Development and Evaluation of a Multifunctional Illuminated Dental Mirror to Improve Patient Comfort During Restorative Procedures

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Received 12 April 2025; 1st revision 28 July 2025; 2nd revision 11 August 2025; Accepted 29 August 2025; Published online 29 August 2025

Keywords:

Multifunctional dental mirror, patient comfort, restorative procedure, oral diagnostic tool, dental innovation

ABSTRACT

Background: *Conventional dental mouth mirrors are prone to fogging and debris accumulation, which compromises visibility and procedural efficiency—particularly in field settings with inadequate lighting. These limitations can affect patient comfort, a critical factor in treatment success. To overcome these issues, a multifunctional dental mirror integrating lighting, anti-fog features, and suction was developed to enhance patient comfort during restorative procedure.*

Method: *This study employed a Research and Development (R&D) approach and a true experimental posttest-only control group design. A total of 60 patients undergoing dental fillings were selected using purposive sampling. Expert validation was conducted to assess the tool's feasibility, and the effectiveness test was analyzed using descriptive statistics and the Mann–Whitney test.*

Result: *Expert validation yielded an average feasibility score of 83.3%, indicating high suitability. The effectiveness test showed statistically significant improvements in patient comfort across four dimensions: physical, psychospiritual, environmental, and sociocultural (p = 0.000).*

Conclusion: *The multifunctional illuminated dental mirror was found to be feasible and effective in enhancing patient comfort during restorative dental procedures. It is suitable for use in both clinical practice and field-based dental services.*

doi: http://dx.doi.org/10.30659/odj.12.172-182
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Odonto : Dental Journal accredited as **Sinta 3 Journal** (https://sinta.kemdikbud.go.id/journals/profile/3200)
How to Cite: Pujianti *et all*. Development and Evaluation of a Multifunctional Illuminated Dental Mirror to Improve Patient Comfort During Restorative Procedures. Odonto: Dental Journal, v.12, n.2, p.172-182 August 2025.

INTRODUCTION

Oral health is an integral part of general health and plays a crucial role in improving the overall quality of life[1]. Good oral health is not only defined by the absence of dental and oral diseases but also by the ability to eat, speak, and socialize comfortably without pain or discomfort[2]. In Indonesia, the prevalence of dental and oral health problems remains high. According to the 2023 Indonesia Health Survey (Survei Kesehatan Indonesia/SKI), 83% of the population suffers from active dental caries, indicating that promotive and preventive efforts in the field of dentistry are still suboptima[3].

The dental mirror is one of the primary diagnostic instruments used by dentists and dental therapists to observe the oral cavity. Although considered a simple tool, it plays a central role in aiding the visualization of intraoral structures[4]. However, in practice, conventional dental mirrors present several limitations. The mirror surface is prone to fogging and contamination from saliva or debris during procedures, often disrupting visibility and forcing the clinician to pause treatment to clean the mirror[5]. This not only compromises patient comfort but also reduces time efficiency and introduces the potential risk of cross-contamination, especially when non-sterile cloths are used for cleaning. A study by Ranjith Raj et al. (2023) found that 53% of dental students experienced difficulty in providing treatment using conventional dental mirrors due to fogging and debris accumulation on the mirror surface[6].In addition, excessive saliva production (hypersalivation) and the use of high-speed instruments, such as handpieces, contribute to the generation of aerosols and droplets that may contain microorganisms[7]. These aerosol particles can remain suspended in the air for extended periods and spread over considerable distances, increasing the risk of cross-infection between patients and healthcare providers[8].

The limitations of conventional dental mirrors become more apparent in outdoor or field-based dental services, particularly when adequate lighting is unavailable. In such cases, dental practitioners often rely on alternative light sources such as sunlight, flashlights, or headlamps, which are not always reliable[9]. Poor lighting conditions may force dental professionals to adopt awkward or non-ergonomic postures, which, over time, can lead to musculoskeletal complaints such as neck, back, shoulder, and hand pain (Bahammam,2021). Consequently, diagnostic efficiency, speed, and accuracy are compromised[10]. Beyond the limitations of conventional mirrors, patient comfort must also be prioritized during examinations and treatment. The physical and social environments surrounding the examination area are critical factors influencing patient comfort[11]. Comfort greatly affects the healing process and is a fundamental need that must be fulfilled for every individual. Achieving comfort provides patients with the energy and mindset to engage positively in managing their health. Providing safe and comfortable care is a fundamental responsibility of healthcare professionals[12]. Furthermore, the presence of aerosol and saliva during procedures can cause discomfort and increase the risk of infection, especially for patients with hypersalivation or during invasive interventions. Consequently, diagnostic efficiency, speed, and accuracy are compromised.

