Original Article

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Dentistry Section

Exploring Intraoral Photography: A Cross-sectional Analysis of Commercially Available versus Newly Designed and Patented Contraster using Self-designed Criteria

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ABSTRACT

Introduction: Intraoral photography is crucial in dentistry for documentation, communication and education. Contrasters play a pivotal role, influencing patient experience and image quality. Traditional metal contrasters have limitations regarding patient friendliness and procedural compatibility.

Aim: To assess ease and comfort among patients and operators and to compare the contrasting ability of commercially available contrasters with newly designed contrasters in intraoral photography.

Materials and Methods: A single-blinded, cross-sectional analytical study was conducted in the Department of Conservative and Endodontics and the Department of Orthodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India, from January 2024 to February 2024. After obtaining ethical approval, 50 patients with no pain, swelling, or discomfort in the maxillary anterior region, as well as, only those operators trained in intraoral Digital Single-lens Reflex (DSLR) photography, were enrolled. Following randomisation and standard camera settings, intraoral images were captured by 50 operators using both conventional metal and newly designed 3D-printed contrasters. Patients and operators evaluated ease, comfort, contrasting ability, and the presence of a palatal gap using self-designed criteria. The data were subjected to statistical analysis using International Business Machines (IBM) Statistical package for the Social Sciences (SPSS) software version 21.0. The Chi-square test of proportion was applied to evaluate differences in proportion, while the Mann-Whitney U test was used to compare the two contrasters. A confidence interval of 95% and p-value <0.05 were considered statistically significant.

Results: The results revealed a statistically significant difference in discomfort and pain experienced by patients during the placement and removal of the contrasters between the conventional and newly designed groups (p-value <0.05). Similarly, operators reported significantly lower ease of placement and removal in the conventional group compared to the newly designed group (p-value <0.05). However, no statistically significant difference in contrasting ability was observed between the two groups (p-value >0.05).

Conclusion: The newly designed contrasters demonstrated superior patient comfort and reduced pain compared to commercially available contrasters. Operators experienced easier placement with similar contrasting abilities.

Keywords: Dental aesthetics, Dental photography, Documentation

INTRODUCTION

One of the major reasons dentists shy away from dental photography is its perceived technical complexity; however, its advantages far outweigh any initial hesitation [1,2]. Dental photography serves not only its primary function of recording clinical information but also fulfills dentolegal needs and aids in education and communication with patients and colleagues [1,2]. It contributes to portfolio building, showcases a practice's expertise, and plays a key role in marketing, ultimately elevating the practice's status and improving patient care delivery [1-4].

Apart from the camera, lens and flash, a few accessories are needed to take high-resolution images, including photographic mirrors, contrasters and retractors [5,6]. The contrasters obscure the surrounding soft tissue structures, providing a uniform black background and enhancing the transparency of incisal edges. Two primary types of contrasters are available in the market: conventional and flexible [5]. Previous studies have concluded that, due to the increasing demand for aesthetic considerations and the greater use of contrasters in today's dentistry, the existing contrasters lack provisions for arch photography. They do not adapt well to the patient's arch and can be cumbersome for both the patient and the operator during the photography process [2,6].

Hence, while different modifications have been introduced to accessories like photographic mirrors and retractors, a similar level of innovation is needed for contrasters. Most research focuses on how to take good pictures and the technical problems involved, but often overlooks the patients' perspectives [2]. Newly designed contrasters have been created to address the challenges faced by operators when taking clinical intraoral pictures and to improve patient comfort. These contrasters utilise 3D printing technology with Polymethyl Methacrylate (PMMA) resin and are subjected to cold sterilisation.

Since there are no established evaluation criteria for comparing different accessories in dental photography, self-designed validated criteria (registration no. L-139246/2023) were developed to compare commercially available contrasters with newly designed ones in intraoral dental photography. Previous studies have shown that, although many designs exist for dental photographic accessories, there are no contrasters currently available that can adapt to the shape of the dental arch [2,6]. These limitations highlight the need for the development of new contrasters. Given that no study has been conducted to compare and assess the different types of contrasters available in the market, the present study was aimed to comparatively evaluate the ease and comfort of conventional and newly designed contrasters in intraoral photography.

