



EVALUATION OF DENTAL HOLDER INNOVATION: PATIENT COMFORT AND PERIAPICAL INTRA-ORAL RADIOGRAPHIC IMAGE QUALITY

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Abstract

This study evaluates an innovative dental holder designed to improve patient comfort and radiographic image quality in intra-oral periapical examinations. Conducted at Muhammadiyah University Semarang Dental and Oral Hospital, the research involved 30 patients who used the modified holder featuring a 20-degree tilt, biocompatible PLA material, and silicone pads. Results showed that 73.33% of patients experienced no nausea, and 93.33% had no allergic reactions, highlighting the holder's safety and comfort. Although 56.67% reported excessive oral pressure, 60% noted reduced pain due to the silicone pads. The holder also improved image quality, with 76.67% of patients acknowledging clear apical images, and 100% reporting no distortion or blurring. The study indicates that while the holder significantly enhances patient comfort and image quality, further design adjustments are needed to address size-related issues. Future developments should focus on customizing the holder for local anatomical variations and exploring additional eco-friendly materials. Enhanced training for practitioners and further research with diverse populations are recommended to optimize the holder's effectiveness.

Keywords: *Periapikal; Dental Holder; Patient Comfort; Image Quality*

1. Introduction

Periapical examination refers to an intra-oral radiography procedure used to reveal individual teeth and tissues at the apex. The resultant images typically show two to four teeth and provide extensive information about the teeth and surrounding alveolar bone (Whaites & Nicholas Drage, 2021). One method that can be used to obtain periapical images is the parallel technique (Iannucci & Howerton, 2016). Based on the idea of parallelism, the parallel approach is used to produce periapical images that are dimensionally precise. The idea behind this parallel technique is parallelism, where the receptor and teeth are positioned parallel to one another and the x-rays' trajectory is perpendicular to the receptor. In addition, a device known as a holder is needed for the parallel approach in order to support the receptors in the mouth cavity (Reynolds, 2016).

The site of the receptor is a drawback of the parallel approach. The radiographer may have trouble placing the receptor because this method employs a holder. Pediatric children and adults with shallow palates or small oral cavities may experience challenges. The primary drawback of the parallel approach, however, is that the holder used to position the receptor may harm the patient's oral tissue and result in discomfort (Whaites & Nicholas Drage, 2021). To accommodate design deficiencies in the previous year, further research has been carried out by (Marichatul, 2023) by revising the products that have been tested in 2021. We have successfully innovated dental holders with silicone rubber modifications. Some of the modifications we made include: uniting the bite-block with the crane part, fixing the slider part on the ring

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with a semi-lock system so that it can be fixed and can still be slid, modifying the bite-block part for laying silicone rubber, thickening the bite-block

film support part, and the molding used in this research was modified so that the silicon used was more suitable and had the right size (Jannah M, 2023).

The results of this research indicate an increase in efficiency in the use of equipment by radiographers in the innovation group. When we talk about efficiency, we're talking about how easy it is to use, how long it takes, and how consistent the outcomes are. The efficiency values of the innovation group with improved dental holders were higher than those of the control group in this study (Cohen's $d=9.632$). This demonstrates how the radiographer's ability to produce images is significantly impacted by the changes made to the dental holder. With a Cohen's d effect value of 0.325, the research findings indicate that the image created by the innovation group is superior to that of the control group in terms of image quality. Among the elements that contribute to (Jannah M, 2023)

Additionally, the improved dental holder's silicone rubber makes patients feel more at ease. An major factor in image quality is patient comfort. Comfortable patients are less likely to move throughout the process, which lowers the possibility of motion artifacts. One of the main motives why dental radiography image quality deteriorates is motion artifacts (Yeung & Wong, 2021). Based on this, the author is interested in continuing research regarding the evaluation of patient comfort and radiographic image quality regarding the use of dental x-ray holders in patients undergoing intra-oral periapical examinations.

2. Method

This type of research is research and development. Research data collection was carried out at the Muhammadiyah University Semarang Dental and Oral Hospital in June-August 2024. Testing of the dental x-ray holder will be carried out on the patient by assessing the patient's comfort and the quality of the radiographic image.

