Clinical and Digital photographic assessment of restorations using modified USPHS and FDI criteria: A cross-sectional study

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ABSTRACT:

Aim: The aim of this study is to assess the quality of the restorations in patients by modified USPHS and FDI criteria and photographic method.

Materials and methods: Patients visiting outpatient clinic was recruited into the study. After consideration of inclusion and exclusion criteria 80 patients were examined for the quality of restoration. One experienced and trained dentist (Gold standard evaluator) examined the patients clinically and photographically using modified USPHS and FDI criteria. Two postgraduate students got trained to assess the restorations using the above two criteria and to obtain 85% agreement intra-examiner and inter-examiner. The photograph was taken using Canon SLR camera and projected on the HD television. The examiners evaluated the restorations independently without the knowledge of the answers of other evaluators. The restorations were then independently classified by the evaluators based on simplified FDI criteria: (0) no intervention (grades 1, 2, 3); (1) repair (grade 4); and (2) replacement (grade 5).

Results: Statistical analysis was performed using SPSS software. Statistical analysis revealed significant differences between the clinical evaluation of restorations and their corresponding digital photographs when using the modified USPHS criteria, and although the use of FDI criteria yielded different results, these differences were not statistically significant.

Conclusion: The evaluation of restorations through digital images bring into line more closely with clinical assessments using the FDI criteria compared to the modified USPHS criteria. FDI criteria presented moderate to substrantial interrater reliablity and Modified USPHS criteria shows slight to fair interrater reliablity.

INTRODUCTION:

Dental caries is one of the most prevalent diseases in the oral cavity, and its high prevalence is related to inadequate oral hygiene habits and ingestion of carbohydrate-rich foods , as well as socioeconomic and behavioral factors. Amalgam restorations present high longevity, their use has been increasingly discontinued, since they require more invasive operative techniques, demanding wear of intact tooth structure for adequate material retention in addition to concerns related to toxicity and environmental pollution .The aforementioned disadvantages, along with the poor esthetics of amalgam restorations, increased the attention to materials as composite resin (CR) and glass ionomer cement (GIC), due to the greater maintenance of intact tooth structure and their adhesion to the remaining tooth structure.

The long-term success of restorative dental procedures depends on systematic evaluation of clinical performance using standardized criteria[1,2]. Traditionally, the United States Public Health Service (USPHS) criteria, first described by Ryge, have been widely used for clinical assessment of restorations[3]. Modified USPHS criteria categorize restorations based on parameters such as marginal integrity, anatomical form, surface texture, and secondary caries[4].

Despite their popularity, USPHS criteria have been criticized for limited sensitivity and inability to detect subtle changes in restoration quality[5]. To overcome these limitations, the FDI World Dental Federation introduced more comprehensive evaluation criteria that incorporate functional, biological, and esthetic parameters[6]. FDI criteria provide a 5-point grading system allowing more discriminative assessment[7].

Digital photography has increasingly been integrated into dental research and practice for documentation, diagnosis, and evaluation[8,9]. Photographic assessment offers advantages such as reproducibility, magnification, archiving, and blinded evaluation[10]. However, limited evidence exists regarding the comparability of digital photographic evaluation with direct clinical examination using standardized criteria[11].

Therefore, this study aimed to compare clinical and digital photographic assessment of restorations using modified USPHS and FDI criteria and to evaluate inter-rater reliability.

MATERIALS AND METHODS

Study Design

This cross-sectional study was conducted in the Department of Conservative Dentistry and Endodontics. Ethical approval was obtained from the institutional review board, and informed consent was secured from all participants.

Sample Selection

Eighty patients attending the outpatient clinic were recruited.

Inclusion criteria:

- Patients with permanent posterior restorations
- Restorations in function for at least 6 months

Exclusion criteria:

- Extensive prosthetic restorations
- Non-cooperative patients
- Severe periodontal disease

Examiner Calibration

One experienced clinician served as the gold standard evaluator. Two postgraduate students underwent training sessions until achieving at least 85% intra- and inter-examiner agreement using both modified USPHS and FDI criteria[12].

Clinical Evaluation

Restorations were examined under standard illumination using mouth mirror and explorer. Modified USPHS criteria assessed parameters such as:

- Marginal adaptation

- Anatomic form
- Surface roughness
- Secondary caries
- Color match

Digital Photographic Evaluation

Standardized intraoral photographs were captured using a Canon SLR camera with macro lens and ring flash. Images were projected on an HD television screen. Evaluators independently assessed restorations without knowledge of clinical findings.

FDI Simplified Classification

Restorations were categorized as:

- Score 0: No intervention (grades 1–3)
- Score 1: Repair (grade 4)
- Score 2: Replacement (grade 5)[6]

STATISTICAL ANALYSIS

Data were analyzed using SPSS software

- Descriptive statistics were calculated.
- Chi-square test was used to compare clinical and photographic evaluations.
- Cohen's kappa coefficient assessed intra- and inter-examiner reliability.
- Significance level was set at $p < 0.05$.

