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Evaluation of the optimal exposure settings for occlusal photography with digital cameras

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ABSTRACT

Background and objective: Recently, there have been produced several kinds of camera systems, lighting devices and image processing programs. The intraoral photographs are periodically required in pediatric dentistry, since the oral environment of children changes rapidly and dramatically because of disease, growth, and tooth eruption. However, the suitable settings for intraoral digital imaging have not yet been reported. In this study, single-lens reflex and mirrorless cameras were used with a ring flash, ring light emitting diode (LED), or standard fluorescent lamp to determine the optimal exposure parameters for occlusal photography.
Materials and methods: Fifty-six dentists evaluated images of a discolored nonvital central incisor and first molar with recurrent caries and stained fissures clipped from a low-magnification photograph of the adult maxillary occlusal surface reflected in a mirror by using various F-numbers (representing aperture), shutter speeds, and International Organization for Standardization (ISO) numbers (representing light sensitivity).
Results: The results showed that F-numbers between 5.6 and 10, shutter speeds faster than 1/30s, and ISO 800 produce the best occlusal images when a 60 mm f/2.8 Macro lens is used. Better images are obtained with ring LED than with ring flash. Furthermore, ISO 3200 is required for low-magnification photography in natural light. Finally, intraoral digital images should be captured under low magnification, because tilted or deflected images can be adjusted by using imaging software.

1. Introduction

Intraoral photographs enable dentists to evaluate various hard and soft tissues [1,2]. These images can be used to record and identify pathological changes in normal tissues, such as caries including recurrent caries, restorative material wear, enamel hypocalcification or hypoplasia, fluorosis, tetracycline staining, dentine exposure, defective restorations, gingivitis, gingival clefts or scarring [1,2]. Intraoral photography is

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especially important in pediatric dentistry because children cannot keep their mouth open for extended periods, but images can be thoroughly analyzed. Furthermore, they allow periodic assessment of therapeutic effects, prognosis, and growth- or disease-induced changes in children, who show dramatic transformations in a short time. The photographic requirement varies according to the situation, such as low-magnification images of the whole dentition and high-magnification images of problematic teeth.

Cameras include single-lens reflex (SLR) and rangefinder cameras. Although rangefinder cameras are convenient for everyday use because of their small size and automatic focus, they have limited applicability in dentistry because parallax is an unacceptable drawback in close-up photography. The viewfinder of a rangefinder camera is inevitably offset from the taking lens, given their different optical axes. Therefore, the seen image will not be recorded correctly on film or a digital sensor. In contrast, the viewfinder of an SLR camera transmits the image directly "through the lens".

The film SLR camera mainly used by dentists in the past had a ring flash included in the macro lens (i.e., Medical Nikkor 120 mm F-number of 4). However, this camera was so heavy that several assistants were needed to hold dental instruments such as the mirror and lip retractor during intraoral photographing. Furthermore, they often failed in taking photographs which could not be previewed. Therefore, balancing of the aperture (F-number), shutter speed, and light sensitivity (ISO number) was difficult. Low and high F-numbers result in shallow depth of field and dark images, respectively. Fast shutter speeds yield dark images and slow shutter speeds cause blurred images, because of camera shake. Further, low ISO numbers result in dark images and high ISO numbers create noise. Therefore, dentists should know the appropriate values of these parameters.

The introduction of digital SLR cameras has allowed instantaneous assessment of photographic errors via the preview function. Mirrorless cameras have also been developed, and the recent digital cameras are compact and lightweight, and offer high definition [3]. Moreover, white light emitting diode (LED) produces bright, power-saving illumination and thus reduces camera weight. Digital images can be saved on a computer, reducing space requirements [4]. Furthermore, images can be compiled easily by using imaging software [5]. Contrast and brightness can be regulated and high-magnification images can be obtained by cropping wider photographs, which may enable better examination by digital zoom. In future, the image may be used for retrospective study such as historical cohort study. Digital photography also helps in treatment planning as the patient can instantaneously view images on electronic visual displays and have a visual guide to understand the disease, treatment, and outcomes.

However, digital zoom causes image deterioration. Therefore, intraoral photography requirements should be investigated while considering digital zoom. Intraoral digital photography involves cutting-edge technologies. However, only a few studies of such imaging have been performed [1–8,10]. This study was aimed at determining the appropriate exposure parameters for occlusal photography in consideration of digital zoom with digital cameras. In this reason, zoomed image of the maxillary occlusal aspect reflected in a mirror was examined for recurrent caries, stained fissures, and nonvitality.

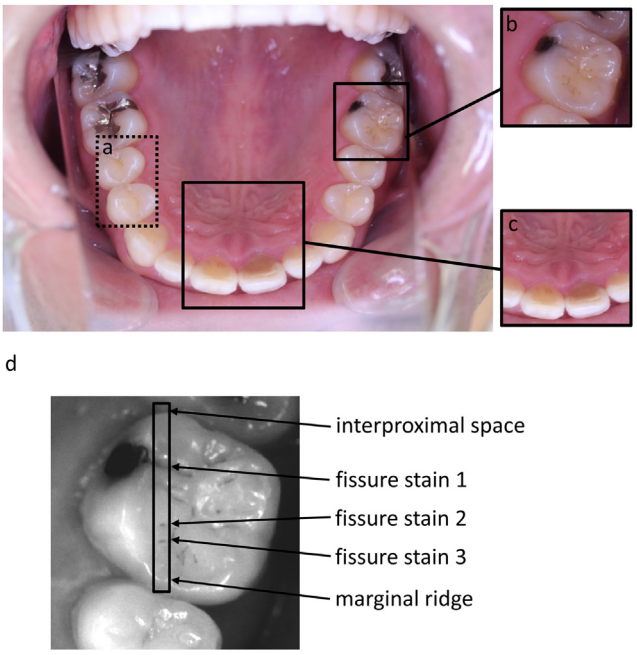

Fig. 1 – Intraoral photographing and clipping. A 1:4 magnification was chosen to image the maxillary occlusal aspect. The focus was the right premolars (a). An amalgam restoration with recurrent caries and stained fissures (b) in the left first molar and a discolored central incisor (c) are noticeable. Images of these teeth were clipped from the whole occlusal image. The first molar photograph was converted to a 16-bit gray-scale image to assess focal accuracy in terms of contrast (d).

2. Methods

2.1. *Cameras*

EOS Kiss X5 (also known as EOS REBEL T3i or EOS 600D; Canon, Tokyo, Japan) and EOS M (Canon) cameras were used for imaging in this study. The former is an 18.0 effective-megapixel APS-C CMOS digital SLR camera weighing 560 g including the battery and card. The available ISO numbers range between 100 and 6400, and the image processor is DIGIC4. The latter is an 18.0 effective-megapixel APS-C CMOS sensor digital mirrorless camera weighing 262 g including the battery and card. Its available ISO numbers range from 100 to 12,800, and the image processor is DIGIC5.

2.2. *Lens and light source*

An EF-S 60 mm f/2.8 Macro USM lens (Canon), weighing 335 g, was used in both the cameras. Its angle of view is equivalent to a 96 mm lens mounted on a 35 mm format camera. F-numbers between 2.8 and 32 can be selected and magnification varies from 1:1 to 1:5.