The object of this research is an innovative dental holder for intra-oral periapical dental radiography examination. The following is an image of the Dental X-ray Holder used in this research whose design has been revised according to previous research in 2023 (Jannah M, 2023)

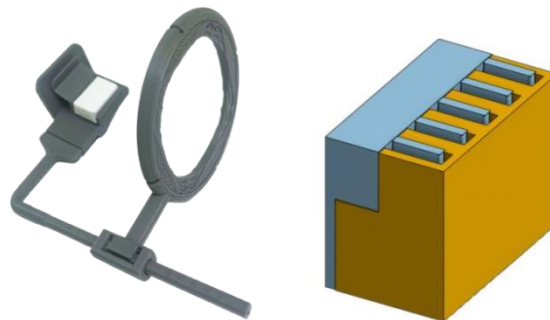


Figure 1. Modified Dental Xray Holder

The sample size in this study was thirty patients with the following inclusion criteria: Patients who require intra-oral periapical radiographic examination, minimum age 18 years, patients who can provide written consent to take part in the research, patients who do not have a history of allergies to silicone. The exclusion criteria in this study are patients who are pregnant or breastfeeding, patients who have dental abnormalities that require special radiographic techniques (for example, horizontal wisdom teeth or impacted teeth that require tomographic techniques) and cannot be performed using conventional intra-oral periapical radiographic techniques. The research instrument is a questionnaire containing questions regarding patient comfort and radiograph image quality. This research has been approved for ethical compliance with certificate number No. 0528/EA/KEPK/2023.

3. Result and Discussion

This study involved thirty patients who underwent periapical intra-oral dental radiographic examinations using an innovative dental holder. Data was collected through two types of questionnaires, namely the first was a patient comfort questionnaire which was designed to assess the level of comfort felt by patients during radiographic examinations with the innovation holder. Second, an image quality

assessment questionnaire filled out by a radiology specialist to evaluate the quality of the radiographic images produced from the examination.

The following table shows descriptive statistics of the data obtained, providing a general overview of the characteristics and data distribution of the two types of questionnaires.

Table 1. Descriptive Statistics of Research Data

Statement	N	Minimum	Maximum	Mean	Std. Deviation
When using this tool, you don't feel nauseous.	30	0	1	0.73	0.450
When using this tool, there are no allergic symptoms.	30	0	1	0.93	0.254
This tool does not put excessive pressure on your mouth.	30	0	1	0.43	0.504
You don't feel pain and relax when using this tool.	30	0	1	0.60	0.498
You feel that this tool can maintain the position of your teeth and make the examination easier	30	1	1	1.00	0.000
The tooth apex or apical area is clearly depicted.	30	2	3	2.77	0.430
Clearly/firmly depict the crown area of the tooth.	30	4	4	4.00	0.000
A clear picture of the dental pulp can be seen.	30	3	4	3.03	0.183
There is no distortion of the teeth or alveolar bone.	30	4	4	4.00	0.000
There is no visible blurring due to movement.	30	4	4	4.00	0.000

From table 1 it can be seen the difference in the rating scale between the questionnaire that measures patient comfort and the questionnaire that assesses the quality of radiographic images. The patient comfort questionnaire uses nominal data, while the radiographic image quality assessment questionnaire uses an interval scale. The data showed variation in ratings of comfort and image quality, with most scores for the image quality assessment questionnaire being at higher levels, indicating consistently good image quality.

Table 2. Analysis of Patient Comfort Questionnaire Data

Statement	Yes	No
Not nauseous	22 (73.33%)	8 (26.67%)
Not allergic	28 (93.33%)	2 (6.67%)
Don't press excessively	13 (43.33%)	17 (56.67%)
Don't feel sick	18 (60%)	12 (40%)
Makes inspection easier	30 (100%)	0 (0%)

Table 2 shows that 73.33% of patients did not experience nausea and 93.33% did not experience allergic reactions when using the modified dental holder. However, 56.67% of patients reported that the holder still felt excessive pressure on their oral cavity. In contrast, 60% of patients stated that they felt no pain during the examination. Apart from that, all patients (100%) felt that using this dental holder made the examination process easier.

Table 3. Image Quality Questionnaire Data Analysis

Statement	Disagree	Sometimes	Agree	Strongly Agree
Apical clarity	0 (0%)	7 (23.33%)	23 (76.67%)	0 (0%)
Crown clarity	0 (0%)	0 (0%)	0 (0%)	30 (100%)
Pulp clarity	0 (0%)	0 (0%)	29 (96.67%)	1 (3.33%)
No distortion occurs	0 (0%)	0 (0%)	0 (0%)	30 (100%)
No blurring occurs	0 (0%)	0 (0%)	0 (0%)	30 (100%)

It can be seen that 76.67% of respondents agreed that the image results were clear in visualizing the apex or apical part of the tooth. In addition, 100% of the resulting radiographs showed crown clarity, no

distortion, and no blurring, with 96.67% confirmation of pulp brightness, which shows that the innovative tooth holder provides excellent results in terms of image quality.