The null hypothesis of the present study was that there will be no difference in the ease, comfort, and contrasting ability of commercially available and newly designed contrast agents in intraoral dental photography when evaluated by patients and operators using self-designed criteria. The alternate hypothesis was that there will be a difference in the ease, comfort and contrasting ability of commercially available and newly designed contrast agents in intraoral dental photography when evaluated by patients and operators using self-designed criteria.

MATERIALS AND METHODS

The present single-blinded, cross-sectional analytical study was conducted in the Department of Conservative and Endodontics and the Department of Orthodontics, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India, from January 2024 to February 2024. Study was conducted on the patients who visited study Institute for a general check-up. The operators taking the photographs were either postgraduate students or staff members from these two departments, all of whom were trained in intraoral DSLR photography. The equipment used included a Canon 1300D camera (Ota, Tokyo, Japan) with a 100 mm macro lens (Canon EF 100mm, Ota, Tokyo, Japan) and a ring flash.

Ethical clearance was obtained from the Institutional Ethical Committee (ethical approval no. SVIEC/ON/Dent/SRP/oct/23/21), and the study protocols were registered at the Clinical Trials Registry of India (CTRI no. CTRI/2024/01/061904). Only patients who consented to photography and documentation were enrolled in the study.

Inclusion criteria: The study included 50 adult male and female patients aged between 18 years and 65 years who had good oral hygiene and did not present with pain, swelling, or any discomfort in the maxillary anterior region. The operators comprised 25 postgraduate students and 25 staff members trained in intraoral DSLR photography.

Exclusion criteria: Patients who were allergic to Polymethyl Methacrylate (PMMA) resin, had limited mouth opening, temporomandibular joint problems, or developmental anomalies such as cleft lip or palate were excluded from the study.

Sample size calculation: The mean and standard deviation of the ICC (2.26±2.06) values for the colour selection method of the two examiners from the study conducted by Atri F et al., were used for sample size estimation. The total sample size was estimated to be 50 per group, with an alpha error of 5%, a power of 80%, and a confidence interval of 95%, considering p-value <0.05 as statistically significant. The formula used for calculation was:

$$n=(\sigma 12+\sigma 22/\kappa)\ (z1-\alpha/2+z1-\beta/2)2\ \Delta^2$$ [7].

Each operator will take two photographs: one using the commercially available metal contraster and the other using the newly designed contraster.

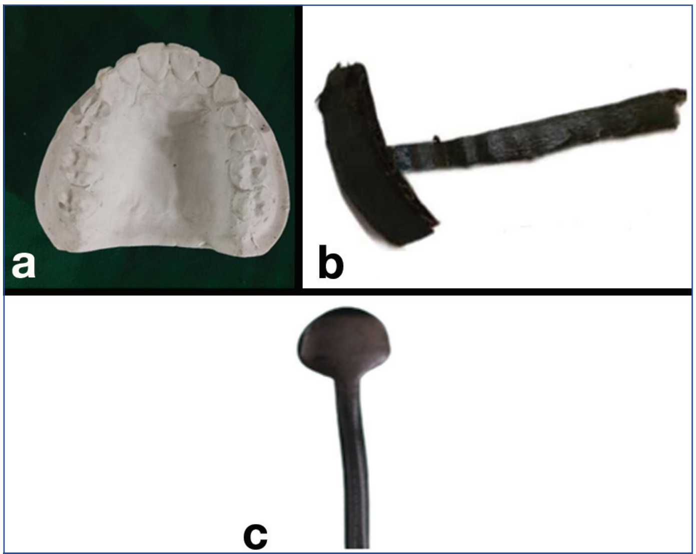
Group A: Photographs taken with commercially available contrasters (n=50)

Group B: Photographs taken with newly designed contrasters (n=50)

Clinical procedure: Making of contrasters (Design No. 381404-001).

