

REVIEW ARTICLE

Digital Photography in General and Clinical Dentistry- Technical Aspects and Accessories

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Abstract

Photography has become a part of contemporary dental practice. Intraoral and Oro-facial conditions during which dental treatment are prone to change can be recorded in detail by means of photographs. They provide forefficient documentation along with the choice of monitoring particular situations over periods of time. With the right skills and photographic methods, the clinician enhances communication and interaction with the patient regarding treatment planning. This article presents an overview of the function, basics and types of camera and the accessories used for intraoral photography which enables the practitioner to make standardized photographic documentation of cases.

Keywords: Dental Photography; Digital Photography; Digital Camera; Intraoral Photography; Single Lens Reflex Camera

Introduction

Dental digital photography has become an important part of standard dental practice. In addition to conventional patient records and radiographs, dental photography offers the dental professional another possibility of visual reconstruction of the various stages of treatment and also a patient's photographic record. Imperfections, not readily visible are sometimes apparent in a photograph. Photographs also allow the patient to visualize the same acute perspective as the dentist and help the patient to understand the rationale for treatment.

Photographs are an essential part of clinical records for number of reasons:¹

- a) *Unreliable memories:* Helps in reminding both the patients and the dentist of the original situation, against which all improvements can be judged.
- b) *Treatment assessment:* A sequential collage of treatment pictures will serve to make the patient understand the intended treatment far better than a verbal explanation.
- c) *Teaching / Presentations/Seminars:* Aid to present cases in lectures, papers and posters.
- d) *Medico legal Disputes:* Proper records will help avoid any post-treatment disputes/medico-legal claims
- e) *Correspondance:* Pictures are indispensable when communicating with the dental laboratory. The ability of laboratory technicians to view the face and smile of the patient for whom they are fabricating prostheses is immensely useful; in addition they can also examine the surface texture, shading, and gingival characteristics to allow for more custom fabrications.
- f) *Screening:* Forwarding images of suspect oral pathology to specialists. This article provides with an overview of the function and basics of digital cameras, the criteria for evaluating and selecting a digital camera system for dental photography, and the clinical applications along with guidelines for good quality dental images.

Basics of Photography²

1. Exposure

Exposure is the measuring and balancing of light. If there is too much of light, the picture will appear washed out i.e. overexposed with loss of detail being

obscured by excess light. If there is not enough light, the picture will be too dark i.e. underexposed. The factors that affect the exposure are aperture (f), shutter speed and ISO (International Standards Organization) settings.

2. Depth of Field

The zone of sharpest focus around the subject (front or back) upon which the lens is focused. Depth of field depends on:

1. Aperture (f-number)
2. Focal length of the lens. (12-400mm)
3. Distance from the lens to the subject

Smaller aperture which is denoted by a larger f number like 20 or above means shorter focal length, and furthest focused distance increasing the depth of field which is desirable for intra-oral photography.

For intra-oral photography ideal aperture is set at f-32 Figure 1 and Figure 2 highlights the correct and incorrect depth of field settings



Figure 1: Incorrect aperture settings, highlighted by the lack of focus in the molar regions



Figure 2: Correct aperture settings, highlighted by the good clarity of detail in the molar regions

3. Aperture

Aperture controls the size of the opening through which light passes and reaches the sensor. It is calculated in f-stop numbers. Typical ranges are from f- 1.4-f32. Larger is the f-stop, smaller will be the aperture.

Aperture is very important for any dentist as it is the deciding factor for ‘depth of field’. In intraoral photographs, ‘depth of field’ is essential as all tooth and perioral structures exist in different planes and in spite of that they should be in focus.

4. Shutter speed

This determines the length of time the shutter stays open. It can range from 1:5000 sec to B (Bulb mode), keeping the shutter open as long as required.

The two controls have a reciprocal relationship. The combination of a long shutter speed and a small aperture can give an equal exposure to a short shutter speed and large aperture.

5. Reflective Exposure Metering

Exposure metering is the process of objectively sensing light to calculate the proper exposure setting. There is usually a choice of three geometric configurations: Spot (For Nikon Cameras)/Partial (For Canon), Center-weighted, or Matrix (Nikon)/Evaluative (for Canon)-.

