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ORIGINAL ARTICLE

Marginal Microleakage Detection and Radiopacity Measurement under Restoration with Conventional and Digital Radiography

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ABSTRACT

Objective: Marginal microleakage detection is performed to prevent secondary caries. The present study aimed to determine the difference in the accuracy between conventional and digital radiography methods in detecting marginal microleakage and the radiopacity measurement of restoration material. **Methods:** We used 44 anterior maxillary teeth after extraction that had been filled with class III glass ionomer cement and then planted in paraffin wax blocks. These samples were then systematically exposed using conventional and digital indirect periapical radiography techniques. Microleakage detection was measured using three marginal microleakage scales. The level of radiopacity of restoration material was measured using ImageJ software and calculated using the standard radiopacity value calculation formula. All data were analyzed using the Mann–Whitney U test. **Results:** Outcome data demonstrated that there was no difference ($p = 0.6$) between the two radiography techniques in detecting microleakage of restoration. However, radiopacity measurements revealed a significant difference ($p = 0.0$) between these two radiography techniques in their ability to determine radiopacity. **Conclusion:** The results suggest that there is no difference between conventional and digital indirect periapical radiography techniques in detecting microleakage of restoration material; however, a high radiopacity level was found from the digital indirect radiography technique.

Key words: radiography, microleakage, radiopacity, teeth

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INTRODUCTION

Periapical radiography is one of the intraoral radiography techniques that can analyze the teeth individually and also the tissue around the apical foreman of the tooth. This technique can show the presence of cavities, hidden tooth structures, bone abnormalities, cysts, infections and other dental disease resulting from natural causes, and from the use of X-rays.¹ Accurate radiographic examination is essential in dentistry, to see the condition of the teeth and for the detection of secondary caries under any restorations.^{2,3}

One aspect of an ideal restoration material is good marginal adaptation so that the gap between the material and the structure of a tooth itself will be minimized.⁴ A popular material used to bind restoration material to a tooth is glass ionomer cement (GIC), and one of its properties is that it more radiopaque compared to the natural tooth structure because it

contains barium and strontium, which are metals and therefore can be used for detecting secondary caries.⁵ By being able to discover marginal microleakages, the clinician can both identify and help prevent the occurrence of secondary caries.⁴ Radiography can be used to both detect marginal microleakages and to assess the radiopacity of various restoration materials, and both of these tasks can be accomplished by either conventional or digital methods.^{6,7}

The primary purpose of this study was to determine if there are significant differences in accuracy between conventional and digital radiography techniques in detecting marginal microleakages of restoration materials. The other purpose was to determine the capabilities of both methods to measure the radiopacity of various restoration materials.

METHODS

A sample of 44 anterior maxillary teeth after extraction that had been filled with class III GIC and then planted in paraffin wax blocks was used in this study. Our inclusion criteria in this selection were: [a] Anterior teeth class III GIC restoration; [b] The color of restoration is clinically similar to the color of the teeth, and [c] No discoloration. The samples were planted in paraffin wax blocks (2.5 cm in length × 1.5 cm in width × 1 cm in height), as high as the cervical of the tooth. The specimens were obtained from preclinical students of the Department of Conservation, Faculty of Dentistry at the Universitas Gadjah Mada.

Conventional periapical radiographic film was placed over a flat base in a horizontal position, and the planted tooth object was placed on top of it in a horizontal position parallel to aluminum step wedges, as illustrated in Figure 1, with a space of 3 mm between the top of the film and the incisal of the tooth. Periapical radiography was then performed using the paralleling technique, specifically with the film parallel to the axis of the tooth, which was exposed to the X-ray. The exposure was performed at 60 kVp, 7 mA, 0.5 seconds, and the film to object distance was 35 cm.

Chemical processing of the conventional X-rays was completed in a dark room with the help of a safelight. It is well known that the result of developing a radiograph film depends on the quality of the developer used. The film was dragged into the developer solution for about 5 seconds to generate a white shadow, and then it was rinsed for about 3 seconds to remove any remaining developer material. The next step was to fix the radiographic film by laying it into the fixer solution for about 1 minute, followed by washing and drying it using a film dryer.