Although the literature and previous innovations have addressed specific limitations, few studies have attempted to holistically integrate solutions into a single instrument. The absence of a comprehensive approach—combining lighting, suction, and anti-fogging capabilities—presents a clear research gap. This underscores the need for a multifunctional diagnostic tool that can enhance patient comfort while addressing operational challenges in diverse clinical and field settings.

Diagnostic instrument innovation has become a key strategy to overcome the limitations of conventional tools, particularly in dental practice. One such innovation is a multifunctional dental mirror equipped with

integrated lighting (LED), anti-fog glass, an automatic water spray system for mirror cleaning, and a High Volume Evacuation (HVE) channel to suction saliva and aerosols. The integration of these features is designed to enhance visibility, operational efficiency, and patient comfort during examinations, both in clinical settings and in field services. This study addresses the identified research gap by developing and evaluating a multifunctional dental instrument designed to holistically enhance patient comfort while also supporting operator ergonomics. In line with this, the present study aims to design, develop, and evaluate the effectiveness of an innovative dental mirror with integrated lighting and supporting features in improving patient comfort during dental examinations and treatments. This innovation is expected to contribute to the advancement of dental healthcare services that are more ergonomic, safe, and patient-centered.

RESEARCH METHOD

The research was conducted using the Research and Development (R&D) method. The aim of this study is to develop an instrument innovation with lighting during examination to enhance operator comfort during the dental examination process. The research and development process includes five key stages: 1) information gathering, 2) product construction, 3) expert validation and revision, 4) product testing, and 5) final product.

The population in this study consists of all dentists and dental therapists working at community health centers (Puskesmas) in Banyumaik District, as well as those practicing in several independent dental clinics, along with patients who undergo dental filling procedures at these dental clinics. The sample in this study consists of three groups, namely: information collection samples, expert validation and product testing. Information was gathered through direct observation and in-depth interviews with dentists, dental therapists, and heads of community health centers. Furthermore, a comprehensive literature review was conducted to support the data obtained. Expert validation was carried out by a dentist, a dental therapist, and a biomedical engineering specialist.

This study conducted a trial using a *post-test only with control group desain*. The data analysis used includes univariate and bivariate analysis. If the data is not normally distributed, a non-parametric test, namely the Mann-Whitney test, is used. This study uses the Mann-Whitney test.

RESULTS

1. Expect Validation Test

   Expert validation was conducted by a dentist, a dental therapist, and a biomedical engineering specialist. This validation aimed to obtain data that would serve as the basis for assessing the feasibility of the device development. The data were analyzed using a Likert scale to determine the feasibility criteria of the instrument. The results of the expert feasibility assessment are presented in the following table:

Table 1 Expert Validation Test Results Table

No	Respondent	Skor	Criterion
1	Expert 1	84,2%	Highly Feasible
2	Expert 2	80%	
3	Expert 3	85,8%	
Average		83,3%	

Likert scale

Table 1 shows that the assessment using the Likert Scale yielded an average score of 83.3%, categorized as "Highly Feasible." This indicates that the development of the innovative mouth mirror with integrated lighting has met the initial feasibility standards for trial use, particularly in supporting dental filling procedures. This innovation not only addresses the limitations of conventional tools but is also designed to enhance patient comfort during examination and treatment. Although the assessment results indicate a high level of feasibility, the validators provided several suggestions for improvement, particularly regarding materials, sensor technology, and clinical application, to further optimize the tool's functionality and patient comfort in daily dental practice.

