

Comparative Evaluation of Orthodontic Photographs Captured Using DSLR, Mirrorless, and Smartphone Cameras: A Cross-Sectional Survey Among Dental Professionals

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ABSTRACT

Objective: To compare the perceived photographic quality and clinical acceptability of orthodontic photographs obtained using a DSLR camera, a mirrorless camera, and a contemporary smartphone.

Materials and Methods: Standardized extraoral and intraoral orthodontic photographs were obtained from a single adult subject using three photographic systems: a Canon EOS 3000D DSLR camera, a Canon EOS R50 mirrorless camera, and an iPhone 16 Pro smartphone. The photographs were obtained under standardized conditions using a uniform photographic protocol and were presented anonymously as Groups I, II, and III. A total of 240 dental professionals, comprising general dentists, orthodontic residents, and orthodontists, evaluated the photographs using an online questionnaire. The questionnaire assessed overall image quality, colour accuracy, sharpness, depth of field, graininess/noise, consistency, natural colour representation, image distortion, clinical suitability, and future preference. Pearson's chi-square goodness-of-fit test was used to compare the distribution of camera selections among the three photographic groups.

Results: For extraoral photographs, Group I was most frequently selected for overall image quality (91, 37.92%), Group II for colour accuracy (92, 38.33%), and Group III for sharpness (87, 36.25%) and depth of field (80, 33.33%). Group I was most frequently perceived as having a grainy or noisy appearance (80, 33.33%). A statistically significant difference was observed only for grainy/noisy appearance ($p = 0.0067$).

For intraoral photographs, Group III received the highest frequency of selections for overall image quality (85, 35.42%), colour accuracy (87, 36.25%), sharpness (95, 39.58%), and depth of field (83, 34.58%). Statistically significant differences were observed for colour accuracy ($p = 0.0489$), sharpness ($p = 0.0281$), and grainy/noisy appearance ($p = 0.0407$).

In the comparative assessment, Group III was most frequently selected for consistency (83, 34.58%), natural colour representation (89, 37.08%), and least image distortion (94, 39.17%). A statistically significant difference was observed for image distortion ($p = 0.0230$). Group III was also most frequently selected as the highest-quality camera (89, 37.08%), the most suitable for clinical documentation (99, 41.25%), and the preferred system for future clinical photography (94, 39.33%).

Conclusion: All three photographic systems were capable of producing clinically acceptable orthodontic photographs. No single system demonstrated uniform superiority across all evaluated characteristics. The smartphone received the highest frequency of selections for several intraoral characteristics and for clinical documentation and future use, whereas DSLR and mirrorless systems remained competitive for several photographic parameters. Camera selection should therefore be based on the intended clinical application, required photographic control, image quality, and clinical workflow.

Keywords: Dental photography; Clinical photography; DSLR camera; Mirrorless camera; Intraoral photography; Extraoral photography

1. INTRODUCTION

Clinical photography is an important component of orthodontic records and provides a visual representation of dentofacial characteristics before, during, and after treatment. Extraoral and intraoral photographs are routinely used for diagnosis, treatment planning, monitoring of treatment progress, assessment of treatment outcomes, patient communication, education, and clinical documentation.¹⁻³ Their usefulness depends not only on image resolution but also on the reproducibility of the photographic procedure. Variations in patient position, camera position, lens selection, working distance, illumination, and magnification can influence the appearance and dimensional representation of facial and dental structures.³⁻⁵ Consequently, standardization of photographic technique is essential when photographs are intended for comparison over the course of orthodontic treatment.

Digital single-lens reflex (DSLR) cameras have traditionally been used for high-quality orthodontic photography because they provide extensive control over exposure, aperture, focal length, and flash illumination and can be coupled with dedicated macro lenses.^{5,6} Appropriate selection of camera settings is particularly important in dental photography because adequate depth of field, illumination, colour reproduction, and sharpness must be achieved simultaneously.^{6,7} Although DSLR systems offer considerable flexibility and reproducibility, their relatively large size, cost, and requirement for dedicated accessories may make them less convenient for routine clinical use. These considerations have encouraged interest in alternative photographic systems that can provide clinically acceptable images with greater portability and ease of operation.

The widespread availability of smartphones has substantially changed the accessibility of clinical photography. Modern smartphone cameras allow clinicians to obtain photographs without carrying a separate dedicated camera system, while improvements in sensor technology, optics, illumination and automated image processing have increased their potential for dental applications.^{8,9} A standardized technique for orthodontic photography using a smartphone has been described, emphasizing appropriate patient positioning, lighting, camera positioning, and image composition.⁸ Studies comparing smartphone and dedicated cameras, however, have produced variable results depending on the photographic parameter examined. Lazar et al. reported differences between DSLR and smartphone photographs in aesthetic assessment, whereas Moussa et al. demonstrated that smartphone photographs could provide comparable dimensional measurements to professional dental photography under specified conditions.^{9,10} These findings suggest that smartphone suitability should be

evaluated according to the intended clinical application rather than assumed from image resolution alone.

Mirrorless interchangeable-lens cameras represent another technological development relevant to orthodontic photography. These systems eliminate the optical reflex mirror found in conventional DSLR cameras while retaining interchangeable lenses and substantial control over photographic parameters. Their smaller form factor and contemporary autofocus and sensor technologies have led to their consideration as alternatives to DSLR systems in orthodontic practice.¹¹ A recent study directly comparing DSLR, mirrorless, and smartphone systems found that DSLR and mirrorless cameras produced consistently high-quality orthodontic photographs, although smartphone photographs were rated less favourably for several assessed parameters.¹² This finding is complemented by other recent comparisons between DSLR cameras and contemporary smartphones. Nandhra et al. reported significantly higher image-quality ratings and dimensional accuracy for DSLR photographs, while finding no significant difference between systems for ease of use or colour-shade representation.¹³ Conversely, Teruya et al. reported favourable ratings for smartphones for selected intraoral photographic characteristics, illustrating that results may vary according to the photographic view, device, photographic protocol, and assessment criteria.¹⁴