Study Procedure

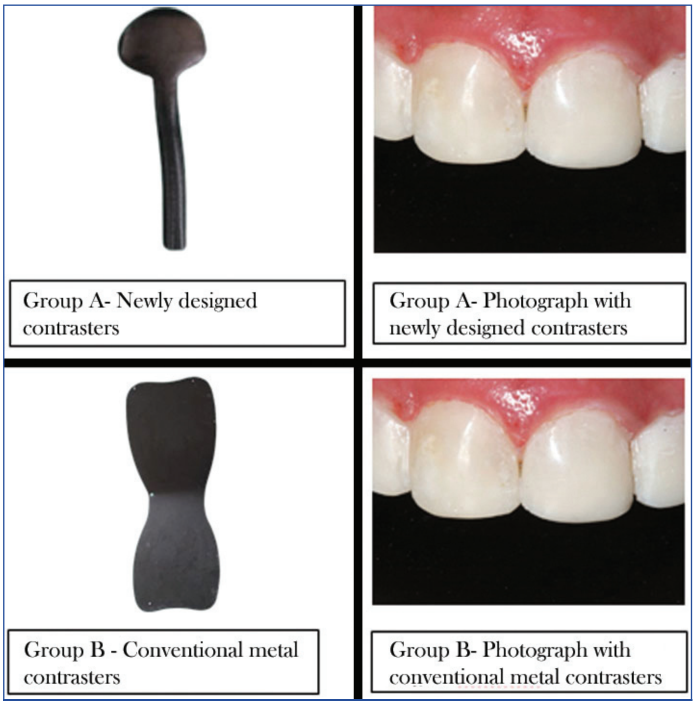
Ten human maxillary casts of different arch forms (normal, ovoid, narrow ovoid, narrow tapered and tapered) were utilised for the study, comprising five males and five females for each arch form. A pilot study was conducted for calibration and feasibility of the contraster; however, the data from the pilot study were not included in the present study. The average length and width of the maxillary incisors were calculated to be 2.5 cm and 4 cm, respectively. To ensure uniform dimensions, these measurements were applied to create a cardboard model, which was then photographed on patients. None of the patients reported any difficulty during this process. Following a successful trial, digital scanning technology was employed to capture data from the casts. This data was integrated into AutoCAD™ software for 3D printing, resulting in the creation of the final model using PMMA resin, after which a pilot study was conducted [Table/Fig-1].



[Table/Fig-1]: Making of contrasters. a) Ten human maxillary casts were taken. Average length and width of maxillary incisors was 2.5 cm and 4 cm, respectively; b) The data was transferred to a cardboard model and later into AutoCAD™ software for 3D printing; c) Final model of newly designed contrasters with Polymethylmethacrylate (PMMA).

Standardisation of equipment and cameras: The intraoral photography process was carried out using a DSLR Canon camera (model no. 1300 D, Ota, Tokyo, Japan), equipped with a 100 mm macro lens (Canon EF 100 mm, Ota, Tokyo, Japan). For consistent and optimal lighting, a ring flash (Canon MR14EX II, Ota, Tokyo, Japan) was used. To maintain precise control over the image capture, the camera settings were configured with an ISO of 100, a shutter speed of 1/200, and an aperture of F32. Images were shot with a magnification ratio set at 1:1 [8]. To provide flexibility in post-processing, images were captured in both RAW and Joint Photographic Experts Group (JPEG) formats. The flash setting was adjusted to a power level of ¼, carefully balanced to achieve the desired outcome while maintaining natural colour representation. Fifty operators were selected, all trained in intraoral DSLR photography (including postgraduate students and staff from the Department of Conservative Dentistry and Orthodontics), and one operator was assigned to each patient. The randomisation of the contraster was conducted using the flip-coin method. Once the above settings were established, images were taken by the 50 operators on 50 different patients' maxillary anterior teeth, using both contrasters [Table/Fig-2]. A total of 100 photographs were obtained.

Self-designed criteria were created as no evaluation criteria were available in the literature. These criteria were validated by five subject specialists who have been using DSLR cameras for intraoral photography for the past five years. After creating the criteria, they were categorised as: 1) essential; 2) useful but not essential; and 3) not essential. To measure internal consistency, the authors asked the experts to rate the questionnaire form to create the evaluation criteria based on their classifications of essential, useful but not essential and not essential. Based on their responses, the internal consistency was validated. The test-retest reliability was evaluated using the Intraclass Correlation Coefficient (ICC), which yielded a calculated value of 0.890. The photographs taken by operators were evaluated by two blinded investigators using the criteria they created. Kappa statistics were used to test interexaminer reliability.



[Table/Fig-2]: Group A: Photograph with conventional metal contrasters, Group B: Photographs with newly designed contrasters.

According to Cohen, Kappa results are interpreted as follows: values ≤0 indicate no agreement; 0.01-0.20 indicate none to slight agreement; 0.21-0.40 indicate fair agreement; 0.41-0.60 indicate moderate agreement; 0.61-0.80 indicate substantial agreement; and 0.81-1.00 indicate almost perfect agreement [9]. The kappa value for interobserver reliability was 0.85.