2. Data on Patient Comfort Questionnaire Responses During Dental Filling Procedures Using the Instrument Innovation with Lighting During Examination in Control and Intervention Groups

The evaluation of the innovation of mouth mirror with integrated lighting was conducted to assess patient comfort during dental examinations and restorative (filling) procedures using the device. Data were collected through questionnaires distributed to patients, with response options, “strongly agree”, “agree”, “moderately agree”, “disagree”, and “strongly disagree”. This assessment aimed to determine the extent to which the multifunctional mouth mirror innovation could enhance patient comfort, which is the primary focus of its development. The results of the respondents' assessment regarding comfort in using the device are presented in the following section:

Table 2. Frequency Distribution of Patient Comfort Questionnaire Responses During Dental Restoration Procedures Using the Instrument Innovation with Lighting During Examination

No	Question	Category	Control Group		Intervention group	
			n	%	n	%
	Physical comfort					
1	The use of this tool does not cause discomfort or pain during examinations of the buccal and lingual areas	Strongly Agree	3	10	16	53,3
		Agree	16	53,3	13	43,3
		Moderately Agree	7	23,3	1	3,4
		Disagree	3	10	0	0
		Strongly Disagree	1	3,4	0	0
2	The ergonomic design of the tool enhances physical comfort during dental examinations	Strongly Agree	6	20	14	46,7
		Agree	17	56,7	14	46,7
		Moderately Agree	7	23,3	2	6,6
		Disagree	0	0	0	0
		Strongly Disagree	0	0	0	0
3	This tool allows more comfortable access to the posterior areas of the oral cavity.	Strongly Agree	1	3,4	14	46,7
		Agree	4	13,4	13	43,3
		Moderately Agree	2	6,6	3	10
		Disagree	10	33,3	0	0
		Strongly Disagree	13	43,3	0	0
	Psychospiritual Comfort					
1.	The automated features of this tool contribute to a sense of calm during the dental procedure.	Strongly Agree	0	0	12	40
		Agree	2	6,6	15	50
		Moderately Agree	1	3,4	3	10
		Disagree	14	46,7	0	0
		Strongly Disagree	13	43,3	0	0
2.	The use of this tool enhances my overall comfort during the procedure.	Strongly Agree	2	6,7	16	53,3
		Agree	13	43,3	10	33,3
		Moderately Agree	12	40	4	13,4
		Disagree	2	6,6	0	0

No	Question	Category	Control Group		Intervention group	
			n	%	n	%
		Strongly Disagree	1	3,4	0	0
3.	This tool facilitates effective communication between the patient and the dental practitioner during the examination.	Strongly Agree	3	10	14	46,7
		Agree	15	50	14	46,7
		Moderately Agree	10	33,2	2	6.6
		Disagree	1	3,4	0	0
		Strongly Disagree	1	3,4	0	0
Environmental Comfort						
1.	Utilizing this tool contributes to a more relaxed experience within the dental clinic setting.	Strongly Agree	4	13,4	15	50
		Agree	15	50	12	40
		Moderately Agree	11	36,6	2	6,6
		Disagree	0	0	1	3,4
		Strongly Disagree	0	0	0	0
2.	This tool contributes to a more sterile and hygienic environment during dental examinations	Strongly Agree	4	13,3	17	56,7
		Agree	14	46,7	7	23,3
		Moderately Agree	11	36,6	5	16,6
		Disagree	1	3,4	1	3,4
		Strongly Disagree	0	0	0	0
3.	I feel that the sound produced by this tool does not disturb my comfort during the examination	Strongly Agree	4	13,3	17	56,7
		Agree	14	46,7	9	30
		Moderately Agree	11	36,6	4	13,3
		Disagree	1	3,4	0	0
	.	Strongly Disagree	0	0	0	0
Sociocultural Comfort						
1.	The features of this tool, such as saliva suction and anti-fog mirror, reflect the clinic's effort to address patients' needs and ensure their comfort.	Strongly Agree	0	0	18	60
		Agree	2	6,6	8	26,7
		Moderately Agree	1	3,4	4	13,3
		Disagree	12	40	0	0
		Strongly Disagree	15	50	0	0
2.	This tool makes me feel more valued during the examination process.	Strongly Agree	4	13,3	21	70
		Agree	14	46,7	6	20
		Moderately Agree	9	30	3	10
		Disagree	2	6,6	0	0
		Strongly Disagree	1	3,4	0	0