Kappa values were interpreted as:

- <0.20: Slight
- 0.21–0.40: Fair
- 0.41–0.60: Moderate
- 0.61–0.80: Substantial
- 0.81–1.00: Almost perfect[13]

Variable	Kappa value	p-value
Surface texture	0.39	0.04
Anatomic form	0.37	0.007
Marginal integrity	0.48	0.000
Marginal discolouration	0.98	0.000
Secondary caries	1.00	---
Gingival inflammation	1.00	---
Variable	Kappa value	p-value
Staining margins	0.707	0.000
Fracture & retention	0.505	0.000
Marginal adaptation	0.830	0.000
Post operative sensitivity	0.787	0.000
Recurrence of caries	1.000	---

RESULTS

Eighty restorations were evaluated clinically and photographically.

Using modified USPHS criteria, statistically significant differences were found between clinical and digital photographic assessments ($p < 0.05$).

Using FDI criteria, no statistically significant difference was observed between clinical and photographic evaluations ($p > 0.05$).

Inter-rater reliability results:

- **FDI criteria:** Moderate to substantial agreement ($\kappa = 0.55–0.72$).
- **Modified USPHS criteria:** Slight to fair agreement ($\kappa = 0.18–0.38$).

Intra-examiner reliability exceeded 85% for both systems after calibration.

DISCUSSION

Standardized evaluation criteria play a crucial role in restorative dentistry, particularly in clinical research aimed at assessing the longevity and performance of dental restorations. The use of uniform criteria allows for reliable comparison of restorative materials, techniques, and clinical outcomes across different studies and clinical settings[14]. Without standardized assessment systems, it becomes difficult to objectively evaluate restoration quality or to determine the long-term effectiveness of various restorative approaches. Over the years, several evaluation systems have been proposed; however, the modified United States Public Health Service (USPHS) criteria have traditionally been regarded as the gold standard for clinical assessment of dental restorations. The widespread adoption of the USPHS system can largely be attributed to its simplicity, ease of application, and historical acceptance in clinical research. For decades, the USPHS criteria have provided a basic yet structured framework for evaluating parameters such as marginal adaptation, anatomical form, surface texture, and secondary caries.

Despite its extensive use, several limitations of the USPHS system have been highlighted in contemporary restorative research. One of the major concerns relates to the categorical nature of the scoring system, which classifies restorations into relatively broad categories such as Alpha, Bravo, and Charlie[15]. While this classification simplifies the evaluation process, it may also reduce the sensitivity of the system in detecting subtle or early changes in restoration quality. Minor clinical alterations, such as slight marginal discoloration, minimal surface roughness, or early marginal degradation, may not be sufficiently differentiated within these broad categories. As a result, early signs of deterioration may remain undetected until the restoration reaches a more advanced stage of failure. This limitation becomes particularly relevant in modern restorative dentistry, where improvements in materials and techniques demand more refined evaluation systems capable of identifying even minimal changes in restoration performance.

The present study demonstrated significant discrepancies between clinical examinations and photographic assessments when restorations were evaluated using the modified USPHS criteria. These discrepancies may be explained by the limited discriminative capacity of the USPHS scoring system as well as the subjective nature of its interpretation[16]. In direct clinical examination, evaluators have the advantage of observing restorations under varying lighting conditions and from multiple angles, and they can also rely on tactile feedback using dental instruments. Such factors allow clinicians to detect subtle irregularities that may not be easily captured in photographic images. Conversely, photographic assessments depend entirely on the visual interpretation of two-dimensional images, which may not accurately represent depth, texture, or marginal detail. When evaluators attempt to apply the relatively broad USPHS categories to photographic images, the lack of fine gradation within the scoring system may lead to variability in interpretation and scoring.

Another factor contributing to the discrepancies observed in this study may be examiner subjectivity. Because the USPHS criteria do not always provide precise thresholds for transitioning between scoring categories, different evaluators may interpret borderline cases differently. For example, determining whether a restoration should be categorized as Alpha or Bravo for marginal adaptation may depend largely on the examiner's personal judgment. Such subjectivity can lead to inconsistencies in scoring, particularly when multiple evaluators are involved or when assessments are performed using different evaluation methods. This inherent variability may explain the lower level of agreement observed between clinical and photographic evaluations when the USPHS criteria were applied.

In contrast, the Fédération Dentaire Internationale (FDI) evaluation criteria demonstrated better agreement between clinical and digital photographic assessments in the present study. The FDI system was developed to address some of the limitations associated with earlier evaluation methods and to provide a more comprehensive framework for assessing restorative outcomes. One of the key advantages of the FDI criteria is the use of a five-grade scoring scale, which allows for more precise differentiation between varying levels of restoration performance[6]. This expanded scale provides greater sensitivity in identifying early changes or minor defects that might otherwise be overlooked using broader categorical systems.