After the criteria were designed, they were given to patients to record their experiences regarding patient-related criteria, followed by operator-related criteria assessed by the operator [Table/Fig-3].

Response	Criteria
Patient response based on experience	
a) Discomfort on placement and removal	0: Severe discomfort
	1: Moderate discomfort
	2: Mild discomfort
	3: No discomfort
b) Pain on buccal mucosa and labial mucosa	0: Severe pain
	1: Moderate pain
	2: Mild pain
	3: No pain
Operator response based on experience	
a) Ease of placement and removal	0: Difficult
	1: Easy
	2: Effortless
b) Contrasting ability	0: Inferior
	1: Superior

[Table/Fig-3]: Self-designed evaluation criteria for dental photographic contrasters. (Registration no- L-139246/2023).

STATISTICAL ANALYSIS

The data was obtained and entered into Microsoft Excel version 13.0 and was subjected to statistical analysis using IBM SPSS statistics software version 21.0. To evaluate the difference in proportions, a Chi-square test was applied. For the comparison between the conventional and newly designed contraster, the Mann-Whitney U test was utilised. All statistical tests were performed with a confidence interval of 95%, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Among the 50 patients, 26 were males and 24 were females. A Mann-Whitney U test was conducted on the distribution of discomfort during placement, using the conventional contraster. Of the patients, 4 (8%) reported severe discomfort, 22 (44%) reported moderate discomfort, and 24 (48%) reported mild discomfort. In contrast, when using the newly designed contraster, 5 (10%) reported mild discomfort, while 45 (90%) reported no discomfort. The comparison revealed that the majority of patients (90%) in the newly designed group showed no discomfort. To evaluate the difference in proportions, a Chi-square test of proportions was applied, and the difference was found to be statistically significant. For the comparison of the two contrasters, the Mann-Whitney U test was applied (p-value <0.001) [Table/Fig-4].

Mann-Whitney U test		Groups		Total n (%)	p-value
		Conventional n (%)	Newly designed n (%)		
Discomfort on placement and removal, n (%)	Severe discomfort	4 (8)	0	4 (4)	<0.001*
	Moderate discomfort	22 (44)	0	22 (22)	
	Mild discomfort	24 (48)	5 (10)	29 (29)	
	No discomfort	0	45 (90)	45 (45)	
Total		50 (100)	50 (100)	100 (100)	

[Table/Fig-4]: Comparison of discomfort on placement and removal of conventional and newly designed contrasters.
*The p-value <0.05 was considered statistically significant

The distribution of pain on the buccal/labial mucosa using the conventional contraster showed that 6 (12%) reported moderate pain, 11 (22%) reported mild pain and 33 (66%) reported no pain. In comparison, using the newly designed contraster, 1 (2%) reported moderate pain, 3 (6%) reported mild pain, and 46 (92%) reported no pain. When the comparison was made, it was observed that the maximum number of patients (92%) with the newly designed contraster reported no discomfort, and the difference in proportions was statistically significant (p-value <0.001) [Table/Fig-5].

Mann-Whitney U test		Groups		Total n (%)	p-value
		Conventional n (%)	Newly designed n (%)		
Pain on buccal/ labial mucosa	Moderate pain	6 (12)	1 (2)	7 (7)	<0.001*
	Mild pain	11 (22)	3 (6)	14 (14)	
	No pain	33 (66)	46 (92)	79 (79)	
Total		50 (100)	50 (100)	100 (100)	

[Table/Fig-5]: Comparison of pain on buccal/labial mucosa using conventional and newly designed contrasters.

Regarding the ease of placement and removal, 42 (84%) operators found it difficult with the conventional contraster, while only 8 (16%) found it easy. Conversely, with the newly designed contraster, 9 (18%) operators found it easy, and 41 (82%) found it effortless. The comparison indicated that the maximum number of operators (92%) in the newly designed group reported effortless placement, and the difference in proportions was statistically significant (p-value <0.001) [Table/Fig-6].

Both the conventional contraster and the newly designed contraster exhibited similar contrasting abilities, with 3 (6%) operators in each group reporting inferior contrasting ability and 47 (94%) reporting superior contrasting ability. The difference in operator contrasting ability between the two groups was not statistically significant (p-value=1.000) [Table/Fig-7].

