observer experience plays a pivotal role in the diagnostic accuracy of periapical radiolucency detection. Understanding the interplay between imaging modality and observer proficiency is crucial for optimizing diagnostic processes in dental practice, ultimately enhancing patient care through prompt and accurate treatment interventions. Studies have shown that experienced clinicians are more adept at identifying subtle radiographic changes associated with periapical diseases, suggesting that the learning curve significantly impacts diagnostic outcomes [11,12]. This present study aims to assess the diagnostic accuracy of PRs and OPGs in detecting periapical radiolucency while examining how observer experience influences the interpretation of these radiographs.

## **2. Materials & Methods**

In this retrospective study, 630 patient records were initially screened from the Oral and Maxillofacial Radiology Department archives. Based on the inclusion and exclusion criteria, 105 patients with previously diagnosed periapical pathology were selected for the final analysis. These patients were initially evaluated using IOPA and OPG as part of their comprehensive treatment planning. The sequential use of IOPA first provided detailed views of specific teeth and periapical areas, while the subsequent OPG offered a broader view of the entire jaw. This approach ensured a more thorough assessment by allowing for the identification of additional pathologies that might not have been visible on IOPA alone, thereby facilitating accurate diagnosis and optimal treatment planning.

### **2.1 Inclusion and Exclusion criteria**

The study included single-rooted maxillary and mandibular anterior teeth, identified as teeth numbers 11, 12, 13, 21, 22, 23, 41, 42, 43, 31, 32, and 33, due to their higher propensity for developing periapical lesions. The exclusion criteria encompassed patients with multirrooted teeth, fractured teeth, dental prostheses, primary dentition, posterior teeth, or superimposed teeth, as these conditions could confound the analysis of periapical pathology. Additionally, patients with systemic diseases affecting bone metabolism, a history of recent dental trauma, or ongoing orthodontic treatment were excluded to ensure a more homogeneous study population.

## **2.2 Radiographic Procedures**

Radiographic images (OPG and IOPA) were retrieved from the patient database of the Dentomaxillofacial Radiology Department. IOPA images were obtained using the paralleling technique with 60-65 kVp exposure settings and the exposure time varied depending on the tooth type to ensure optimal image quality for accurate diagnosis. The OPG images were acquired using a CS8100 machine, operating at 78 kVp and 10.0 mA.

## **2.3 Observer Calibration and Image Analysis**

A total of five experienced maxillofacial radiologists independently reviewed the collected radiographic images. To minimize subjectivity and improve diagnostic accuracy, the radiologists underwent training and calibration before image analysis. For this purpose, 50 radiographic images were provided to all the observers for training and calibration sessions. These images were used exclusively for calibration and were not included in the study's sample size. Disagreements among the observers regarding the presence or absence of periapical lesions were resolved through discussion until a consensus was reached.

### **2.3.1 Assessment Criteria**

Each root was evaluated for periapical lesions using the Periapical Index (PAI) Score established by Ørstavik et al (1986).

### **2.3.2 PAI Score**

Score 1 represents normal periapical anatomy, with no visible abnormalities in the bone surrounding the root tip. Score 2 indicates mild changes in the bone pattern, characterized by subtle alterations such as slight thickening or rarefaction. Score 3 involves more pronounced changes with diffuse mineral loss, showing evidence of significant bone loss. Score 4 denotes apical periodontitis, marked by clear evidence of bone destruction and a radiolucent area (dark spot) at the root tip. Score 5 reflects severe periodontitis with features of exacerbation, including extensive bone destruction and signs of infection or inflammation, such as a larger radiolucent area or a periapical abscess.



Figure 1: Orthopantomogram revealed a periapical radiolucency in relation to 11



Figure 2: Intra oral periapical radiograph revealed a periapical radiolucency in relation to 11

### 2.4 Statistical Analysis

The results obtained from the evaluation of periapical lesions on OPG and IOPA were tabulated and analyzed. Quantitative measures, including sensitivity, specificity, PPV and NPV, were calculated to assess the diagnostic accuracy of the OPG compared to IOPA. Additionally, interobserver variability was assessed using kappa statistics to evaluate the consistency and reliability of the radiographic interpretations.

### 3. Results

A retrospective analysis was performed on periapical radiographs and orthopantomograms (OPG) of 105 patients, consisting of 27 men (age range: 27-84 years) and 78 women (age range: 11-76 years). The overall mean age of the patients was 49 years. A total of 105 single-rooted teeth were evaluated in the study. The highest PAI score noted was 4 in both IOPA and OPG and the lowest PAI score was reported as 1 in OPG and 3 in IOPA (Table 1).

