

UNIVERSITI TEKNOLOGI MARA

**VALIDITY AND RELIABILITY OF
DIGITAL INTRAORAL IMAGE FOR
CARIES DETECTION USING
INTERNATIONAL CARIES
DETECTION ASSESSMENT
SYSTEM (ICDAS)**

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ABSTRACT

Introduction: Dental caries remains a major global health burden, particularly in underserved populations with limited access to dental care. With the rise of telehealth and advancements in smartphone technology, this study investigates the potential of self-captured intraoral images for caries detection using the International Caries Detection and Assessment System (ICDAS). It aims to evaluate the validity and reliability of smartphone-based images for ICDAS scoring and to develop a standardized protocol for public use.

Objectives: (1) Assess the validity of smartphone images versus conventional ICDAS charting by dental clinicians, (2) Develop and validate a self-guided intraoral photography protocol and (3) Determine the reliability of self-taken images for caries diagnosis.

Methodology: This prospective study involved three phases: examiner validation, expert-driven protocol development, and patient-based protocol validation. ICDAS scoring from smartphone and DSLR images was compared with conventional charting. A Delphi process involving experts established a photography protocol. A quasi experimental study followed on 1152 teeth, where images captured by patients and clinicians were analysed using Kappa statistics, sensitivity, specificity, and repeated measures to assess agreement and diagnostic accuracy.

Results: A standardized smartphone photography protocol was successfully developed. Substantial inter-rater reliability ($\kappa = 0.68\text{--}0.78$) was found, with DSLR and iPhone images yielding the highest diagnostic performance. Summary of developed protocol revealed practicality, simplicity and ease of use. The validated protocol significantly improved sensitivity (91%) and specificity (89%) compared to non-standard methods. Even non-experts achieved acceptable agreement with conventional ICDAS scoring.

Conclusion: Within limitations of the study, smartphone self-taken intraoral images are clinically acceptable in agreement with conventional ICDAS caries charting. The validated protocol enables effective use by the public, supporting broader application in tele-dentistry and improved access to oral healthcare. Further validation may be needed in different settings or populations with improvement of image quality.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Dental caries is one of the most prevalent chronic diseases globally, affecting approximately 2.3 billion people, with 530 million children suffering from untreated caries in primary teeth (Qin et al., 2022). The disease's high prevalence underscores the need for accurate, early detection and intervention to prevent progression and minimize invasive treatments. The International Caries Detection and Assessment System (ICDAS) was developed to standardize caries detection, offering a visual-tactile classification system that improves diagnostic consistency (Ismail et al., 2007). ICDAS uses a 0–6 scale, where scores 1–2 indicate early enamel changes, such as white spot lesions, that are visible only under optimal lighting and dryness. These early lesions are inherently more difficult to identify in photographs, particularly when factors such as glare, saliva, or low image resolution obscure subtle surface changes. In contrast, higher ICDAS codes (3–6) represent cavitated or more advanced lesions, which are visually obvious and easier to capture consistently in images. However, ICDAS traditionally relies on in-person clinical examinations, which may not be accessible to all populations, particularly in low-resource settings or remote areas where dental professionals are scarce (Balasubramanian et al., 2016).

With the rapid advancement of digital imaging technologies, there is growing interest in tele-dentistry as a means of remote caries assessment. Smartphone cameras, now equipped with high-resolution sensors (often exceeding 12 megapixels) and advanced computational photography, have demonstrated potential as diagnostic tools in dentistry (Mohamed Estai, Kanagasingam, Huang, Shiikha, et al., 2016). Studies suggest that intraoral photographs captured with smartphones can be useful for detecting dental caries, periodontal conditions, and oral mucosal lesions (Duong et al., 2021; Estai et al., 2017). However, the diagnostic accuracy of these images depends on factors such as:

1. **Image resolution and focus** – Blurring or poor focus may obscure early caries lesions (ICDAS codes 1-2).