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ASESSING EFFICIENCY AND IMAGE QUALITY OF DENTAL RADIOGRAPHY USING MODIFIED DENTAL HOLDERS WITH SILICONE RUBBER INTEGRATION

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Abstract

This study aims to evaluate the efficiency of use by radiographers and image quality in the use of dental holders that have been modified with silicone rubber in dental radiography procedures. Motivated by the problem in the use of conventional dental holders that often cause discomfort for patients and the potential for motion artifacts, a modification with silicone rubber was proposed. The study sample involved 16 repetitions on each head cadaver using both the innovative and control dental holders. The results of the paired t-test showed a significant difference in efficiency of use by radiographers and image quality between the two groups. The efficiency of use by radiographers increased, supported by a Cohen's d value of 9.632. The modification with silicone rubber showed better images, with a Cohen's d value of 0.325, attributed to the adjustable conus guide capability according to the size of the patient's mouth and jaw as well as the increased comfort with the silicone rubber material. This study recommends the adoption of the modified dental holder to improve procedure efficiency and quality of dental radiography results.

Keywords: *dental holder; silicone rubber; dental radiography; efficiency; image quality*

1. Introduction

Intra-oral radiographic examination is known as the basic examination in dental radiography. Through this technique, receptors, such as film or Imaging Plate (IP), are placed inside the oral cavity to obtain detailed images of the teeth and their supporting tissue structures. This examination divides the oral cavity into several parts: incisors, canines, premolars, and molars. Among the various types of intra-oral radiographic examinations available, such as occlusal, bitewing, and periapical, the periapical examination is a technique designed to display detailed images of the teeth and the tissue around its apex (Whaites and Nicholas Drage 2021).

The parallel technique, which is one of the methods in periapical examination, focuses on the accuracy of image dimensions based on the concept of parallelism between the receptor and the tooth, with the direction of the x-ray being perpendicular to the receptor (Iannucci and Howerton 2016). Although this technique allows for accurate imaging, there are some challenges, especially with the placement of the receptor. This placement can be a challenge for radiographers, especially for patients with a small oral cavity or a shallow palate. One factor adding to the complexity is the use of holders to support the receptor (Reynolds 2016). Conventional holders, required in the parallel technique, can sometimes damage oral tissues and cause discomfort for patients (Whaites and Nicholas Drage 2021).

As a solution to this problem, an innovation has been proposed by Jannah (2021). In her research, Jannah developed a holder lined with synthetic rubber or silicone, which comes into direct contact with the patient. Silicone rubber, known to be tolerable and safe for the human body, offers a more comfortable solution for

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patients and improves work efficiency for radiographers (Mojsiewicz-Pienkowska et al. 2016). The study showed that the innovation of the dental x-ray holder with a silicone rubber lining resulted in a better efficiency with an impact of 10.5% and an increased image quality by 18.5% (Jannah et al. 2021).

Considering this, there is a need for further refinement in the design of the dental x-ray holder. Especially in the telescopic ring system for beam alignment to be more ergonomic and easy to operate (Jannah et al. 2021). Based on the recommendations and findings, the author wishes to continue research on the innovation of the dental x-ray holder, hoping that the refined design will provide more optimal results when applied to intra-oral periapical examinations.

2. Method

This study employs a quasi-experimental quantitative approach, specifically using a post-test only research design. Data collection was conducted at the Dental and Oral Hospital of Universitas Muhammadiyah Semarang, from May to July 2023.

This research focuses on the design modification of the dental x-ray holder and subsequently tests its work efficiency and image quality. Using 3D design software, the holder was updated considering ergonomics and ease of use. The modified design was then printed using a 3D printer, where silicone rubber was chosen as the primary material for the parts that come into direct contact with patients.

Figure 1. Modified Dental Xray Holder

This study was conducted by performing periapical dental radiographic examinations on cadaver skulls with a dental holder. The steps for data collection and processing included modifying the dental holder and testing the efficiency and image quality of the resulting radiography. The research instrument used was a questionnaire consisting of 5 questions for each research aspect. Data obtained from Likert scale responses, which ranged from 1 to 4 and included criteria 1. Strongly Disagree, 2. Disagree, 3. Agree, and 4. Strongly Agree, were analysed using the paired t-test for differences and calculating effect size.

3. Result and Discussion

Before proceeding to the main analysis, here is the descriptive statistics of the data that has been collected to get a general overview of its characteristics and distribution:

Table 1. Descriptive statistic of questionnaire data results

Question	N	Min	Max	Mean	Std. Deviation
This tool makes your work faster and more practical	32	2	4	3.22	.792
This tool can make your work easier	32	2	4	3.25	.762
This tool does not easily shift or move when in use	32	2	4	3.09	.777
This tool provides satisfaction for your work	32	2	4	3.28	.813
This tool is safe in terms of occupational safety	32	2	4	3.16	.767
The apex or apical area of the tooth is clearly/precisely depicted	32	2	4	3.34	.745
The crown area of the tooth is clearly/precisely depicted	32	2	4	3.06	.801
The pulp of the tooth is clearly/precisely depicted	32	2	4	3.22	.832
There's no distortion in the images of the tooth or alveolar bone	32	2	4	3.09	.856
There are no blurred images due to movement.	32	2	4	3.16	.847