Taking a digital periapical radiograph was similar to the conventional approach, but the differences were in the image receptors and the processing method. We used a PSP image receptor that was placed under the samples and the aluminum step wedges. The next process was the setting the exposure of the digital radiography, followed by processing using the DBSWin 5.7.0 (Durr Dental, Bietigheim-Bissingen, Germany) software.

Marginal microleakage detection can be performed using either conventional or digital radiography, but in both cases with the help of an illumination box. Measurements were made intra-observer with an interval of two weeks and inter-observer with the help of one researcher from the author's team (two observers total). Previously, perception capability was equalized between observers to make the forthcoming measurements reliable. The authors used three modified scales,⁶ namely: 1 = definitely microleakage detected; 2 = unsure if microleakage detected; and 3 = microleakage not detected.

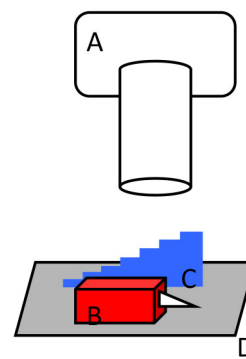


Figure 1. Sample and aluminum step wedges placement. X-ray tube (A), sample (B), aluminum step wedges (C) and film (D).

Measurement of the radiopacity of the restoration with the conventional method needs first to be digitized with a scanner to get the picture in jpg format. In contrast, the images from the digital approach were converted into a digital format using a VistaScan Combi View (Durr Dental, Bietigheim-Bissingen, Germany) scanner and processed via DBSWin 5.7.0 (Durr Dental, Bietigheim-Bissingen, Germany) software. The level of radiopacity was measured with ImageJ software using both conventional and digital indirect techniques, and the resolution of the images was equated. Then on the measurements, the Mean Gray Value was selected. The area of the measurement was determined by making a macro on the aluminum step wedges and on the restoration area. Macros made for recording a size of sections in each step on the aluminum step wedges. Macros were made so that the area of the aluminum step wedges and the restorations were the same across all 44 samples for the Mean Gray Value Measurement. The author used macros at each of the various levels on the aluminum step wedges, with 1242 pixels for step 1 to 14, and 585 pixels for step 15, and the restoration area being captured at 208 pixels.

Radiopacity measurement was performed by selecting the Analyze and Measure menu for each level on the aluminum step wedges and separately on the restoration area using each macro. The results obtained in the restoration area were calculated using a radiopacity value calculation formula (Equation 1).

Subject recruitment

This study was approved by the Ethics Committee of the Faculty of Dentistry at the Universitas Gadjah Mada.

Specific methods used

The samples were exposed to conventional and digital radiography using paralleling techniques. The X-ray beam used was generated by the Instrumentarium Dental PaloDex system, Tuusula, Finland. The detection of marginal microleakage was performed

using three microleakage scales developed explicitly for this purpose.⁶ Radiopacity measurements of the restoration material were performed using ImageJ software with the help of the aluminum step wedges.

Data analysis

Detection of marginal microleakages from restorations was determined by two specialists using intra- and inter-observer methods. The relation between the perceptions of the two observers was analyzed using Spearman's rank correlation coefficient. Radiopacity measurements of the restoration material were analyzed using Pearson's correlation coefficient to determine the relationship between both of the radiography techniques. All data were compared using the Mann-Whitney U test with a value of $p < 0.05$ considered significant.

RESULTS

Detection of marginal microleakages

Both conventional and digital radiographs in this research were used to detect marginal microleakage (Figure 2). A correlation analysis of intra- and inter-observer inspections used 16 samples and revealed coefficients of intra- and inter- methods of 1.0 and 0.6.⁸

The difference in the capability of conventional and digital indirect periapical radiography to detect marginal microleakage was determined to be minimal, as shown in Figure 3.