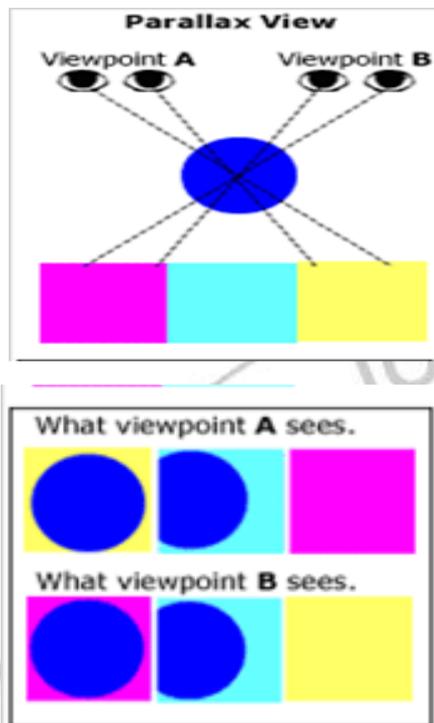
Spot metering measures a small area of the scene (i.e., usually 2% or less of the entire image area). Center-weighted metering evaluates the light reflected from the entire scene, but gives priority to a defined area in the center of the frame with less attention to the corners and edges.

Matrix metering divides the frame into segments, then measures and evaluates against a proprietary database library of anticipated image algorithms to yield the final averaged reading.

TTL Flash Metering is the standard metering mode that your camera employs where you’re using the camera’s built-it or pop-up flash. You can also use this metering mode with some of the dedicated flash units available for your camera. TTL flash metering measures the burst of flash output light reflecting back from the subject and takes its reading through the lens. It will take this reading from the section in your view where the active focusing point is set. TTL manipulates the flash exposure with a dedicated sensor that measures the flash output reflected from the surface of the image sensor during active exposure. When you have your camera set in Program, TTL will choose an aperture setting based on the amount of available ambient light. For high quality dental photography, Automatic TTL is preferred.³

6. Parallax

In clinical photography one is interested in recording the accurate correlation between teeth (e.g. molar relation, inter-cuspal relationship of canines or premolars, midline relationship). Parallax refers to the apparent movement of two fixed points that an observer sees as he changes positions. Any dentist must have a clear conceptual awareness of parallax phenomenon. (Figure 3 and 4)



Figures 3 and 4: Schematic representation of the parallax phenomenon

7. Exposure Compensation

Contemporary camera systems are engineered to set the exposure for a subject that is approximately 18% gray in reflectivity. If the camera monitors an area of the image that is highly reflective, it will mistakenly perceive that a darker exposure is required and will inadvertently underexpose and vice versa.

Unfortunately, dentists are usually taking images of white teeth surrounded by dark shadows. The high contrast between the dark and light areas of intraoral images presents a genuine problem as in there is a potential for inconsistent and unpredictable exposure results when metering.

The camera feature that allows an intentional modification in exposure metering is called exposure compensation. A positive exposure compensation setting would be required for spot metering highly reflective subjects such as white teeth. By warning the metering system that the subject is bright, the operator avoids an unwanted under-exposure.

Many cameras are capable of “bracketing”. This setting helps the operator take a series of photographs—each with slightly raised and lowered exposure values (relative to the metered exposure). The use of bracketing can overcome the possible error in estimating how much exposure compensation is required for a particular.

8. Exposure Modes

Contemporary DSLR cameras typically offer a selection among four automated exposure assignment alternatives. In the Program (P) mode, the camera selects both the aperture and exposure time for the photographer. In the Shutter Priority (S in Nikon/TV in Canon) mode, the photographer selects the desired exposure time while the camera selects the matching aperture. In the Manual (M) mode, the photographer has complete control over both shutter speed and aperture. Lastly, in Aperture (A) Mode, the desired Aperture is selected and the camera matches shutter speed.

The authors emphasize on understanding the function of each mode rather than the nomenclature presented by different cameras.

For dental photography, the aperture priority is ideal. For full-face images apertures of f-5.6 to f-8 work well. Aperture selections of approximately f-22 are for smile views and full-arch views, while aperture settings of approximately f-32 maximize the depth of field for close-up views.

Digital Dental Cameras³

To explain about different cameras it is necessary to understand a few basic principles of digital cameras.