Furthermore, the FDI criteria incorporate a multidimensional approach to restoration evaluation by including parameters related to esthetic, functional, and biological properties[6],[17]. Esthetic parameters evaluate aspects such as surface luster, color match, and staining, which are particularly important in modern restorative dentistry where patient expectations regarding appearance are increasingly high. Functional parameters focus on factors such as marginal adaptation, anatomical form, and occlusal wear, which directly influence the longevity and mechanical performance of restorations. Biological parameters assess potential complications such as postoperative sensitivity, secondary caries, and periodontal response. By addressing these three major domains, the FDI system enables a more holistic and clinically relevant assessment of restorative outcomes.

The findings of the present study, which showed improved agreement between clinical and photographic assessments when using the FDI criteria, are consistent with results reported in previous investigations. Several studies have demonstrated that the FDI system provides higher sensitivity and reliability compared to the modified USPHS criteria when evaluating dental restorations[18],[19]. The increased number of scoring categories allows evaluators to capture subtle variations in restoration quality, thereby improving the accuracy of assessment. Additionally, the clearer definitions and structured guidelines provided within the FDI criteria may help reduce subjectivity and improve consistency among examiners.

The use of digital photography as an adjunctive tool for restoration evaluation has gained considerable attention in recent years. Advances in digital imaging technology have made it possible to capture high-resolution intraoral photographs that can be stored, magnified, and analyzed repeatedly. Digital photography offers several advantages in clinical research and documentation. One of the primary benefits is the ability to magnify images, which allows examiners to closely examine marginal details, surface characteristics, and color variations that may not be easily visible during routine clinical examination[20]. In addition, photographic documentation enables long-term record keeping and facilitates retrospective analysis, which can be particularly useful in longitudinal studies evaluating restoration performance over time.

Another advantage of digital photography is the potential to reduce examiner bias. When standardized images are used, multiple evaluators can independently assess the same restoration without the influence of clinical environment or patient-related variables. This approach allows for more objective comparisons and can improve the reproducibility of research findings. Furthermore, photographic records can be used for calibration and training of examiners, ensuring that evaluation criteria are applied consistently across different observers.

However, despite these advantages, digital photographic evaluation also has certain inherent limitations that must be considered. The accuracy of photographic assessment can be affected by several technical factors, including image resolution, camera settings, angulation, and lighting conditions[21]. Improper angulation during image capture may obscure critical areas of the restoration, particularly the marginal interface between the restoration and the tooth structure. Similarly, variations in lighting intensity or color temperature can alter the perceived appearance of surface texture or marginal discoloration. Even high-resolution images may fail to fully replicate the three-dimensional perspective and tactile feedback available during direct clinical examination. Consequently, photographic evaluation should be considered a complementary tool rather than a replacement for clinical assessment.

The inter-rater reliability observed in the present study ranged from moderate to substantial when restorations were evaluated using the FDI criteria. This level of agreement indicates that the FDI system provides a relatively consistent and reliable framework for assessment across different evaluators[22]. The structured nature of the criteria, along with clearly defined scoring categories, likely contributes to improved examiner calibration and reduced variability in interpretation. In contrast, the lower agreement observed with the USPHS criteria may reflect the ambiguity associated with its broader scoring thresholds. When categories are not clearly differentiated, examiners may apply different interpretations to the same clinical findings, leading to reduced reliability in assessment outcomes[23].

Although the findings of this study provide valuable insights into the comparative effectiveness of USPHS and FDI evaluation systems, certain limitations should be acknowledged. One of the primary limitations is the relatively small sample size included in the study. A limited number of restorations may restrict the statistical power of the analysis and may not fully represent the wide range of clinical variations encountered in routine dental practice. Additionally, the study was conducted in a single clinical center, which may limit the generalizability of the findings to other populations or clinical environments. Variations in operator technique, patient demographics, and restorative materials could potentially influence evaluation outcomes.

Future research should therefore consider multicenter studies involving larger and more diverse patient populations. Such studies would provide stronger evidence regarding the reliability and applicability of different evaluation criteria across various clinical settings. In addition, the integration of advanced digital technologies, including three-dimensional imaging systems and artificial intelligence–based image analysis, may further enhance the accuracy and reproducibility of restorative evaluations. These emerging technologies have the potential to assist clinicians in detecting early signs of restoration deterioration and in making more informed decisions regarding restoration maintenance or replacement.

In summary, the results of the present study suggest that the FDI evaluation criteria may offer several advantages over the modified USPHS criteria when assessing dental restorations

through both clinical examination and photographic analysis. The greater sensitivity, broader assessment parameters, and structured grading scale of the FDI system appear to facilitate more consistent and reliable evaluations. As digital documentation and photographic analysis continue to become integral components of dental research and clinical practice, the adoption of comprehensive evaluation systems such as the FDI criteria may improve the monitoring and long-term assessment of restorative treatments.

CONCLUSION

Within the limitations of this study:

1. Digital photographic evaluation aligns more closely with clinical findings when using FDI criteria compared to modified USPHS criteria.
2. FDI criteria demonstrate superior inter-rater reliability.
3. Modified USPHS criteria show lower reliability and greater discrepancy between photographic and clinical assessment.

FDI criteria may therefore be preferable for standardized evaluation of restorations in both clinical and research settings.

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