Mann-Whitney U test		Groups		Total n (%)	p-value
		Conventional n (%)	Newly designed n (%)		
Operators ease of placement and removal	Difficult	42 (84)	0	42 (42)	<0.001*
	Easy	8 (16)	9 (18)	17 (17)	
	Effortless	0	41 (82)	41 (41)	
Total		50 (100)	50 (100)	100 (100)	

[Table/Fig-6]: Comparison of operators ease of placement and removal using conventional and newly designed.

Mann-Whitney U test		Groups		Total n (%)	p-value
		Conventional n (%)	Newly designed n (%)		
Operators contrasting ability	Inferior	3 (6)	3 (6)	6 (6)	1.000
	Superior	47 (94)	47 (94)	94 (94)	
Total		50 (100)	50 (100)	100 (100)	

[Table/Fig-7]: Comparison of operators contrasting ability using conventional and newly designed.

DISCUSSION

Based on the results, the null hypothesis was rejected for the parameters of ease and comfort; however, it was accepted for contrasting ability. In contrast, the alternative hypothesis was accepted for ease and comfort, while it was rejected for contrasting ability. Previous studies have compared various photographic accessories and their modifications; therefore, there exists a gap in the literature regarding contrasters [2,6]. The present study evaluates a newly designed contraster in comparison to commercially available contrasters, focusing on aspects of patient comfort, operator ease and contrasting ability. The findings highlight significant advantages associated with the new design, indicating potential improvements in the overall experience and efficiency of intraoral photography procedures.

Dental photography is a routine procedure in contemporary dental practice [10,11]. A photographic black contraster is a tool used in dental photography that provides a black background to isolate the teeth of interest. The black colour neutralises the background, making it easier to visualise colour matches or mismatches [5]. This aids in transferring information about shade, enamel staining, characterisation, and incisal edge translucency between the dentist and the dental laboratory technician [12,13].

Commercially available contrasters have been found to be bulkier, as they do not conform to the arch. Furthermore, the frequent contact of metal with oral soft tissue can cause significant discomfort for patients, as well as difficulty for the operator during placement and removal [7,11,14]. In contrast, the newly designed contrasters are anatomically shaped, smaller in size and better adapted to the arch. Additionally, the smaller handle size allows for easy placement, resulting in minimal contact with oral structures. This addresses a common challenge associated with conventional contrasters, potentially reducing procedure time and increasing workflow efficiency. This is especially important in modern dental practice, where time management is key to providing timely and effective patient treatment [13].

Despite the improvements in patient comfort and operator ease, the newly designed contraster maintains equally good contrasting ability compared to conventional contrasters. This ensures that the innovative design's primary function is providing a uniform black background for clear intraoral images, which are not compromised [12,14].

In addition to the features mentioned above, macrophotography requires photographs of maxillary anterior teeth for discolouration identification, translucency enhancement and post-treatment evaluation following aesthetic restoration. This provides significant assistance to clinicians [12,13,15,16].

The present study is the first of its kind, meaning that no one has conducted similar research before. Because of this, the authors do not have previous evidence to support the present study findings. The authors believe the new contrasters are more effective because they are smaller and have a narrow handle, making it easy to place them in the narrowest parts of the human arch without causing discomfort to the patient. The authors designed these contrasters after studying 50 casts of human teeth from both men and women, ensuring that they fit well and are easy for dentists to use.

While existing studies have mainly focused on technical aspects and camera usage, they often overlook the patient perspective [2]. Hence, the current study will undoubtedly open the door for new ideas and research aimed at creating better designs that improve patient comfort and facilitate easier use for dentists. Additionally, the evaluation criteria used are subjective and require further validation to ensure reliability and consistency in future research.

Limitation(s)

However, there are some limitations to these new contrasters. They can only be used for upper incisors, so if we need to take a picture of a larger area, we cannot use them. Being 3D printed, they cannot be autoclaved and can only be disinfected.

CONCLUSION(S)

The findings of the present study suggest that the newly designed intraoral contraster offers significant advantages over conventional contrasters in terms of patient comfort and operator ease. While both designs exhibit comparable contrasting abilities, the innovative design of the newly developed contraster has the potential to enhance the overall experience and efficiency of intraoral photography procedures.

Authors' declaration: The name of the conventional contraster has not been revealed here on purpose. If anyone wishes to know the name, can directly contact the authors.

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