Figure 3 indicates that when using scale 1, 93.2% of the leakage was detected using the conventional radiography method. However, as measured by scale 2 the detected leakage was only 2.3% of the sample, and with scale number 3 only 4.5% of the leakage was detected. Likewise, using the digital approach resulted in 95.4% of the leakage being detected on the basis of scale 1, while using scales 2 and 3 found that only 2.3% of the leakage was detected in both cases. We further tested for normality of the data using the Saphiro-Wilk method and found that it was not normally distributed ($p < 0.05$). Applying the Mann-Whitney test to our data, we found that there was no significant difference between the two radiography techniques in being able to detect marginal microleakages.

Radiopacity measurement of restoration material

Radiopacity measurements of the restoration material in this study were performed using both conventional and digital indirect methods with the help of ImageJ software (Figure 4). Aluminum step wedges were employed here as a gold standard in accordance with the ISO standard of using 15 steps in this procedure, each with a thickness of 0.5 mm.

Our analysis began with a Pearson correlation test on the average radiopaque value of the aluminum step

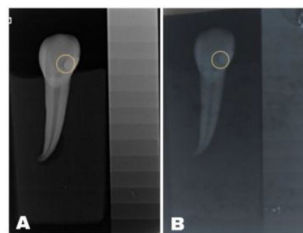


Figure 2. Periapical radiographs showing marginal microleakage (yellow circle) in both a digital (A) and a conventional radiographs (B).

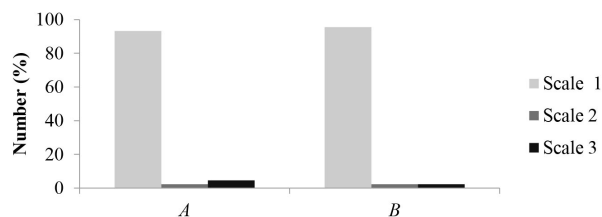


Figure 3. The percentage of marginal microleakage detected with (A) conventional radiography and (B) digital indirect radiography, using three different scales, such as: definitely microleakage detected (Scale 1), unsure if microleakage detected (Scale 2), and microleakage not detected (Scale 3).

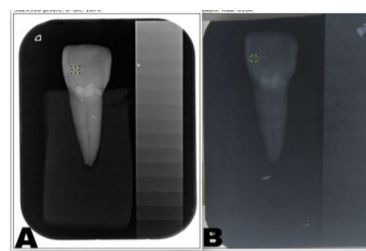


Figure 4. Radiopacity measurement of restoration material using ImageJ software with digital (A) and conventional radiography (B)

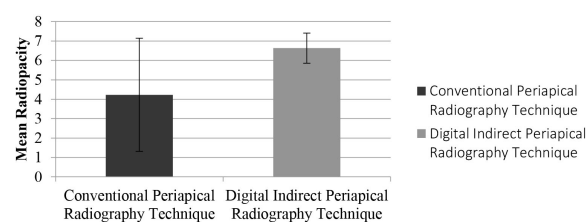


Figure 5. The mean value of radiopacity measurement of restoration material leakage using conventional and digital indirect periapical radiography

wedges exposed using both radiography techniques. This effort produced a correlation coefficient of 0.5, implying that both methods had an average correlation.⁹ Figure 5 shows the mean radiopacity between the conventional and digital methods. The average radiopacities were obtained from the calculated values using the standard radiopacity value calculation formula, shown in equation 1. The result for the digital

technique was 6.6 ± 0.7 mmAl, which was higher than the corresponding value for the conventional method, of 4.2 ± 2.9 mmAl.

We used this equation to calculate radiopacity (Equation 1):⁹

$$\text{Eq mmAl} = \frac{\text{Specimen Radiopacity} \times \text{Degree thickness (mm)}}{\text{Degree Radiopacity}}$$

Tests for normality using the Saphiro–Wilk method revealed that that the data from the conventional method was not normally distributed ($p < 0.05$), while the digital method's data was normal ($p > 0.05$).

Since parametric independent t-tests cannot be performed in this situation, we used the Mann–Whitney U test, and obtained a significance value of 0.0, indicating that there was a significant difference between the ability of the two methods to detect microleakages of restoration material.