Colour reproduction, sharpness, distortion, and dimensional fidelity are particularly relevant when determining whether a photographic system is suitable for orthodontic documentation. A recent comparative investigation of DSLR and smartphone systems found differences among devices in resolution, distortion, magnification, colour accuracy, and overall image quality.¹⁵ Such findings reinforce the importance of evaluating photographic systems using multiple parameters rather than relying on a single measure of image quality. Earlier work has similarly demonstrated that camera selection and photographic settings can influence the reproducibility and quality of orthodontic images.^{5-7,16}

Despite the rapid development of smartphone and mirrorless technologies, the available evidence remains heterogeneous. Earlier studies predominantly focused on DSLR-versus-smartphone comparisons, while fewer investigations have incorporated mirrorless systems into the same comparative framework.¹¹⁻¹⁴ Differences in camera generation, lens configuration, lighting, subject characteristics, photographic technique, and assessor group further limit direct comparison between published studies. In addition, perceived image quality may differ according to the professional experience of the observer. Evaluating photographs among a broader population of dental

professionals may therefore provide clinically relevant information regarding the practical acceptability of contemporary photographic systems.

The present study was designed to compare the perceived quality and clinical acceptability of standardized orthodontic photographs obtained using three contemporary photographic systems: a DSLR camera, a mirrorless camera, and a smartphone. Both extraoral and intraoral photographs were evaluated by dental professionals with different levels of orthodontic experience. The assessment included overall image quality and specific characteristics such as colour accuracy, sharpness, graininess, depth of field, and image distortion. The study also evaluated perceptions regarding the most suitable system for clinical documentation and future orthodontic use. The null hypothesis was that there would be no significant difference among the three camera systems in the perceived quality and clinical acceptability of orthodontic photographs.

2. MATERIALS AND METHODS

2.1 Study design and participants

This cross-sectional, questionnaire-based observational study was conducted to evaluate dental professionals' perceptions of orthodontic photographs obtained using three different camera systems: a digital single-lens reflex (DSLR) camera, a mirrorless interchangeable-lens camera, and a smartphone camera. The photographic images were obtained under standardized conditions and subsequently evaluated by dental professionals through a structured online questionnaire.

A total of **240 dental professionals** completed the questionnaire. The participants comprised general dentists, orthodontic residents, and orthodontists. Participation was voluntary, and electronic informed consent was obtained before commencement of the questionnaire. Demographic information, including age, sex, and professional category, was collected at the beginning of the questionnaire.

2.2 Subject selection

Photographs were obtained from an adult subject who was not undergoing orthodontic treatment. The eligibility criteria specified an individual older than 18 years without gross facial asymmetry and with a Class I skeletal pattern. Subjects with craniofacial anomalies, skeletal Class II or Class III patterns, a history of previous orthodontic treatment, facial trauma, or previous orthognathic surgery were excluded.

The same subject was photographed using all three camera systems to minimize variation attributable to differences in facial and dental morphology.

2.3 Ethical considerations

The study was conducted following approval from the Institutional Ethical Committee of **Sri Rajiv Gandhi College of Dental Sciences and Hospital,**

Bengaluru, India. Written/electronic informed consent was obtained from the photographic subject and survey participants before their participation.

2.4 Photographic equipment

Three photographic systems were evaluated:

- **Group I:** DSLR camera — Canon EOS 3000D with an 18–55 mm lens and Godox Ring 72 flash.
- **Group II:** Mirrorless camera — Canon EOS R50 with an 18–45 mm lens and Godox Ring 72 flash.
- **Group III:** Smartphone — Apple iPhone 16 Pro (2024 model).

The three systems were used to obtain comparable extraoral and intraoral orthodontic photographs⁵. The camera systems and their principal specifications are summarized in Table 1.

Table 1. Photographic systems used in the study

Parameter	Group I – DSLR	Group II – Mirrorless	Group III – Smartphone
Camera	Canon EOS 3000 D	Canon EOS R50	Apple iPhone 16 Pro
Camera type	Digital single-lens reflex	Mirrorless interchangeable-lens	Smartphone
Lens	18–55 mm	18–45 mm	Integrated multi-camera system
Auxiliary flash	Godox Ring 72	Godox Ring 72	Built-in smartphone illumination/system
Year/model generation	EOS 3000 D	EOS R50	iPhone 16 Pro, 2024
Group designation	Group I	Group II	Group III

2.5 Standardization of photographic procedure

All photographs were obtained by a **single operator** under standardized clinical photographic conditions. The same subject, background, photographic

environment, and general positioning protocol were used for all three camera systems. A white background was used, and the camera-to-subject distance for extraoral photography was maintained at approximately 6 feet.^{3,16}

Exposure settings, framing, and angulation were kept consistent according to the established photographic protocol. For intraoral photography, retractors and intraoral mirrors were used uniformly across the three camera systems.

The use of a single operator and the same photographic subject was intended to reduce variability associated with operator technique and subject-related anatomical differences.

2.6 Photographic views

The photographic series comprised both extraoral and intraoral views.

Extraoral photographs included:

1. Frontal view at rest
2. Frontal smiling view
3. Profile view
4. Oblique smiling view

Intraoral photographs included:

1. Frontal intraoral view
2. Right buccal view
3. Left buccal view
4. Maxillary occlusal view
5. Mandibular occlusal view

Each view was obtained using each of the three camera systems under the standardized conditions described above.

