# Validation of assessment of intraoral digital photography for evaluation of dental restorations in clinical research

Cácia Signori[a], Kauê Collares[a], Catarina B.F. Cumerlato[a], Marcos B. Correa[a], Niek J.M. Opdam[b], Maximiliano S. Cenci[a],*

[a] Federal University of Pelotas, Graduate Program in Dentistry, Gonçalves Chaves, 457, 5th floor, Pelotas, RS, 96015560, Brazil
[b] Radboud University Nijmegen Medical Centre, College of Dental Sciences, Preventive and Restorative Dentistry, Ph van Leydenlaan 25, PO Box 9101 6500HB Nijmegen, The Netherlands

## ARTICLE INFO

## ABSTRACT

*Objectives:* The aim of this study was to investigate the validity of assessment of intraoral digital photography in the evaluation of dental restorations.

*Methods:* Intraoral photographs of anterior and posterior restorations were classified based on FDI criteria according to the need for intervention: no intervention, repair and replacement. Evaluations were performed by an experienced expert in restorative dentistry (gold standard evaluator) and 3 trained dentists (consensus). The clinical inspection was the reference standard method. The prevalence of failures was explored. Cohen's kappa statistic was used. Validity was accessed by sensitivity, specificity, likelihood ratio and predictives values.

*Results:* Higher prevalence of failed restorations intervention was identified by the intraoral photography (17.7%) in comparison to the clinical evaluation (14.1%). Moderate agreement in the diagnosis of total failures was shown between the methods for the gold standard evaluator (kappa = 0.51) and consensus of evaluators (kappa = 0.53). Gold standard evaluator and consensus showed substantial and moderate agreement for posterior restorations (kappa = 0.61; 0.59), and fair and moderate agreement for anterior restorations (kappa = 0.36; 0.43), respectively. The accuracy was 84.8% in the assessment by intraoral photographs. Sensitivity and specificity values of 87.5% and 89.3% were found.

*Conclusions:* Under the limits of this study, the assessment of digital photography performed by intraoral camera is an indirect diagnostic method valid for the evaluation of dental restorations, mainly in posterior teeth. This method should be employed taking into account the higher detection of defects provided by the images, which are not always clinically relevant.

## 1. Introduction

Studies on the clinical performance of dental restorations are essential to investigate outcomes related to the diagnosis, treatment and longevity of restorations [1]. The demand for evidence-based dentistry resulted in the increase of clinical studies in the last years [2]. In this context, practice-based studies using data from general dental practice networks (PBRN) emerged and gained a relevant role [3]. This type of study allows the investigation of interventions and associated risk factors in a real-world setting, with access to a representative amount of restorations treated by general practitioners, and to long-term observation periods [4]. On the other hand, these studies are often less standardized in comparison with clinical controlled trials [1,5]. Practitioners without previous training in diagnosis, treatment and assessment of restorations can incorporate some level of bias in the research

[1], since there is still great heterogeneity among dentists in the diagnosis and decision to repair or replace restorations [6,7]. This may be a reason for the great variation in longevity of dental restorations that is found in practice based studies [8–10].

Different criteria have been developed and used in clinical research to diagnose restorations and establish their quality [11]. The main criteria used are the FDI World Dental Federation [12] and modified US Public Health Service (USPHS)/Ryge criteria [13]. The available criteria, although well described, are complex for the use by the general practitioner in everyday practice [14]. Clinical diagnosis is a subjective process, and therefore susceptible to different interpretations, even among experienced clinicians, depending on whether they are more or less conservative [11]. The use of digital photography in PBRN is an alternative to evaluate the quality of restorations reducing the risk of reporting bias. The purpose is that general dental practitioners take the

photograph in their clinical practice and send it to independent investigators for assessment [1].

For caries diagnosis, photographic evaluation showed compatible results with the visual detection method [15–17], and can serve as an important source of information. Likewise, intraoral digital photography has been investigated for use in restorative dentistry, and is reported as a suitable diagnostic tool for dental conditions such as tooth decay [18,19], dental trauma [20], tooth wear [21] and for the assessment of dental sealants and restorations [22–25]. In this context, the intra-oral camera seems to be a promising and viable tool for use in the PBRN [26–28]. The portable device provides fast and easy collection of digital images, allowing the register of the treatment performed by the dentist and subsequent follow-ups [23].

Therefore, the aim of this study was to investigate the validity of assessment of intraoral digital photography in the evaluation of dental restorations. The hypothesis tested was that the assessment of digital photography performed with intraoral camera has similar outcome compared to direct evaluation of restorations.