Based on Table 2, the respondents' assessment of the physical comfort category for Question 1 showed that in the control group using the conventional mouth mirror, the majority answered "agree" (16 respondents or 53.3%), while in the intervention group using the *Innovation of Mouth Mirror with Integrated Lighting*, most respondents answered "strongly agree" (16 respondents or 53.3%). For Question 2, the control group mostly responded "agree" (17 respondents or 56.7%), and in the intervention group, the majority responded "agree" and "strongly agree" (14 respondents or 46.7% each). For Question 3, most respondents in the control group chose "strongly disagree" (13 respondents or 43.3%), whereas in the intervention group, the majority answered "strongly agree" (14 respondents or 46.7%).

In the psychospiritual comfort category, for Question 1, most respondents in the control group selected "disagree" (14 respondents or 46.7%), while the intervention group mostly chose "agree" (15 respondents or 50%). For Question 2, the control group predominantly answered "agree" (13 respondents or 43.3%), while the intervention group mostly answered "strongly agree" (16 respondents or 53.3%). For Question 3, the control group's highest response was "agree" (15 respondents or 50%), while the intervention group mostly answered "agree" and "strongly agree" (14 respondents or 46.7% each).

Regarding the environmental comfort category, Question 1 responses showed that most respondents in the control group chose "agree" (15 respondents or 50%), while the intervention group mostly answered "strongly agree" (15 respondents or 50%). For Question 2, the control group mostly chose "agree" (14 respondents or 46.7%), while the intervention group predominantly selected "strongly agree" (17 respondents or 56.7%). In Question 3, the majority in the control group answered "agree" (14 respondents or 46.7%), whereas in the intervention group, most respondents answered "strongly agree" (17 respondents or 56.7%).

In the sociocultural comfort category, Question 1 results showed that most respondents in the control group answered "strongly disagree" (15 respondents or 50%), while the intervention group's majority chose "strongly agree" (18 respondents or 60%). For Question 2, the highest response in the control group was "agree" (14 respondents or 46.7%), while the intervention group predominantly selected "strongly agree" (21 respondents or 70%).

3. Effectiveness Test of the Use of Innovative Mouth Mirror with Integrated Lighting on Patient Comfort During Dental Examination and Filling Procedures

Table 3 Effectiveness Test of the Use of Innovative Mouth Mirror with Integrated Lighting on Patient Comfort During Dental Examination and Filling Procedures

Variable	Statistics
Aspect of Physical Comfort	
Z	-5.812
*p-value**	0,000
Aspect Psychospiritual Comfort	
Z	-6.184
*p-value**	0,000
Aspect Environmental Comfort	
Z	-4.065
*p-value**	0,000
Aspect Sociocultural Comfort	
Z	-6.315
*p-value**	0,000

***Mann Whitney**

Table 3 presents the results of the effectiveness test on the use of the Innovation of Mouth Mirror with Integrated Lighting in enhancing patient comfort during dental fillings, based on four aspects: physical comfort, psychospritual comfort, environmental comfort, and sociocultural comfort.

In the aspect of physical comfort, a significant difference was found between the control and intervention groups. The Z value = -5.812 indicates that the score distribution in the control group was significantly lower than in the intervention group. The p-value of 0.000 (< 0.05) suggests that the innovative tool is effective in improving patients' physical comfort during dental filling procedures.

In terms of psychospiritual comfort, the Z value = -6.184 also shows a significant difference, with a p-value of 0.000. This indicates that the mouth mirror innovation significantly enhances patients' psychological calmness and sense of well-being during treatment compared to conventional tools.

For environmental comfort, the Z value = -4.065 and p-value of 0.000 indicate a significant positive impact of the tool on the patients' perception of a more comfortable and hygienic clinical environment.

Regarding sociocultural comfort, the Z value = -6.315 with a p-value of 0.000 confirms that the innovation also improves patients' feelings of being respected and cared for during dental examinations and procedures.