DISCUSSION

Spearman correlation tests revealed that the observers had the same perception in detecting marginal microleakages of restoration material. The majority of samples showed microleakages with a score of 1 from both conventional and digital techniques (Figure 3). The data on the microleakage of restoration material was analyzed by the non-parametric Mann–Whitney U test, and we found that there was no significant difference between conventional and digital radiography techniques in detecting marginal microleakage of restoration material. This finding was likely due to the lack of use of a contrast setting when performing the digital indirect radiography technique. So the marginal microleakage can be detected in both digital and conventional radiograph.

These results are consistent with earlier research⁶ showing that conventional and digital techniques differ only slightly in their ability to detect marginal microleakages. However, our findings may have also demonstrated that both of these techniques have the same ability to detect marginal microleakages macroscopically. Microscopic marginal microleakage detection can be performed by using the immersion method in a 0.5% methylene blue solution. The teeth that had been cut from the mesiodistal direction will leak the methylene blue penetration 0.5% solution when observed via a microscope.¹⁰

Quality control procedures that were not performed during the chemical processing of the conventional imaging procedure are probably one of the causes of the results showing no significant differences between the two techniques in the detection of marginal

microleakage. The outcome of the conventional radiography processing was difficult to manipulate because chemically processed methods often experience failure and require extensive repetition.¹¹

Another possibility is that the use of calcium hydroxide under a GIC restoration caused difficulties in detecting marginal microleakage. The use of a material under a restoration can produce a transparent halo image causing difficulty in obtaining an accurate diagnosis. Radiography examinations seem to be less relevant to detecting marginal microleakage because they frequently give false-positive and false-negative results.⁶

Our radiopacity measurement of restoration material employed aluminum step wedges as a control because this protocol provides a level of radiopacity that resembled the structure of dentin (Figure 3).¹² A Pearson correlation test was calculated using an aluminum step wedge radiopacity value generated by both conventional and digital periapical radiography techniques. The 0.5 result we obtained indicates that there was a correlation between both of radiography techniques in measuring the radiopacity level of the restoration material we examined. The mean value of radiopacity we found using the conventional method was 4.2 ± 2.9 mmAl, and the digital approach produced a value of 6.6 ± 0.7 mmAl, as shown in Figure 5. Radiopacity values of both groups have met the ISO 4049 standard, which states that the radiopacity of GIC material must have a value of more than 1.5 mm thickness of aluminum step wedges. Statistical analyses demonstrated a significant difference in the measurement of the radiopacity values. Our results here were consistent with previous studies, which showed that the radiopaque level achieved by the digital approach is higher than what is produced by the conventional technique.⁹ This outcome is likely due to how the digital approach has better contrast compared to its conventional counterpart. However, in our research, the low level of radiopacity of the conventional radiograph was likely influenced by an error in the chemical processing process needed to obtain a radiographic representation of the film. Due to mistakes in chemical processing, the resolution of a conventional radiographic image can sometimes be inaccurately low. Dark radiographs can be caused by using a development process that is too long, or because the solution's temperature is too high.¹³ These errors can happen if quality control procedures prior to the start of the study were inadequate, leading to an outcome that is not homogeneous throughout.

Another factor that may have caused a decrease in image resolution was the presence of light leaks during chemical processing in the darkroom. This type of mishap can cause the result to become darker, such that the radiopacity obtained was low. Light leaked in darkrooms can also cause the film to be foggy because

the silver halide crystals are more exposed than normal, so after the processing of the film the results darken, reducing the diagnostic value of the radiographs.¹⁴

CONCLUSION

From our analysis, we found two results. One is that there was no difference in accuracy between conventional and digital indirect periapical radiographic techniques in detecting marginal macroleakage. The second outcome is that we found a significant difference in the measurement capability regarding radiopacity levels between the two methods, with the digital approach demonstrating higher analytical power.

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CONFLICT OF INTEREST

The authors confirm that there are no known conflicts of interest. There has been no financial support for this study.

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