This study aims to evaluate patient comfort and radiographic image quality using an innovative dental holder. The research results show that the innovative holder provides significant benefits in increasing patient comfort during procedures. A total of 73.33% of patients reported not feeling nausea, which can be attributed to the holder design with a 20 degree tilt. This tilt is designed to reduce discomfort by ensuring an optimal and stable position during the examination (Sanghvi et al., 2018). In addition, 93.33% of patients did not experience allergic reactions to the holder, which shows that the material used, namely PLA from bagasse and corn, is very safe. PLA is a biocompatible material that causes minimal allergic reactions compared to conventional plastic materials. This is in line with the results of research by Connolly et al in 2019, which emphasized the importance of choosing the right ingredients in reducing the risk of allergies in patients (Connolly et al., 2019; Gigante et al., 2019). The use of PLA material also contributes to the sustainability aspect, considering that PLA is an environmentally friendly material that can decompose more quickly than petroleum-based plastic (Balla et al., 2021; Elsayy et al., 2017; Naser et al., 2021; Teixeira et al., 2021).

However, 56.67% of patients still reported excessive pressure in the oral cavity, which may be caused by the size of the holder not being fully adapted to the dimensions of the average Indonesian mouth. These holders follow global sizing standards, which may not correspond to local mouth morphology. This shows the need for more specific design adjustments to meet the needs of users in certain regions, as revealed in research by Frostell in 2018 regarding the importance of adjusting tool size (Calero Castro et al., 2023; Frostell et al., 2018). However, 60% of patients do not feel pain because of the silicone pads on the bite block. These silicone pads provide gentle support and reduce the risk of injury to oral tissues, as well as improving overall comfort during the procedure. Research by Hui Dong in 2017 confirmed that silicone pads can significantly increase comfort and reduce pain in patients (Dong et al., 2006). This suggests that innovation in bite block design plays an important role in reducing discomfort.

The success of the innovative dental holder in making the examination process easier is also reflected in the research results, where 100% of patients felt that this holder made the examination process easier for them. By not having to manually handle the imaging plate or radiology film, patients can focus better and feel more comfortable during the procedure. This is consistent with Jannah's 2021 and 2023 findings, which showed that efficient design can improve the patient experience during radiographic examinations (Jannah et al., 2021; Kesehatan et al., 2023).

In terms of image quality, table 3 shows that the innovative holder succeeded in increasing the clarity of the apical, crown and pulp images. A total of 76.67% of patients reported adequate apical clarity, while 100% of the analyzed images showed crown clarity, no distortion, and no blurring. Telescopic cones on the holder allow adjustment of the angle and tilt of the film or imaging plate, which helps minimize artifacts and improve image quality.

The reason behind the absence of distortion in the image can be attributed to the ability of the telescopic cone to adjust the tilt of the film or imaging plate. This ensures that the film or imaging plate remains in the correct position, reducing the risk of distortion that often occurs with traditional holders. Research by Kwak et al in 2021 and Steffensen et al in 2019 supports that correct angle adjustments can increase the accuracy of radiographic images (Kwak et al., 2021; Steffensen et al., 2019).

In addition, the sturdy and comfortable holder design contributes to the elimination of blurring in the image. The stable holder reduces vibration and movement that can cause blurring, ensuring higher image quality. These findings are in line with studies by Jensen et al in 1978 and Chauhan et al in 2023, which emphasized the importance of stable device design to produce clear and accurate radiographic images (Chauhan et al., 2023; Jensen, 1978).

Overall, this study shows that the innovative dental holder provides significant improvements in patient comfort and radiographic image quality. The 20 degree tilt design, use of PLA material, and silicone pads have proven effective in improving the patient experience during the examination. Although there are still some shortcomings regarding the size of the holder, this innovation shows great potential in improving dental radiography procedures. In the future, further design modifications to suit local sizes and improvements in materials and holder features are expected to further optimize comfort and radiographic image quality.

4. Conclusion and Suggestion

This study demonstrates that the innovative dental holder significantly enhances both patient comfort and radiographic image quality in dental intra-oral periapical examinations. The holder's 20-degree tilt design, biocompatible PLA material, and silicone pads contribute to reduced discomfort, nausea, and allergic reactions, resulting in a better overall patient experience. The holder also ensures superior image quality with clear visualization of dental structures, free from distortion and blurring. However, some patients reported excessive pressure due to the holder's size, indicating a need for further adjustments to accommodate local population variations.

Future design iterations should focus on customizing the size and shape of the dental holder to better fit the average oral cavity dimensions of specific populations, such as those in Indonesia, to reduce discomfort. Additionally, exploring alternative biocompatible and eco-friendly materials could enhance comfort and environmental sustainability. Enhanced training for dental practitioners on the holder's optimal use and adjustment will ensure consistent radiographic image quality. Further studies with larger, diverse samples are recommended to validate these findings and guide future improvements. Continuous feedback from patients and practitioners should be incorporated to refine the design and functionality of the dental holder.

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