DISCUSSION

These findings indicate that improving patient comfort during dental procedures may enhance patient cooperation, reduce anxiety, and support overall clinical outcomes. The integration of lighting, suction, and anti-fog features into a single instrument facilitates a more ergonomic workflow, reduces procedural time, and enhances safety especially in field-based or limited-resource settings.

Despite the promising outcomes, this study had several limitations. The instrument's sterilization mechanism and component durability over long-term use were not evaluated. Additionally, this study was limited to a single clinical setting with a specific procedure (restorative fillings). Future research should explore multi-center trials, broader dental applications, and long-term user feedback to refine the design and assess cost-effectiveness.

1. Information Collection

The process of information gathering serves as the initial stage in identifying issues encountered in the field and collecting data to support the development of an instrument innovation with integrated lighting, aimed at enhancing patient comfort during dental examinations. This stage is essential for gaining a comprehensive understanding of the device to be developed and is supported by various sources, including journals, books, and previous research. The information obtained will serve as the foundation for the development process. One of the advantages of using the Research and Development (R&D) method over other approaches lies in its comprehensive nature, as it enables the creation of a highly validated product through a series of rigorous tests that bridge theoretical and practical research[13].

Based on information collected through field interviews, it was found that patient comfort during dental examinations, both in the field and in dental clinics, has not yet been fully optimized. One of the factors affecting patient comfort is the use of conventional mouth mirrors, which have several limitations. In field settings, conventional mirrors cannot function effectively without additional lighting, making examinations less efficient and potentially uncomfortable for patients due to longer and less precise procedures. Furthermore, the mirror surface easily fogs up and becomes dirty, reducing visibility and potentially compromising the quality and accuracy of the examination.

In clinical settings, patient comfort may also be disrupted by technical issues such as power outages. During such events, dental unit lighting and suction cannot function properly, delaying procedures like fillings. These delays not only affect treatment effectiveness but also cause anxiety, discomfort, and fatigue for patients. Recognizing the importance of maintaining patient comfort during dental care, there is a need for diagnostic tools that remain functional under various conditions. In response to this, the researcher developed an Innovation of Mouth Mirror with Integrated Lighting to improve examination efficiency while enhancing patient comfort in both field and clinical settings.

2. Expect Validation Test

Expert validation testing was conducted by involving dentists, dental and oral therapists, as well as biomedical engineering experts. This validation aimed to assess the feasibility of the Innovation of Mouth Mirror with Integrated Lighting as a multifunctional diagnostic tool that supports patient comfort during dental examinations. Based on the evaluations from experts, the device received a feasibility score of 83.3 percent, which falls into the highly feasible category. This indicates that the instrument has met most of the essential criteria in dental health services, particularly in enhancing patient comfort and examination effectiveness. Several important inputs from the validators served as valuable feedback for further development.

The first validator noted that some parts of the tool could not yet be sterilized optimally, highlighting the need for careful material selection and redesign of certain components. However, overall, the device was able to be operated properly on several patients and provided clear benefits during the examination process.

The second validator stated that the tool's development was already in line with actual needs in the field, especially in supporting visibility during dental examinations. Nevertheless, there is still room for improving certain features, such as adjustable lighting intensity and a more ergonomic design to enhance user comfort.

The third validator emphasized that this tool is more recommended for use in field-based dental health services, such as community service events, outreach in remote areas, or oral health promotion in schools. This is due to its integrated lighting feature and portable design, which allow usage without relying on a dental unit or external power source.

The anti-fog feature was also considered a significant advantage that improves comfort and examination speed. Moreover, the use of lightweight materials and an ergonomic structure supports the comfort of both operator and patient, while also minimizing the risk of muscle fatigue among healthcare personnel. Considering all the feedback from the validators, future development of the Innovation of Mouth Mirror with Integrated Lighting will focus on improving sterilization, optimizing lighting functionality, and enhancing ergonomic comfort. The goal is to create a tool that is not only clinically effective but also provides a comfortable, safe, and efficient examination experience for patients in a variety of healthcare settings, both in clinics and in the field.