From the data in Table 1, we can understand how respondents evaluated each aspect of efficiency and image quality of the researched dental x-ray holder. In general, the average score for each aspect is above 3 (out of a scale of 4), indicating that this dental x-ray holder innovation received favourable assessments from the respondents. A normality test was then

conducted to evaluate the data distribution. Here are the results of the normality test that was conducted:

Table 2. Results of Data Normality Test

Groups	Shapiro-Wilk		
	Statistic	df	Sig.
Efficiency (Innovation)	.648	16	.000
Efficiency (Control)	.364	16	.000
Image Quality (Innovation)	.627	16	.000
Image Quality (Control)	.364	16	.000

From Table 2, it can be observed that the results of the normality test indicate the data is not normally distributed. This can be seen from the Sig. (p-value) for all groups being less than 0.05. A paired t-test analysis was then performed to determine the significant differences between the innovation and control groups in efficiency and image quality. Here are the results of the paired t-test that was conducted:

Table 3. Results of the Paired T-Test Analysis

Pairs	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Effeciency Innovation vs Control Group	1.3650	.4688	11.646	15	.000
Image Quality Innovation vs Control Group	1.3187	.4361	12.097	15	.000

From Table 3, it can be discerned that the analysis results indicate a significant difference between the innovation and control groups in efficiency and image quality, with a p-value of .000 for both groups. Furthermore, to calculate the effect size, Cohen's d was used to determine the magnitude of the innovation's influence on work efficiency and quality. Here are the results of the Cohen's d score calculations:

Table 4. Cohen's d Scores

Aspects	Cohen's d
Efficiency	9.632
Image Quality	0.325

From Table 4, it can be observed that the innovation of the dental holder has a very strong effect on work efficiency (d = 9.632) and a moderate effect on image quality (d = 0.325).

Efficiency

The research results show an increase in efficiency in the tool's usage by radiographers in the innovation group. The efficiency referred to in this context relates to ease of use, the time required, and the consistency of the results obtained.

In dental radiography practice, the efficiency of radiographers plays a crucial role in influencing the final image results and patient satisfaction. Efficiency in using the tools and the right techniques can reduce radiation exposure time, enhance patient comfort, and produce high-quality images with better consistency (Okano and Sur 2010; Towbin, Perry, and Larson 2017). In this study, the innovation group with the modified dental holder displayed a higher efficiency value (Cohen's d = 9.632) compared to the control group. This indicates that the modifications made to the dental holder genuinely impact the radiographer's performance in producing images.

Additionally, this increase in efficiency can have long-term implications for dental radiography practice. A study indicates that enhanced efficiency can reduce the workload of radiographers, increase patient throughput, and ultimately improve both patient and radiographer satisfaction (Lewis, Restauri, and Clark 2019; Nairz et al. 2018). With improved efficiency, radiographers can focus more on other aspects, such as enhancing communication quality with patients.

The relevance of this efficiency to the research findings is an indication that the modified dental holder not only produces better quality images but also a more efficient process. This aligns with on-field findings that show radiographers often face the challenge of producing quality images in a short amount of time, especially in healthcare facilities with a high patient frequency.

Image Quality

As for the aspect of image quality, the research results show that the images produced by the innovation group have better quality compared to the control group, with a Cohen's d effect size of 0.325. One of the contributing factors to the improvement in image quality is the optimization of FFD (Focal Film Distance) using the modified dental holder.

The use of a dental holder that can be adjusted to the patient's mouth and jaw allows for

the optimization of FFD. An optimal FFD has a direct influence on the quality of radiographic images. A study by Ye-Won Park et al. (2015) indicates that appropriate FFD adjustments can reduce image distortion and enhance detail resolution (Park et al. 2015). By reducing distortion, the produced images are more accurate and allow for more precise diagnosis.

Moreover, the conus guide section of the modified dental holder allows radiographers to position the equipment more precisely, reducing positioning errors and producing more consistent images. Accuracy in the placement of equipment and the patient is a key factor in obtaining high-quality images. This is emphasized by Khator (2017), where the proper placement of equipment and the patient can minimize artifacts and other errors that can reduce image sharpness (Khator, Motwani, and Choudhary 2017).

Furthermore, with the silicone rubber on the modified dental holder, patients feel more comfortable. Patient comfort plays a crucial role in image quality. Patients who feel comfortable tend to move less during the procedure, which can then reduce the risk of motion artifacts. Motion artifacts are one of the primary causes of image quality degradation in dental radiography (Yeung and Wong 2021).

4. Conclusion and Suggestion

This study demonstrates the significance of dental holder modifications in enhancing radiographer work efficiency and dental radiography image quality, particularly through FFD optimization and patient comfort. It reaffirms that modifications to the dental holder provide a positive contribution to improving radiographer work efficiency and optimizing radiography image quality, thus recommending its adoption.

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