#### 3.1 Periapical Radiographs (IOPA)

##### PAI Score Observations

Table 1: Average PAI score of individual teeth in percentage

PAI Scores	Number of teeth N [%] IOPA	OPG N [%]
1	15 (14.28%)	10 (9.52%)
2	23 (21.90%)	22 (20.95%)
3	11 (10.47%)	15 (14.28%)
4	41 (39%)	36 (34.28%)
5	25 (23.80%)	22 (20.95%)

PAI- Periapical Index Score

Table 2 provides the results of a Mann-Whitney U test, comparing IOPA (Intraoral Periapical Radiograph) and OPG (Orthopantomogram) across different methods in different teeth from 11 to 43.

The test statistics, including the Mann-Whitney U, Wilcoxon W, Z-value, and p-value, are listed for each method. The p-values for all comparisons are greater than 0.05, indicating no statistically significant differences between the two imaging methods across all methods tested. Based on the Mann-Whitney U test results, there is no significant difference. However, table 1 shows a wide numerical range of differences, indicating that IOPA is better than OPG.

Table2: Mann-Whitney and Wilcoxon test

Tooth number	Mann-Whitney U	Wilcoxon W	Z	p-value
11	40.500	85.500	-.380	.704
12	38.500	83.500	-.545	.586
13	37.000	82.000	-.670	.503
21	40.500	85.500	-.377	.706
22	42.000	87.000	-.250	.802
23	43.500	88.500	-.125	.900
31	43.000	88.000	-.166	.868
32	38.500	83.500	-.545	.586
33	33.500	78.500	-.969	.333
41	41.500	86.500	-.293	.770
42	39.000	84.000	-.506	.613
43	35.500	80.500	-.800	.424

The sensitivity of IOPA is 83%, indicating it is better at detecting periapical pathology but has a specificity of 55%, meaning it has a higher chance of false positives. On the other hand, OPG has a lower sensitivity of 52.5%, making it less effective at detecting pathology, but it has a higher specificity of 66.5%, reducing the likelihood of false positives. In short, IOPA is more sensitive in identifying pathology, while OPG is more specific in confirming the absence of disease (Table 3).

Table 3: Sensitivity and Specificity of intraoral periapical radiograph and orthopantomogram

Parameters	IOPA [%]	OPG [%]
True Positive Rate	71%	53%
False Negative Rate	7%	24%
False Positive Rate	5%	24%
True Negative Rate	29%	47%
Sensitivity	83%	52.5%
Specificity	55%	66.5%
Positive Predictive Value (PPV)	78.5%	68.5%
Negative Predictive Value (NPV)	52%	50%

A comparative analysis was conducted between intraoral periapical (IOPA) and orthopantomographic (OPG) radiographs. Results indicated that IOPA exhibited superior diagnostic accuracy for identifying periapical lesions. The following metrics were determined by a highly experienced radiologist with over 15 years of specialization in the field. The graphical depiction of interobserver agreement, using observer 1's scoring as the baseline, shows that observers 2 and 4 had almost perfect agreement. In comparison, observers 5 and 3 exhibited moderate and fair agreement. However, when applying kappa statistics, no significant differences were found among all four observers. Our study found that the agreement level between different observers when diagnosing periapical pathology in OPG and periapical radiographs varied. Observer 1 result is considered a gold standard as the person is well-experienced in oral and maxillofacial radiology. As per observer 1 Intraoral periapical radiograph is well and good and has high accuracy in the detection of periapical pathology in anterior single-rooted teeth than Orthopantomogram. Observer 2 had the highest agreement with Observer 1, at 92.7%, considered almost perfect. Observer 3 had the lowest agreement, at 45.3%, which is fair. Observers 4 and 5 had agreements of 87.9% and 53.2%, respectively, considered almost perfect and moderate, respectively. The above findings emphasize the importance of utilizing intraoral periapical radiographs as the primary radiographic technique for diagnosing periapical conditions, particularly in single-rooted teeth, where higher diagnostic accuracy is critical for effective treatment planning (Figure 3).