- a) **Noise:** Under desirable salt and pepper effect i.e. a severely graining image in a photograph when correct ISO, Exposure times are not used. Low ISO (range of 200-640) + Large Sensor + Adequate exposure will produce the least noise and clear images.¹
- b) **Sensors** are devices that convert an optical image from the lens to an electronic signal / digital image in the camera. The sensors are usually CMOS (Complementary Metal-oxide-semiconductor) or CCD (Charged Couple Device). Another important factor in sensors is the size; the size of the sensor in most basic DSLR cameras (Advanced Photo Sensor- Type C or APS-C) is approximately 16 mm x 24 mm, which is significantly smaller than full frame sensor at 24 mm x 36 mm.⁴ The lens will project the same size image in the back of the camera, regardless of the size of the sensor. Since a smaller portion in the center of the focused image is captured and then expanded to full size when it is viewed, the effective magnification of the lens is increased when utilizing a APS-C system to 1.5X times.
- c) **ISO:** This is the sensitivity of light of the camera. The ISO can be anywhere from 24-128000. Lower setting implies less sensitive and higher setting more sensitive.
- d) **Megapixels (MP):** It is used to express the number of image sensor elements of digital cameras. Cameras with a “full frame” sensor may have the same “count” of pixels as an APS-C or

CX (such as 24MP), but the Full frame camera will capture better dynamic range, less noise and better low light performance. Due to more information being captured on each pixel on a larger image sensor

Classification

Digital dental cameras can be divided into 3 categories.

- a) The **compact point-and-shoot cameras**, without interchangeable lenses: This type of camera allows varying amounts of exposure control and mixed results in the unique setting of the oral cavity. Full-face photos can be acceptable, but intraoral and close-up views remain variable. The amount of noise in the images is also quite significant. A slightly higher variant is available called Prosumer cameras in which, the size and form of the Prosumer camera is smaller than a Digital SLR camera. Prosumer camera is light and equipped with a super zoom lens. It is cheaper than entry level Digital SLR camera.
- b) The second type of camera used is the **DSLR (Digital single lens reflex)** camera. DSLR cameras are designed for semi-professionals to professionals. DSLR cameras have the advantage of interchangeable lenses, including macro (or Micro in a Nikon System), telephoto and metered lenses. They also have ports for accessories such as a ring flash or a dual flash system. All controls can be set manually. An 85mm- to 105mm telephoto macro lens is used ideally- the reason is quite simple to maintain natural height-width ratio when reproduced in a photograph. A ring flash is placed around the lens to distribute the light evenly with intraoral exposures. Some cameras are also fitted with point flashes to reduce red-eye with full-face views. A drawback is that these cameras can be expensive and bulky.
- c) **Intraoral cameras**⁵- An intraoral camera is a tiny device with a video camera that moves around inside the mouth and generates a surface video examination of the teeth. The images or videos can be stored, and later enlarged and showcased. Patients can see their teeth and any issues such as a fractured tooth, plaque, decay, and gingival disease, among others. This allows for better education of the patients and also allows dentists to catch problems in the early stages for analysis or to record patient progress.

Camera Accessories

- a) **Lens**- A lens selected for dental purposes must be able to capture diagnostic and accurate views of teeth, gingiva and surrounding structures.

Specially fixed focal length macro lenses are able to capture an image of a subject while focusing at a very close range. Macro lenses with a fixed focal length designation of 85 to 105 mm provide the ideal combination of magnification ability and working distance convenience for dental purposes. The quality of the lens has a significant influence on the sharpness, clarity, and ultimate quality of the final image.

The magnification ratio is the ratio of the size of the image projected on the sensor compared to the actual size of the object. A magnification ratio of 1:10 means the image on the sensor is one-tenth life-size, while a 1:1 magnification ratio signifies a life-size image on the sensor. The 1:1 setting is ideal for close-up imaging of teeth while the 1:10 setting is useful for full-face views.

- b) **Light and Electronic Flash Systems**- Proper illumination is one of the most significant factors in achieving a quality image. Since natural ambient light is usually inadequate to illuminate all the dark areas in most intraoral photographic situations, a supplemental electronic flash source is needed. An electronic flash can provide light with neutral color temperature i.e. relatively high output light for a short duration.

In flash photography, the lighting effect is dependent on the form and arrangement of the flash sources. There are three types of electronic flash system configurations available for dental photography:

- i. **Ring Flash (Figure 5)**: It is considered the universal flash system for general macro-photography. This system furnishes either a single ring flash tube or individual sector flash tubes that surround the lens. The specular or mirror-type reflection created by this type of flash tends to eliminate shadows in the image. The disadvantage in the reduction of shadows is that the image may appear to "flatten out" with reduced discernable contours.