Figure 1. Representative extraoral photographs

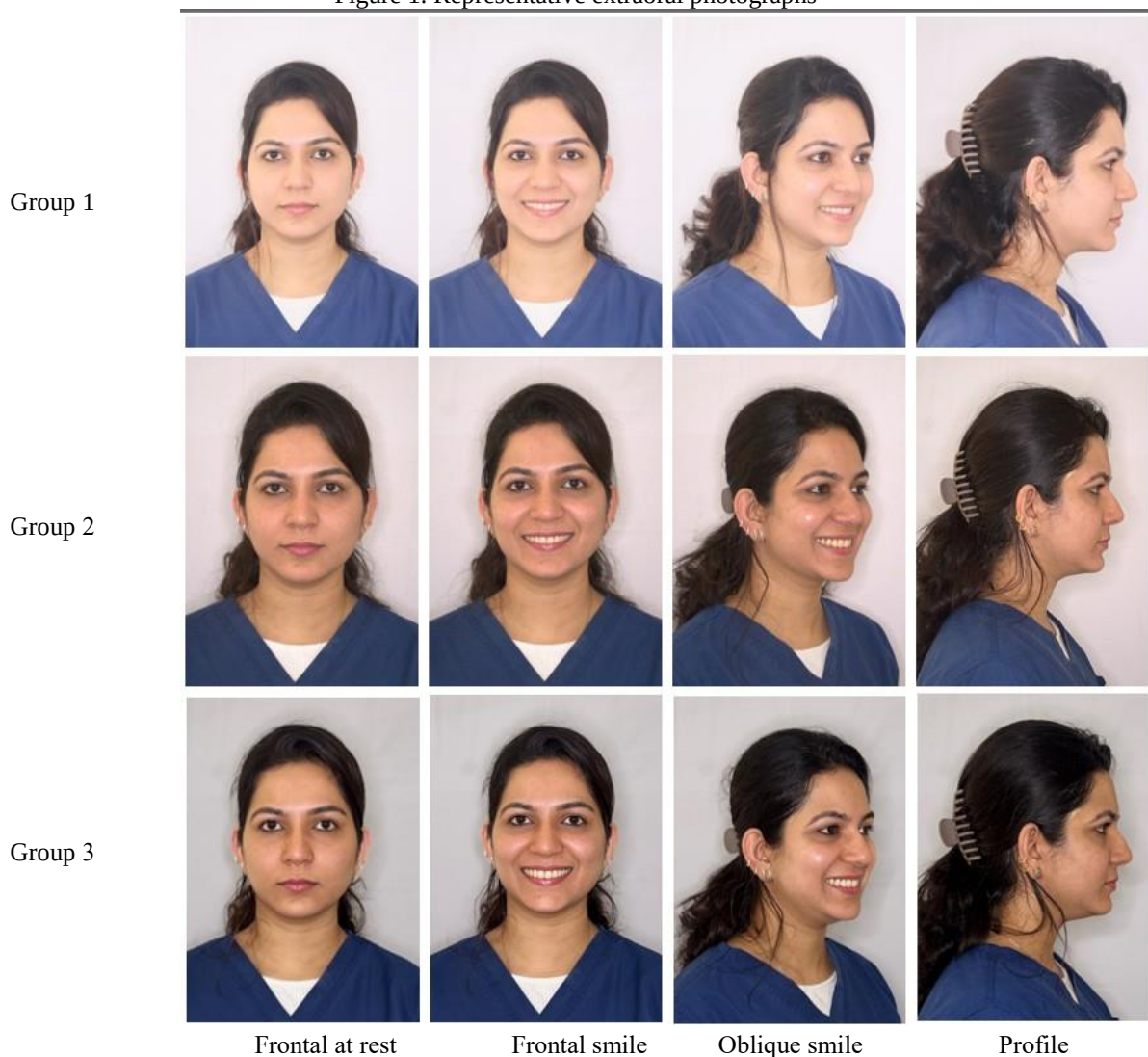


Figure 2. Representative intraoral photographs
Group 1



Group 2



Group 3



2.7 Image preparation and blinding

The photographs obtained from the three camera systems were organized into corresponding image sets. To minimize recognition of the photographic equipment, the camera identity was not disclosed to the survey participants. The image groups were labelled using neutral identifiers rather than camera names.

The anonymized image sets were subsequently incorporated into the online questionnaire.

2.8 Questionnaire development

A structured questionnaire was developed using **Google Forms**. The questionnaire was divided into sections addressing specific characteristics of extraoral and intraoral photographs.

For the extraoral photographs, participants were asked to identify the camera group they considered to provide:

- the best overall image quality;
- the most accurate colour representation;
- the greatest sharpness;
- the most appropriate depth of field; and
- the least graininess.

The same photographic characteristics were evaluated for the intraoral images.

A separate comparative-perception section assessed:

- image consistency;

- natural colour representation; and
- visible image distortion.

Participants were subsequently asked to identify which camera they believed produced the highest-quality images, which system they considered most suitable for clinical documentation, and which camera they would prefer for future clinical use.

2.9 Content review of the questionnaire

The questionnaire was reviewed by **four orthodontic faculty members** for relevance, clarity, comprehensiveness, and applicability to orthodontic clinical photography.

2.10 Survey participants and data collection

The questionnaire was distributed electronically among dental professionals, including general dentists, orthodontic residents, and orthodontists. Participation was voluntary, and electronic informed consent was obtained before questionnaire completion. Participants evaluated the photographic images and completed the questionnaire; one item had a missing response.

A total of 240 participants completed the questionnaire. One participant did not respond to the personal-preference question; therefore, 239 responses were available for that item.

2.11 Outcome variables

The primary outcomes were participants' perceptions of the photographic characteristics of the three camera systems.

For extraoral and intraoral images, the evaluated characteristics included:

- overall image quality;
- colour accuracy;
- sharpness;
- depth of field; and
- graininess.

Additional comparative outcomes included:

- image consistency;
- natural colour reproduction;
- image distortion;
- perceived highest-quality camera;
- suitability for clinical documentation; and
- preference for future clinical use.

The overall image-quality assessment was additionally summarized using an ordinal score, with higher values representing more favourable perceived image quality.^{5,8}

2.12 Statistical analysis

The collected data were entered into a statistical analysis program and analyzed with assistance from a statistician. Categorical variables were summarized using frequencies and percentages. Pearson's chi-square goodness-of-fit test was used to compare the distribution of camera selections among Groups I–III. Responses indicating no noticeable difference, inability to judge, or no preference were retained descriptively but were not assigned to a camera group and were excluded from the three-group inferential comparison.