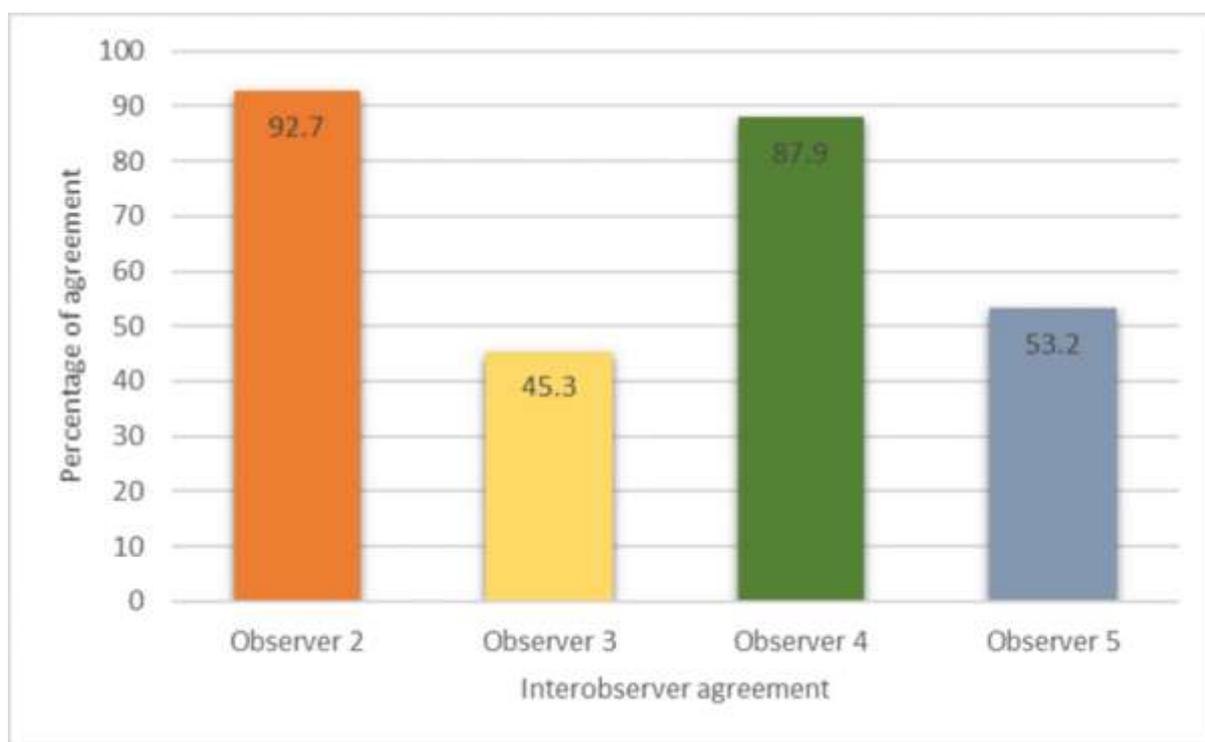


Figure 3: Interobserver Variability using Kappa statistics on comparing with baseline

#### 4. Discussion

The most frequent cause of pulp and periapical disease is dental caries. The pulp undergoes histological and morphological changes as the carious lesion worsens, which results in an inflammatory reaction [13,14]. This study only included single-rooted anterior teeth because they are more likely to have periapical pathology. Intraoral periapical radiographs (IOPA) and orthopantomograms (OPG) are two commonly used radiographic techniques in dentistry. IOPA radiographs provide a detailed view of a few teeth and their surrounding bone, while OPG radiographs provide a panoramic view of the entire jaw. In the diagnosis of periapical pathology, both IOPA and OPG radiographs can be useful. An intraoral periapical radiograph (IOPA) offers several advantages over an OPG in diagnosing periapical pathology [15,16,17]. IOPA provides superior image resolution and detail, which is crucial for accurately identifying small periapical lesions and subtle changes in the periapical region. It focuses