Figure 5: A typical ring flash system

- ii. **Point flash**: This provides a single strobe light source mounted in different positions around the lens to provide a unidirectional light from different angles. Photographic compositions for frontal, right lateral, and left lateral views require

the flash to be placed at the 12, 9, and 3 o'clock positions, respectively. Control of the light direction allows shadows to be cast by the three-dimensional topography of the objects in the scene. The appearance of shadows improves the visual definition of contour and texture to emphasize the apparent depth within the image. The advantage of this flash system design is its ability to record surface texture detail and contour. However, it is suggested that multiple images with several flash positions be taken to establish adequate information. This type of flash system requires considerable experience and additional set-up time to maneuver the flash position before each exposure.

iii. **Twin flash (Figure 6):** Its configuration consists of two flash units that are mounted next to the lens. The light sources can be positioned to create custom mild shadowing to reveal texture with depth and life-like effects. Mastering the use of this lighting system will yield professional photographic results. While requiring more experience and thought for proper use, the twin flash design system may offer the best combination of soft, uniform illumination because it simultaneously reveals surface detail, color transitions, translucency variations, and crack lines. (Figure 7)



Figure 6: A typical twin flash system



Figure 7: Note the lack of shadow and plasticity of the ring flash photo (top). The twin flash photo (bottom) shows soft, uniform illumination that reveals surface detail and color transitions.²

- c) **Memory card** – Memory cards are available in different formats such as CF (CompactFlash), Micro SDHC (Secure Digital High Capacity), Micro SD (Secure Digital) and SDHC. They can reach up to 512 GB in size and store thousands of images. Blue/Standard for Point and Shoot cameras and Ultra for DSLRs should suffice the needs of the dental setup.
- d) **Filter**– It serves the dual purpose of lens protection and if required changing the lightening conditions.
- e) **Batteries** – It is required to get an extra battery pack with a quick charger, to ensure you never run out of battery during a shoot.
- f) **Camera Bags** – This is useful to protect the camera and to be able to carry your camera, lenses and accessories in an organized fashion.

Clinical Dentistry Photographic Accessories

- a) **Cheek Retractors:** Available in clear plastic or metal, it is used to retract the lips, labial and buccal mucosa. Retractors are either single or double-ended. Double-ended retractors provide both a small and large curvature allowing adaptability. Single-ended plastic retractors have longer, tapered handles. The curved end is larger for excellent lip retraction. ¹ Figure 8 and 9 point out how a colored retractor ideally should not be used for retraction.

Technique for inserting retractors:

- a) Moisten the retractors in warm water.
- b) Ask the patient to relax the lips and open the mouth slightly.
- c) Place the rim of the retractor onto the edge of the lower lip.
- d) Rotate the handle of the retractor until it is parallel to the corner of the mouth.
- e) Repeat this for the other side of the mouth if necessary.
- f) Instruct the patient to bite down on the posterior teeth. Pull out the retractors laterally and slightly forward. Avoid pulling the retractor handles toward the ears. This will cause the buccal mucosa to be pressed onto the buccal surfaces of the teeth, as well as cause the patient discomfort when the retractor is pressed against the gingiva and alveolar process.



Figures 8 and 9: highlight the incorrect and correct accepted colour of the cheek retractor used for dental photography

Modification of Cheek Retractor

- **Columbia Wire Lip Retractor** - Combines buccal mirror & cheek retractor (Figure 10)

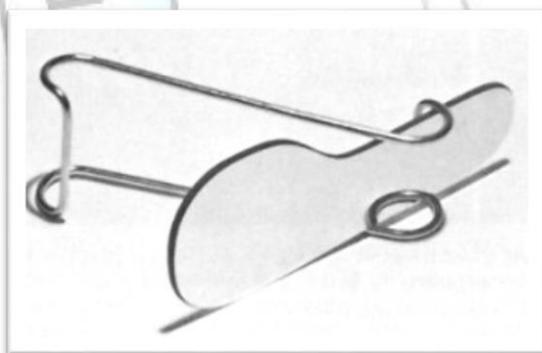


Figure 10: Columbia Wire lip retractor

- **The Martin Metal Retractors** - They are easily sterilized and, being slim, do not cause distracting reflections. The vertical frame on either side allows the comfortable use of mirrors and retractors simultaneously. (Figure 11)

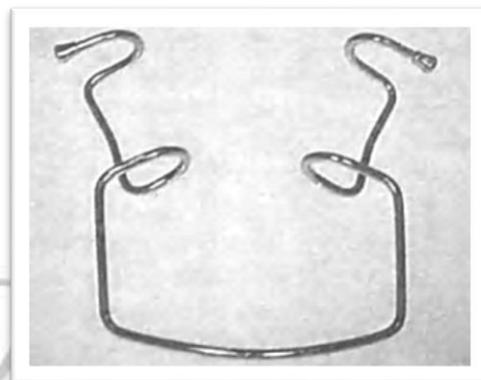


Figure 11: Martin metal retractor

- b) **Intraoral mirrors-** Intraoral mirrors are used to provide a reflected image when areas of difficult access are photographed. Glass mirrors that have been rhodium plated on both sides create an excellent reflective surface (Table 1). Intraoral mirrors are available in several sizes for both adults and children. The large end of the mirror provides an excellent surface for capturing occlusal views, and the smaller end can be placed for palatal and lingual views.