Overall image-quality scores were treated as ordinal data and compared among the three camera systems using the Kruskal–Wallis test. The median score for each camera group was reported. A two-sided P value <0.05 was considered statistically significant. The analysis was performed separately for extraoral and intraoral photographic characteristics, followed by an overall comparative assessment of the three camera systems.

3. RESULTS

3.1 Sociodemographic characteristics

A total of 240 dental professionals completed the questionnaire. The majority of participants were aged 26–35 years (128, 53.33%), followed by those aged 18–25 years (65, 27.08%), 36–45 years (39, 16.25%), and ≥ 46 years (8, 3.33%). There were 123 male participants (51.25%), 103 female participants (42.92%), and 14 participants (5.83%) who preferred not to disclose their gender. Regarding professional role, 106 (44.17%) were general dentists, 84 (35.00%) were orthodontic residents, and 50 (20.83%) were orthodontists.

3.2 Extraoral photographic assessment

For extraoral photographs, Group I was most frequently selected for overall image quality (91, 37.92%), whereas Group II was most frequently selected for colour accuracy (92, 38.33%). Group III received the highest frequency of selections for sharpness (87, 36.25%) and depth of field (80, 33.33%). Group I was most frequently perceived as showing a grainy or noisy appearance (80, 33.33%). The three-camera comparisons demonstrated no statistically significant differences for overall image quality ($p = 0.2045$), colour accuracy ($p = 0.1137$), sharpness ($p = 0.4095$), or depth of field ($p = 0.9142$). A statistically significant difference was observed for grainy/noisy appearance ($p = 0.0067$).

3.3 Intraoral photographic assessment

For intraoral photographs, Group III was most frequently selected for overall image quality (85, 35.42%), colour accuracy (87, 36.25%), sharpness (95, 39.58%), and depth of field (83, 34.58%). Group I was most frequently perceived as showing a grainy or noisy appearance (77, 32.08%). The three-camera comparison demonstrated statistically significant differences for colour accuracy ($p = 0.0489$), sharpness ($p = 0.0281$), and grainy/noisy appearance ($p = 0.0407$). The difference in depth of field was not statistically significant ($p = 0.1221$), and the difference in overall image quality was not statistically significant ($p = 0.4127$).

3.4 Comparative perception

Group III was selected most frequently as the most consistent photographic group (83, 34.58%), as representing colours most naturally (89, 37.08%), and as showing the least image distortion (94, 39.17%). The three-camera comparison was not statistically significant for consistency ($p = 0.7640$) or natural colour representation ($p = 0.1020$),

whereas a statistically significant difference was observed for least image distortion ($p = 0.0230$).

3.5 Overall assessment

Group III was most frequently identified as the group most likely to have been captured with the highest-quality camera (89, 37.08%), most suitable for clinical documentation (99, 41.25%), and personally preferred for future clinical photography (94, 39.33%). The corresponding three-camera comparisons were statistically significant for perceived highest-quality camera ($p = 0.0120$), clinical suitability ($p = 0.0061$), and personal preference ($p = 0.0041$). One participant did not respond to the personal-preference question; therefore, 239 responses were available for that item.

3.6 Overall quality score

The reported overall quality scores differed significantly among the three photographic groups according to the Kruskal–Wallis test ($p = 0.002$). Group III had the highest mean score (7.60 ± 2.87 ; median 7), followed by Group II (5.27 ± 2.24 ; median 5) and Group I (4.79 ± 2.33 ; median 4).

Tables

Table 1. Sociodemographic characteristics of study participants.

Characteristic	Category	n (%)
Age	18–25 years	65 (27.08)
	26–35 years	128 (53.33)
	36–45 years	39 (16.25)
	≥ 46 years	8 (3.33)
Gender	Male	123 (51.25)
	Female	103 (42.92)
	Prefer not to say	14 (5.83)
Professional role	General Dentist	106 (44.17)
	Orthodontic Resident	84 (35.00)
	Orthodontist	50 (20.83)

Table 2. Participants assessment of extraoral photographic characteristics.

Parameter	Group I n (%)	Group II n (%)	Group III n (%)	No noticeable difference n (%)	p
Overall image quality	91 (37.92)	70 (29.17)	74 (30.83)	5 (2.08)	0.2045
Colour accuracy	66 (27.50)	92 (38.33)	77 (32.08)	5 (2.08)	0.1137
Sharpness	71 (29.58)	75 (31.25)	87 (36.25)	7 (2.92)	0.4095

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Depth of field	75 (31.25)	79 (32.92)	80 (33.33)	6 (2.50)	0.9142
Grainy/noisy appearance	80 (33.33)	60 (25.00)	45 (18.75)	55 (22.92)	0.0067

Table 3. Participants' assessment of intraoral photographic characteristics.

Parameter	Group I n (%)	Group II n (%)	Group III n (%)	No noticeable difference n (%)	p
Overall image quality	81 (33.75)	69 (28.75)	85 (35.42)	5 (2.08)	0.4127
Colour accuracy	60 (25.00)	86 (35.83)	87 (36.25)	7 (2.92)	0.0489
Sharpness	62 (25.83)	75 (31.25)	95 (39.58)	8 (3.33)	0.0281
Depth of field	60 (25.00)	80 (33.33)	83 (34.58)	17 (7.08)	0.1221
Grainy/noisy appearance	77 (32.08)	57 (23.75)	50 (20.83)	56 (23.33)	0.0407

Table 4. Comparative assessment of the three photographic groups.

Parameter	Group I n (%)	Group II n (%)	Group III n (%)	No noticeable difference n (%)	p
Consistency across images	77 (32.08)	74 (30.83)	83 (34.58)	6 (2.50)	0.7640
Most natural colours	63 (26.25)	81 (33.75)	89 (37.08)	7 (2.92)	0.1020
Least image distortion	62 (25.83)	69 (28.75)	94 (39.17)	15 (6.25)	0.0230

Table 5. Overall assessment and clinical preference.