on a small number of teeth, allowing for a more targeted and detailed examination of the periapical area, essential for diagnosing conditions like periapical abscesses, cysts, and granulomas. IOPA typically exposes the patient to a lower dose of radiation compared to an OPG, making it safer, especially when multiple images are required over time for follow-up. Additionally, IOPA images have less distortion and magnification, providing more accurate measurements of periapical pathology. Moreover, IOPA is generally more cost-effective than OPG, making it a practical choice for routine periapical pathology diagnosis [18,19]. OPG offers several advantages over IOPA in diagnosing periapical pathology. OPG provides a comprehensive view of the entire dentition and surrounding structures, allowing for the simultaneous assessment of multiple teeth and their periapical regions. In contrast, IOPA is limited to a few teeth in a single image. OPG can reveal pathologies in various regions of the jaw in a single exposure, making it easier to detect multiple periapical lesions or other anomalies that might be missed in IOPA. Additionally, OPG is less invasive and more comfortable for patients, especially those with gag reflexes or limited mouth opening, as it does not require the placement of film or sensors inside the mouth. OPG also provides a broader view of the jawbone, enabling better assessment of bone structure, density, and any pathological changes extending beyond the periapical region. Furthermore, taking an OPG is quicker compared to capturing multiple IOPA images, making it more efficient for diagnosing extensive dental issues in a single appointment. Although OPG involves a higher dose of radiation than a single IOPA, it often results in lower overall exposure when multiple periapical radiographs are required to assess the same area. While OPG has these advantages, it is important to note that IOPA still offers superior resolution for detailed evaluation of individual teeth and their immediate periapical regions, making it invaluable in certain diagnostic scenarios [20,21].

The study carried out by Persson RE et al [15] showed an enhanced degree of accuracy in assessing periodontal alveolar bone loss shown by the agreement between the two observers of the digitized OPG image as compared to IOPA whereas our present study findings showed higher agreement levels among observers using IOPA compared to OPG in detecting periapical pathology. This was attributed to the clearer and more detailed images provided by IOPA, which facilitated more consistent interpretation across different observers. The present result is inconsistent with the previous result as this is because the previous study compared generalized and localized periodontal alveolar bone loss but in present study aimed to assess the periapical pathology of anterior single-rooted tooth. IOPA demonstrates higher sensitivity and PPV, indicating it is better at correctly identifying cases of periapical pathology and providing true positive results. OPG shows higher specificity, meaning it is better at correctly identifying cases without periapical pathology and providing true negative results. Overall Performance of IOPA appears to be more effective in diagnosing periapical pathology accurately, while OPG is better at ruling out non-pathological cases but less effective in identifying true pathological cases. The present study results showed that OPG has a lower accuracy than IOPA in detecting periapical radiolucency in anterior single-rooted teeth in the maxilla and mandible. Respectively. The results of this study were in agreement with those of Mishra et al in the year 2018 [22]. In the previous study [22], the image quality of intraoral periapical radiographs showed that intraoral periapical radiographs had a higher percentage of sensitivity. The present study was in correlation with the previous study. IOPA radiographs provide a more detailed and accurate image of the periapical region than OPG radiographs. This is because IOPA radiographs are taken at a closer distance to the tooth and a right angle to the long axis of the tooth. This reduces distortion and magnification and allows for better visualization of the periapical region. OPG radiographs, on the other hand, are panoramic radiographs that provide a wide view of the jaws. While OPG radiographs can be useful for detecting large periapical lesions, they may not be able to detect small or early lesions. Additionally, OPG radiographs can be distorted by the presence of other structures in the jaws, such as the sinuses and the nasal cavity. Therefore, IOPA radiographs are the recommended radiographic projection for diagnosing periapical pathology of anterior teeth. However, it is important to note that both IOPA radiographs and OPG radiographs are limited in their ability to diagnose all cases of

periapical pathology.

## 5. Limitation

The sample size of the study may be too small to be statistically significant. The study design is retrospective and may not be robust enough to control for all potential confounding factors and the quality of the IOPA and OPG images may vary, which could affect the results of the study and there may be inter-rater variability in the interpretation of the IOPA and OPG images, which could affect the results of the study.

## 6. Future Scope

A larger sample size and a prospective study design would allow researchers to better control for confounding factors. Artificial intelligence models could be used in the future to improve the interpretation of IOPAs and OPGs. In addition to that CBCT can be utilized for its detailed three-dimensional imaging, allowing for a more definitive assessment. CBCT offers superior visualization of complex anatomical structures and early lesions, making it an essential tool when traditional radiographs are inconclusive.

## 7. Conclusions

This study determined that intraoral periapical radiographs have better image quality than orthopantomograms. Intraoral periapical radiographs are a well-accepted diagnostic tool in dental practice. When comparing intraoral periapical radiographs and orthopantomograms, it is better to recommend intraoral periapical radiographs because they expose the patient to less ionizing radiation. Since intraoral periapical radiographs have good image quality, they may contribute to better radio diagnosis of periapical pathology. Intraoral periapical radiographs are an efficient technique, both economically and diagnostically

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