Table 1: Reflectance values of Rhodium vs Chromium-coated and Metal mirrors

Reflectance value of Rhodium vs. Chromium-Coated and Metal Mirrors	
TYPE OF MIRROR	VALUE OF REFLECTANCE
Rhodium-coated glass	75%
Chromium-coated glass	65 - 70%
Metal	55 - 60%

Long-handled, front-silvered, rhodium coated glass mirrors- ideal tool for clinical photography. (Figure 12)

Technique for inserting mirrors:

- Place the mirror in warm water before use to prevent fogging. A small heating pad could also be used to keep mirrors warm.
- Insert the appropriate cheek retractors.
- Select the mirror and the appropriate end for the desired view.
- Place the mirror flat into the mouth. As you retract with your fingers, rotate the mirror into position. Take care not to hit the teeth or press into the alveolar process, as this is annoying and uncomfortable for the patient.
- Hold the mirror securely at the opposite end while maintaining retraction.

- f) If fogging occurs, blow a gentle stream of compressed air onto the mirror.

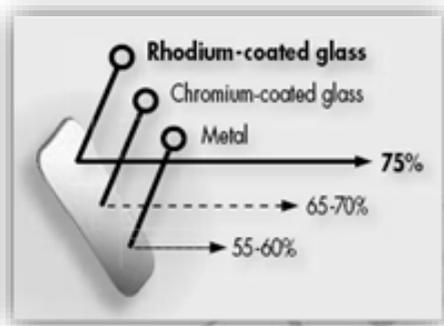


Figure 12: Different reflective capacities of different coated mirrors

Need For Standardization

Shaffer in 1936 wrote, “A review of the orthodontic illustrations in our orthodontic and dental journals revealed that they have an amazingly small percentage of standardized photographs of orthodontic patients. One needs to study the before-and-after photographs used as illustrations in our textbooks and journals to realize the need of more standardization.”⁶

Linear scale

The magnification of clinical photographs should always be controlled and standardized. This principle was firmly established in what have come to be known as the 'Westminster scales', summarized in Table 2 for recording the views of different body parts. The scales refer to primary magnification on the film itself, and apply to photography with a 35mm camera.

Table 2: The Westminster Scale Ratios

STANDARD ADULT MAGNIFICATION RATIOS	VIEW RATIO
Full length	1:50
Head & neck	1:10
Face	1: 8
Both hands	1: 10
Single hand	1: 5
Single eye	1: 2

The best way to standardize scale is to use a lens that is marked with reproduction ratios on the barrel. The lens is set to a specific magnification ratio and focusing is achieved by moving the whole camera back and forward.

Standardizing images

For producing a serial record of a patient- the head positioning should be consistent (either oriented to

Frankfort Horizontal plane or Natural Head position). One of the commonly used methods is to ask the patient to look afar or straight at a mirror (or imagining themselves looking into a mirror). While displaying serial photographs to show the therapeutic changes over the period- the only variable should be the patient. Everything else- viewpoint, positioning, lighting, color, magnification, perspective, contrast, and background etc. should stay the same.⁷

Standardization requires a certain amount of planning, a systematic approach, and adherence to protocols and attention to detail. Many cameras these days offer a view of a grid through their eyepiece or LCD. With extra-oral shots, lines can be placed parallel to the inter-pupillary line on the front shot, or to the Frankfort plane on the side and three-quarter view to give reproducibility between the shots. The line across the middle of the viewfinder during intraoral photography is kept coincident with occlusal plane and the shot can be symmetrically composed. For macro photography, a macro lens and ring flash is recommended.

Conclusions

The rapid rate of innovation in the field of photography often confounds dental professionals regarding the same. Digital photography has been gradually adopted, accepted and standardized by all dental specialties and has become an important resource. Photographs can be easily obtained using the correct equipment, proper settings and the most effective techniques, thereby increasing the chances of obtaining high-quality images. This article covers the bare minimum that a dentist needs or rather ought to know before he ventures into the interesting world of digital clinical photography.

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