## 2. Materials and methods

### 2.1. Study design

This was a validation study for the assessment of intraoral digital photography in the evaluation of anterior and posterior resin restorations. The photographs were taken with an intraoral camera. Restorations were classified based on FDI criteria according to the need for intervention: (0) no intervention, (1) repair and (2) replacement. Evaluations were performed by an expert in restorative dentistry, with training and extensive experience in the diagnosis of restorations (gold standard evaluator), and by 3 trained dentists (consensus). The clinical inspection was the reference standard method. The main factor under analysis was the validity of assessment of intraoral photographic method for the diagnosis of restorations and decision of treatment.

### 2.2. Study participants

The present study was performed with a sample of individuals, aged between 18 and 57 years, selected from an ongoing randomized clinical trial (RCT) related to the evaluation of several restorative dentistry outcomes, including clinical performance of materials and restorative techniques. The RCT is held in the School of Dentistry (Federal University of Pelotas, Pelotas, Brazil). The study participants were all adults, having at least one composite restoration placed in anterior or posterior teeth (from 1 up to 5 restored surfaces). The individuals were invited to participate to the study on the RCT follow-up visits. The study was approved by the local Ethics Committee (protocol N° 1.468.455/2016), and participants have signed a written informed consent.

### 2.3. Sample size

Sample size was estimated based on data from a previously published study [29]. Considering a prevalence of 10% of unsatisfactory restorations in the population a desired specificity and sensitivity of 80% for intra-oral digital photography, 80% of power and 5% of confidence level, a total of 165 restorations was required to perform the study. Taking into account that all the patients in the randomized trial follow-up visits were invited to participate and the possibility of exam of more than 1 restoration per patient, at the end 198 restorations were included in the study. The calculation was performed with PS Power and Sample Size Program software, version 3.0.43 [30].

### 2.4. Clinical examination (reference standard method)

Composite restorations were clinically evaluated by one experienced and trained dentist (gold standard evaluator) (MSC) with dental explorer and mirror, air of a triple syringe and artificial light, according to FDI criteria [12]. Patients were examined in a clinic of Dental School, with an average of 10 patients per day (20 min for each patient). Teeth were initially cleaned with dental gauze as necessary. The quality of the restorations was based in the following criteria described by FDI: surface roughness, surface and marginal staining, color and translucency, anatomic form, fracture and retention, marginal adaptation, wear, contact point and proximal contour (when applicable), caries recurrence and dental integrity. Restorations were classified according to the need for intervention: (0) no intervention, (1) repair, and (2) replacement. No intervention was assigned for restorations judged clinically acceptable, with characteristics of grades 1, 2 or 3 of FDI criteria. Restorations compatible with grades 4 and 5 were considered as clinically unacceptable failures, with indication of repair or replacement, respectively.

### 2.5. Intraoral photographic method

After the clinical examination, intraoral photographs were taken under standardized conditions, by one previously trained dentist for the use of photographic equipment. Each individual was positioned on a dental chair, with the Frankfort maxillary plane 45° to the floor and a disinfected cheek retractor was inserted into the patients' mouth. For each restoration, two photographs were taken with the camera located 3 cm from the tooth surface. The camera was positioned perpendicular to the buccal and lingual surface for anterior teeth, and in a 45° angle from the buccal and lingual direction for posterior teeth. The digital intraoral camera CS 1200 (Carestream Health Inc, Rochester, New York, USA) was used for all cases. The camera includes ranging from 3 to 25 mm and has a 6-LED illumination, which adjusts automatically to environmental practice light conditions. In relation to quality and size of images, the camera delivers a $1024 \times 768$ fixed image resolution. All images were registered and stored in a database. No image correction related to color, brightness, and contrast was performed. Fig. 1 shows examples of photographs used in the study for anterior and posterior restorations with and without failures.

### 2.6. Photographic evaluation

Three trained dentists (KC, MBC, NO) who participated in previous clinical studies as an evaluator using FDI criteria and who did not participate in the data collection evaluated the photographs based on the FDI criteria [12]. The recorded images were projected at the same time for all examiners by one of the authors, using 50" HD television in a dark room. The examiners evaluated independently each restoration, without knowledge of the answers of the other evaluators. Moreover, evaluators indicated the need for intervention for each restoration based on simplified FDI criteria: (0) no intervention (grades 1, 2, 3); (1) repair (grade 4); and (2) replacement (grade 5). Following the separate evaluation, a final photographic diagnosis was set based on the classification agreement between at least two of the three evaluators (Consensus). One month after the clinical evaluation, the gold standard examiner (MSC) also evaluated the restorations from the photographs in the same way as the other examiners.

### 2.7. Statistical analysis

Data were double typed and statistical analysis was conducted with STATA/SE 12.0 (Stata Corp, College Station, TX, USA). The prevalence of failed restorations according to the gold standard and to the photographic method with respective 95% confidence intervals (95% CI) was calculated. Level of agreement between the clinical and photographic evaluation of failed restorations was assessed. The Cohen's kappa statistic was used to measure the reproducibility of the intraoral photographic method and the reproducibility of each of the dentists and the consensus evaluation compared to the reference standard method