Parameter	Group I n (%)	Group II n (%)	Group III n (%)	Other response n (%)	p
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Highest-quality camera	87 (36.25)	56 (23.33)	89 (37.08)	Cannot say: 8 (3.33)	0.0120
Most suitable for clinical documentation	67 (27.92)	63 (26.25)	99 (41.25)	No preference: 11 (4.58)	0.0061
Personally preferred for future photography	87 (36.40)	55 (23.01)	94 (39.33)	No preference: 3 (1.26); missing: 1	0.0041

Table 6. Overall quality score among the three photographic groups.

Parameter	Group I	Group II	Group III	P-value
Overall	4.79 ± 2.33; median, 4	5.27 ± 2.24; median, 5	7.60 ± 2.87; median, 7	0.002

Figure 1. Participants' assessment of extraoral photographic characteristics across Groups I–III.

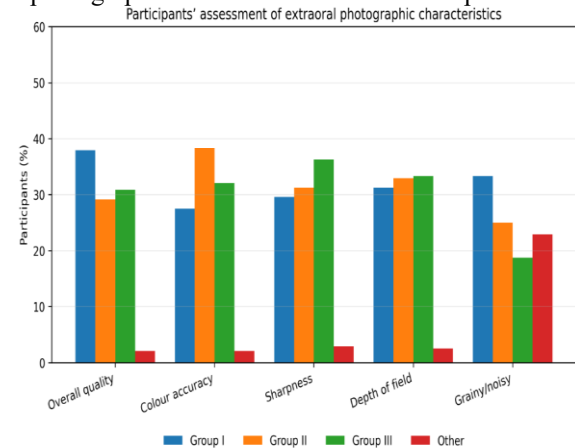


Figure 2. Participants' assessment of intraoral photographic characteristics across Groups I–III.

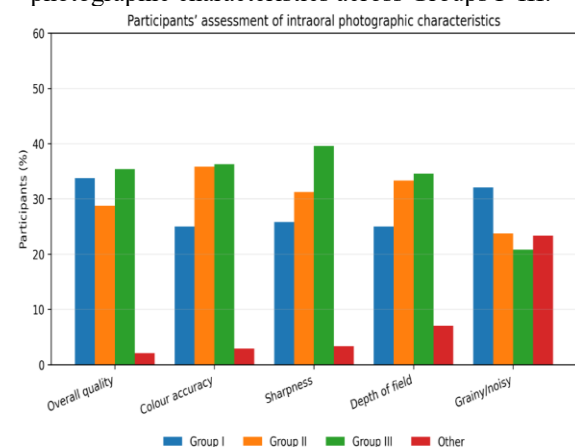


Figure 3. Comparative perception of consistency, natural colour representation, and image distortion across Groups I–III.

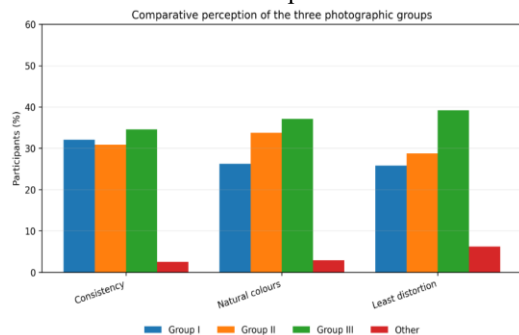


Figure 4. Overall assessment of perceived camera quality, suitability for clinical documentation, and future clinical preference across Groups I–III.

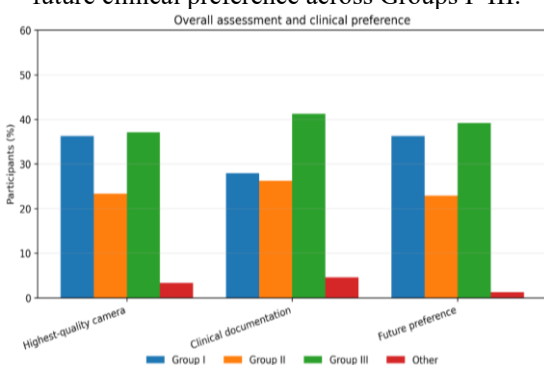
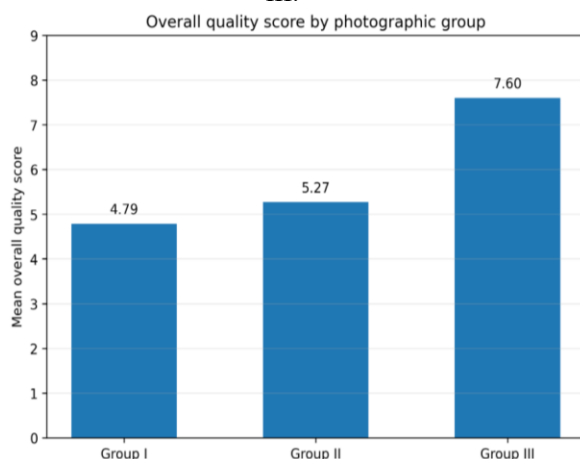


Figure 5. Mean overall quality score for Groups I–III.



4. DISCUSSION

Clinical photography is an established component of orthodontic diagnosis, treatment documentation, communication, and assessment of treatment progress.^{1,2} The conventional approach has relied predominantly on DSLR cameras because they provide control over exposure, aperture, depth of field, focal length, illumination, and image acquisition.^{5–7} However, advances in mirrorless technology and smartphone-based computational photography have expanded the range of equipment

that can potentially be used for clinical documentation.^{8,11–15} The present study compared a DSLR camera, a mirrorless camera, and a contemporary smartphone using a standardized photographic protocol and assessment by 240 dental professionals.