3. Effectiveness Analysis of an Instrument Innovation with Lighting During Dental Examinations on Patient Comfort

a. Physical comfort

Comfort is a fundamental human need that must be fulfilled for all individuals. Comfort refers to a condition in which a person feels at ease based on individual perception. Achieving physical comfort provides individuals with the strength to become more aware of their health, particularly oral health, thus increasing patient satisfaction with the care they receive[14].

Oral health encompasses the care and maintenance of teeth, gums, and other oral structures to prevent diseases within the oral cavity[15]. Dental and oral health services aim to improve health, prevent and treat diseases, and restore oral health in a comprehensive and integrative manner with high quality[16]. Physical comfort during dental procedures, especially during restorative treatments such as fillings, plays an essential role in reducing anxiety and increasing patient satisfaction.This is in line with

the study by Maritsa A et al. (2023), which found that high levels of anxiety can negatively affect dental care procedures and impact the effectiveness of treatment[17]. With the innovation and development of the Instrument Innovation with lighting during examination, patients are able to receive treatment more comfortably, allowing them to remain calm and cooperative throughout restorative procedures

b. Psychospiritual Comfort

Psychospiritual comfort is related to the absence of fear and anxiety during dental procedures[18]. The automatic features of the Instrument Innovation with Lighting During Examination help minimize the number of tools entering the patient's oral cavity, thereby reducing the patient's fear during treatment. A study conducted by Hardono et al. (2019) states that patient anxiety arises from an excessive transmission of anxiety-related stimuli to the brain, triggering physiological responses such as increased heart rate, elevated blood pressure, and muscle tension[19]. By minimizing several anxiety-inducing factors, patients can feel more at ease during restorative procedures. This indicates that the use of the Instrument Innovation with Lighting During Examination can help reduce patient anxiety, enhance psychospiritual comfort, and support the success of dental treatment procedures.

c. Environmental Comfort

Environmental comfort is related to factors such as privacy, odors, noise, lighting, and the overall condition of the examination area[20]. the instrument innovation with lighting during examination is designed to operate without producing excessive noise, and its lighting does not emit heat that could disturb the patient's comfort in terms of environmental conditions. This is supported by a study conducted by Bulbuloglu et al. (2022), which states that environmental stressors, such as noise from medical devices, can trigger or worsen patient anxiety. This indicates that the use of the Instrument Innovation with Lighting During Examination can support patients' environmental comfort during dental restoration procedures[21].

d. Sociocultural Comfort

Sociocultural comfort involves the interpersonal relationship between healthcare providers and patients, referring to a communication system that provides support during procedures. The automatic features of the *Instrument Innovation with Lighting During Examination* can support effective and inclusive sociocultural communication between dentists and patients, thereby having a positive impact on enhancing the patient's confidence

CONCLUSION

The development and implementation of the instrument innovation with lighting during examination, evaluated through a posttest-only with control group design, demonstrated its effectiveness in enhancing patient comfort during dental restorative procedures. The intervention group, which utilized the innovative instrument, reported significantly higher levels of comfort compared to the control group using a conventional dental mirror.

This multifunctional diagnostic tool integrates several key features designed to optimize the clinical experience. These include integrated LED illumination, an anti-fog mechanism, a high suction system, and an automatic water spray function. The suction maintains a dry operative field, reducing the need for additional suction instruments and enhancing procedural efficiency. The water spray feature assists in cleaning the mirror surface during use, ensuring continuous visibility without interrupting the procedure.

In addition, the instrument's ergonomic and lightweight design supports operator comfort and minimizes patient discomfort, thereby facilitating improved communication and cooperation throughout the procedure. Expert validation further confirmed the tool's high feasibility and applicability, with an overall eligibility score of 83.3%, reflecting strong alignment with clinical standards of safety, efficiency, and patient-centered care.

Overall, this innovation offers a comprehensive and practical solution that enhances both the quality of dental examinations and patient comfort, making it particularly suitable for use in clinical practice as well as in field-based dental services.

ACKNOWLEDGEMENT

The author extends sincere gratitude to all respondents and parties who contributed to the success of this research. Their time, support, and willingness to participate played a valuable role in the completion of this study.

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