4.1 Principal findings

The principal finding of the present study was that **no single photographic system demonstrated statistically significant superiority across all evaluated characteristics**. Group I was most frequently selected for overall extraoral image quality, whereas Group II was most frequently selected for extraoral colour accuracy. Group III was most frequently selected for several intraoral characteristics, including overall image quality, colour accuracy, sharpness, and depth of field. Statistically significant differences were observed for selected parameters, particularly grainy/noisy appearance, intraoral colour accuracy, intraoral sharpness, least image distortion, perceived highest-quality camera, suitability for clinical documentation, and future preference.

These findings suggest that camera performance in orthodontic photography should not be considered as a simple hierarchy in which one category of camera is universally superior. Instead, perceived photographic quality appears to vary according to the type of photograph and the characteristic being assessed. This observation is consistent with the evolving literature, in which DSLR, mirrorless, and smartphone systems have demonstrated different strengths depending on the photographic task and assessment method.^{12–15}

4.2 Extraoral photographic characteristics

For extraoral photographs, Group I was most frequently selected for overall image quality, while Group II was most frequently selected for colour accuracy. Group III received the highest number of selections for sharpness and depth of field. However, none of these four comparisons reached statistical significance.

The lack of a statistically significant difference in overall extraoral image quality indicates that the perceived advantage of the DSLR system was not sufficiently consistent across participants to establish a difference among the three systems. This is clinically relevant because DSLR systems have historically been regarded as the reference standard for orthodontic clinical photography.^{1,5,6} Standardization of patient position, camera-to-subject distance, background, illumination, and photographic views is fundamental to obtaining reproducible clinical records.^{3,4,16}

The present findings suggest that, when a standardized protocol is followed, the differences in perceived extraoral image quality between contemporary camera systems may be less pronounced than might be expected from their technical specifications alone. The use of controlled

illumination and a standardized background in the present study may also have reduced some of the differences that could occur under routine, uncontrolled clinical conditions.

This interpretation should nevertheless be distinguished from objective optical performance. A lack of statistical difference in perceived quality does not imply that the three systems have equivalent sensor characteristics, lens performance, or geometric accuracy. Rather, it indicates that these technical differences did not translate into a statistically significant difference in the participants' assessment of the evaluated extraoral characteristics.

4.3 Intraoral photographic characteristics

The pattern was different for intraoral photography. Group III was most frequently selected for overall image quality, colour accuracy, sharpness, and depth of field. Statistically significant differences were observed for colour accuracy and sharpness, whereas the difference in overall image quality and depth of field was not statistically significant.

This finding is of particular interest because intraoral photography presents different technical demands from extraoral photography. Dental arches are relatively close to the camera, reflective surfaces are present, and adequate illumination and depth of field are essential. Bister et al. emphasized the importance of appropriate camera settings, illumination, and depth of field for high-quality intraoral photography.⁵ Ahmad similarly highlighted the importance of exposure, depth of field, colour balance, and appropriate camera settings in dental photography.^{6,7}

The greater frequency of selections for Group III in several intraoral parameters may partly reflect the computational image processing used by contemporary smartphones. Automatic exposure, white-balance adjustment, sharpening, local contrast enhancement, noise reduction, and high-dynamic-range processing can influence the visual appearance of a photograph. These processes may increase the perceived clarity and visual balance of an image even though they do not necessarily indicate superior underlying optical performance.

The present findings are supported by some recent comparative evidence but differ from other studies. Teruya et al. reported that smartphone photographs were perceived as superior to DSLR photographs for several intraoral characteristics, including overall quality, colour, sharpness, and depth of field.¹⁴ This is broadly consistent with the present observation that Group III received the highest frequency of selections for these parameters.

Conversely, Shahrul et al. reported that DSLR and mirrorless systems produced 100% photographs rated as good, whereas photographs obtained using an iPhone 14 Pro were rated good in 41.7% and acceptable in 58.3% of cases.¹² Nandhra et al. also reported significantly higher image-quality ratings and better dimensional accuracy for DSLR

photographs compared with smartphones, although colour-shade representation did not differ significantly.¹³

The apparent discrepancy between these studies is important rather than problematic. The studies used different smartphone generations, camera systems, photographic protocols, assessor groups, outcome definitions, and statistical approaches. The present study used an iPhone 16 Pro, whereas Shahrul et al. evaluated an iPhone 14 Pro and Nandhra et al. compared several smartphones with DSLR systems.^{12,13} Therefore, the findings should be interpreted in the context of the specific device and protocol studied rather than generalized to smartphones as a homogeneous category.

4.4 Colour representation

Colour accuracy is an important consideration in dental photography because colour differences may be relevant to assessment of teeth, gingiva, mucosal tissues, restorative materials, and treatment-related changes.^{6,7} In the present study, Group II was most frequently selected for extraoral colour accuracy, whereas Group III was most frequently selected for intraoral colour accuracy. The extraoral difference was not statistically significant, whereas the intraoral difference was statistically significant.

The different pattern between extraoral and intraoral photography suggests that colour perception may be influenced by the photographic environment as well as the camera system. Extraoral photographs were acquired against a standardized white background, whereas intraoral photographs involved mirrors, retractors, teeth, gingival tissues, and flash illumination. Reflective surfaces and differences in illumination can influence both camera processing and human perception of colour.

The findings should, however, be described as differences in perceived colour representation, rather than objective evidence of colorimetric accuracy. A camera can produce a visually pleasing photograph while still altering the physical colour values of the subject. This distinction is particularly important when photography is used for shade matching or quantitative colour analysis.

Lazar et al. demonstrated that photographic systems differed in their aesthetic assessments, with a DSLR and twin-flash system achieving the highest overall scores, followed by a smartphone-based system and DSLR with ring flash.⁹ Moussa et al., in contrast, demonstrated that smartphone and DSLR photographs could provide comparable linear measurements under appropriate conditions, indicating that smartphone photography can be sufficiently accurate for selected documentation purposes.¹⁰ These findings reinforce the importance of distinguishing subjective image quality from objective measurement accuracy.

4.5 Sharpness and depth of field

Sharpness was one of the parameters for which Group III received the highest frequency of

selections in both photographic categories, and the difference in intraoral sharpness was statistically significant. However, depth of field did not show a statistically significant difference for either the extraoral or intraoral comparison.

Sharpness and depth of field should not be considered interchangeable properties. Depth of field is primarily an optical characteristic influenced by factors such as aperture, focal length, sensor size, magnification, and subject distance.^{5,7} Perceived sharpness, on the other hand, may be substantially influenced by digital image processing.

This distinction provides a possible explanation for the present findings. Computational sharpening can increase apparent edge definition and therefore make an image appear sharper to an observer without producing a corresponding increase in true optical resolution or depth of field. Thus, the higher frequency of selections for Group III in sharpness should not be interpreted as evidence that the smartphone possesses superior optical depth of field. Bister et al. demonstrated that camera settings substantially influence intraoral photographic quality and that inappropriate automatic settings may result in poor depth of field or exposure.⁵ The present findings similarly emphasize that the photographic system cannot be evaluated independently of the method used to operate it.

4.6 Image noise and graininess

Group I was most frequently perceived as producing a grainy or noisy appearance in both extraoral and intraoral photographs. The differences were statistically significant for both photographic categories.

Image noise is influenced by sensor characteristics, illumination, exposure, ISO sensitivity, and subsequent image processing. Dedicated cameras may provide advantages in signal-to-noise performance because of their larger sensors and greater control over exposure parameters. However, the present study did not objectively measure sensor noise or signal-to-noise ratio. Therefore, the appropriate interpretation is that participants **more frequently perceived Group I as grainy or noisy**, rather than that Group I objectively generated greater sensor noise.

The relatively large proportion of participants selecting “no noticeable difference” for this parameter is also important. It indicates that the perceived difference was not universal and that a substantial proportion of observers could not distinguish the systems on the basis of graininess/noise alone.

4.7 Consistency, natural colour, and image distortion

Group III was most frequently selected for consistency across images, natural colour representation, and least image distortion. Only the difference in perceived image distortion was statistically significant.

Standardization is particularly important when orthodontic photographs are used longitudinally.^{3,4,16} Even relatively small changes in camera position, focal length, subject distance, head orientation, or mirror positioning can alter the apparent dimensions and relationships of anatomical structures. Claman et al. emphasized that photographic distortion can make pretreatment and posttreatment comparisons misleading if photographs are not standardized.³

The significant difference observed for least image distortion therefore warrants attention. However, the questionnaire assessed **perceived distortion** rather than geometric distortion measured using calibrated landmarks. The result should consequently be interpreted as a difference in observer perception rather than objective proof that Group III generated the least lens or perspective distortion.

This distinction is particularly relevant because smartphone cameras frequently use multiple focal lengths and computational image processing. The physical distance between the camera and the subject may also influence perspective distortion. Moussa et al. demonstrated that DSLR and smartphone photographs can provide comparable linear measurements when an appropriate distance is maintained, while shorter smartphone working distances can increase measurement differences in some posterior regions.¹⁰

4.8 DSLR, mirrorless, and smartphone comparison

An important strength of the present study is the simultaneous comparison of all three major camera categories currently available to clinicians: DSLR, mirrorless, and smartphone.

The mirrorless system showed competitive performance across several parameters and was most frequently selected for extraoral colour accuracy and intraoral depth of field. Although Group II did not consistently receive the highest frequency of selections, its performance was generally comparable to that of the other dedicated camera system.

This observation is consistent with Shahrul's discussion of mirrorless technology in orthodontic practice, which identified mirrorless cameras as a practical alternative to conventional DSLR systems because of their technological development and potential ergonomic advantages.¹¹ More recent comparative data from Shahrul et al. demonstrated identical ratings between a DSLR and mirrorless camera, with 100% of photographs from both systems rated as good.¹²

The present findings therefore support the view that the DSLR-versus-mirrorless distinction may increasingly be driven by factors such as handling, size, lens selection, workflow, and clinician preference rather than by a major difference in perceived clinical image quality.

4.9 Overall clinical suitability and preference

Group III was most frequently selected as the system perceived to represent the highest-quality camera, the most suitable camera for clinical documentation, and the camera participants would prefer for future clinical photography. These three comparisons were statistically significant.

The finding has practical implications because camera selection in clinical practice is influenced by more than image quality. Accessibility, portability, speed, ease of acquisition, sharing of images, storage, and integration with digital workflows can all influence whether a photographic system is used consistently.

Smartphones have a major advantage in these respects. Smartphone photography can be incorporated into routine clinical workflow without requiring a separate camera body, lens, flash, and associated equipment. Shahrul et al. have described techniques for obtaining orthodontic clinical photographs using smartphones, illustrating the increasing feasibility of smartphone-based documentation.⁸

However, the preference for Group III should not be interpreted as evidence that smartphones have replaced dedicated camera systems. Nandhra et al. found that DSLR cameras remained superior for overall image-quality ratings and dimensional accuracy, and Shahrul et al. reported consistently good ratings for both DSLR and mirrorless systems compared with lower ratings for an iPhone 14 Pro.^{12,13} The present study therefore contributes to a growing body of evidence suggesting that **smartphone suitability is application-dependent rather than universally superior or inferior.**

4.10 Relationship to recent evidence

The recent literature demonstrates considerable variation in the relative performance of smartphones and dedicated cameras. This variation is important when interpreting the present findings.

Teruya et al. reported superior perceived intraoral image quality with smartphones but found that DSLR systems remained superior for facial photographs.¹⁴ This pattern resembles the present distinction between extraoral and intraoral photography, in which the smartphone performed particularly strongly for intraoral characteristics while the DSLR remained competitive for extraoral overall quality.

Nandhra et al. reached a different overall conclusion, finding that DSLR systems were significantly superior to smartphones for image-quality ratings and dimensional accuracy, although colour-shade representation did not differ significantly.¹³ Shahrul et al. similarly found DSLR and mirrorless systems to be consistently rated as good, while smartphone photographs were more often rated acceptable.¹²

The recently published pilot study by Momin et al. further demonstrates the complexity of this comparison. Using a full-frame DSLR and three flagship smartphones, the authors found that

smartphone performance varied by outcome: the iPhone 15 Pro demonstrated favourable performance for distortion and clarity, while the DSLR retained advantages in magnification, resolution, and colour accuracy.¹⁵

Collectively, these studies suggest that the question is no longer simply whether a smartphone is “better” than a DSLR. Instead, camera performance depends on the specific device, photographic view, illumination, working distance, image-processing pipeline, and outcome used to define quality. The present study is consistent with this interpretation.

4.11 Clinical implications

The findings suggest that a contemporary smartphone can be considered a clinically viable option for routine orthodontic photography, particularly when convenience and accessibility are important. This may be especially relevant in postgraduate training environments, general dental practices, and clinical settings where a dedicated photographic system is not readily available.

Nevertheless, dedicated DSLR and mirrorless systems remain valuable where precise control of exposure, magnification, focal length, depth of field, illumination, and reproducibility is required. For research photography and longitudinal records, standardized technique remains more important than the camera category alone.^{3,4,16}

Thus, the present study supports a **purpose-based approach to camera selection.** A smartphone may be sufficient for routine documentation, communication, and rapid clinical recording, whereas a DSLR or mirrorless system may remain preferable for highly standardized clinical photography, research documentation, and situations requiring greater optical control.

4.12 Strengths of the study

Several methodological features strengthen the present investigation.

1. The same subject was photographed using all three systems, thereby minimizing intersubject variability.
2. The photographic protocol was standardized with respect to the background, operator, camera-subject distance for extraoral photography, photographic views, retractors, and intraoral mirrors.
3. The identity of the camera systems was concealed from participants during assessment, reducing the possibility of equipment-related expectations influencing responses.
4. The study included 240 dental professionals from three professional categories, providing a relatively large observer sample.
5. The study evaluated both extraoral and intraoral photography and included specific

photographic characteristics as well as broader clinical preference.

4.13 Limitations

The study has several limitations. First, photographs were obtained from a single adult subject. This facilitated strict standardization but limits generalizability to patients with different facial morphology, skin characteristics, dental anatomy, malocclusion patterns, and soft-tissue features.

Second, the principal outcome was professional perception of photographic quality rather than objective instrumental measurement. Parameters such as colour difference, geometric distortion, spatial resolution, and signal-to-noise ratio were not directly quantified. The results therefore describe perceived photographic performance and should not be interpreted as a laboratory assessment of camera specifications.

Third, smartphone photographs inherently involve manufacturer-specific computational processing. Automatic exposure, white balance, sharpening, noise reduction, and other computational processes may influence perceived image quality. These processes cannot be completely separated from the smartphone camera system in a real-world clinical comparison.

Fourth, the study used a single operator and a standardized photographic environment. Although this improved internal consistency, the findings may not completely represent routine clinical practice in which operators differ in experience and photographic technique.

Fifth, multiple questionnaire outcomes were analyzed. The nominal p-values should therefore be interpreted in the context of multiple comparisons. The statistically significant findings identify differences in the distribution of responses for particular parameters but should not be interpreted as independent evidence that one camera system is globally superior.

Finally, the overall quality score was analyzed using the Kruskal–Wallis test. The score should be interpreted according to the scoring methodology defined in the statistical analysis plan, and pairwise interpretation should only be made if appropriate post-hoc testing has been performed.

4.14 Future research

Future research should evaluate multiple subjects representing a wider range of facial and dental characteristics and should include multiple operators with different levels of photographic experience. Objective assessment using calibrated colour targets, geometric reference markers, resolution targets, and standardized illumination would provide complementary information to subjective observer assessment.

Longitudinal studies are also required to determine whether smartphone images provide sufficient reproducibility for serial orthodontic records. Additional investigations should compare the

newest generations of smartphones and mirrorless cameras with established DSLR systems while controlling for lens focal length, working distance, flash configuration, exposure, and image-processing settings.

Cost-effectiveness and workflow efficiency should also be considered. A camera that produces marginally better technical images but is rarely used because of its complexity may have less practical value than a highly accessible system that allows standardized photographs to be obtained consistently.

4.15 Interpretation of the present findings

The present findings should therefore be interpreted as evidence that **contemporary camera systems can produce clinically acceptable orthodontic photographs with different perceived strengths**, rather than evidence that one technology has completely replaced another.

The iPhone 16 Pro (Group III) demonstrated particularly strong perceived performance for several intraoral characteristics and received the highest overall preference in the present sample. However, the DSLR and mirrorless systems remained competitive, particularly for extraoral photography and selected technical characteristics. The findings are therefore best understood as supporting the increasing clinical utility of smartphone photography while retaining an important role for dedicated camera systems.

6. CONCLUSION

Within the limitations of this study, DSLR, mirrorless, and smartphone systems were all capable of producing clinically acceptable orthodontic photographs. No single camera system demonstrated uniform superiority across all evaluated photographic characteristics.

The **iPhone 16 Pro (Group III)** was most frequently preferred for several intraoral characteristics, including colour representation and sharpness, and was also most frequently selected for clinical documentation and future clinical photography. The **DSLR system (Group I)** remained competitive, particularly for extraoral overall image quality and perceived image-noise characteristics, while the **mirrorless system (Group II)** demonstrated comparable performance across several parameters. These findings indicate that contemporary smartphone photography can serve as a practical alternative for routine orthodontic clinical documentation when a standardized photographic technique is followed. Nevertheless, DSLR and mirrorless systems remain valuable when greater control over photographic parameters, reproducibility, and standardized image acquisition is required. Camera selection should therefore be based on the intended clinical application, required photographic quality, and workflow rather than camera category alone.

DECLARATIONS

Ethical Approval: The study was conducted following approval from the Institutional Ethical Committee of Sri Rajiv Gandhi College of Dental Sciences and Hospital, Bengaluru, India. Ethical approval number (SRGCDS/2025/103), Written/electronic informed consent was obtained from the photographic subject and survey participants before participation.

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