Review Article

DIGITAL DENTAL PHOTOGRAPHY: THE GUIDELINES FOR A PRACTICAL APPROACH

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Abstract

It is becoming increasingly important to maintain high quality clinical records during the course of medical and dental treatment and research. Photographs of a patient's face provide a significant amount of information to aid diagnosis and treatment planning as well as to document preoperative and postoperative conditions. This article offers a brief history of digital photography along with the basic elements and techniques implemented for the better results. Recommendations are made as to the system best suited for capturing various intraoral areas.

Key Words: - Clinical photography, digital cameras, digital photography and flash

Introduction

Photographs of a patient's face provide a significant amount of information to aid diagnosis and treatment planning as well as to document preoperative and postoperative conditions. Clinical photographs, therefore, can offer at least as much, if not more, information provided care is taken when obtaining these photographs. Technological developments in photography have continued to facilitate and enhance the practice of dentistry.[1] Digital photography almost has overtaken the conventional photographic film industry. Most professional photographers are using either digital photography alone or a combination of digital and conventional film photography. Digital technology has revolutionized clinical dental photography.[2]

The trend toward digital photography is not likely to change. Using digital photography in the dental office is fast, easy and highly useful for documenting treatment, carrying out patient education and accomplishing clinical research. It has greatly increased the ease of documenting treatment, which can be significant in not only a clinical sense but also a legal sense.

Photographs are essential part of clinical documentation. Current best practice is full set of intra and extra oral photographs, both at the start and the completion of a course of dental treatment and ideally, some mid treatment photographs showing key stages in the treatment.[3] The aim of this paper is to highlight the technical elements of digital photography for the better results. Recommendations are made as to the system best suited for capturing various intraoral areas.

Technical Elements for clinical photography:

In the process of photography the light is transformed in color, space and time.

- COLOR: is a 3 dimensional entity consisting of hue, value and chroma.
- SPACE: defines transparency, size, shape/form and texture.
- TIME: indicates movement, flicker, sparkle (vitality), fluctuation and glitter.

For example, a pink gingival *color* is indicative of health, a correct tooth proportion *(space)* conveys pleasing esthetics, and a smile suggests a pleasurable moment in *time.*

Realization of the above triad is achieved by the presence and manipulation of light. All photography requires the continuous spectrum of light source, i.e. one in which all the colours of the visible spectrum overlap completely e.g. natural day light. For dental photography the sources available are electronic flash, Tungsten incandescent bulbs (domestic or photoflood lamps), quartz lighting fixtures, hydrargrum medium arc-length iodide (HMI) illumination, ultraviolet illumination (for intrinsic fluorescent properties of natural teeth and for checking porcelain in a restoration).

The light needs to be modified according to the subject matter being photographed. For e.g. light setup to capture margins of prepared tooth will be different from that for choosing the shade for ceramic restoration.[4]

Angle of illumination: Illumination for dental photography can either be uniform or directional. Uniform illumination refers to 360˚ coverage, typical produced by electronic ring flash. This is particularly used where the access is limited e.g the posterior regions of the mouth. The uniform illumination renders a flat image, lacking form, texture and perspective.

Directional light can be adjusted in the horizontal plane (right to left from 0 to 180˚) and in vertical plane (up to down 0 to 180˚).Directional lighting is the choice for photographing the anterior dentition, where capturing form, texture and perspective are paramount. Source can also be moved towards or away from the subject. Because of versatility of placing lights in three dimensions, a variety of lighting set ups can be assembled for a given dental procedure to emphasize specific details of hard or soft tissues.[4]

Depth of field: It is to ascertain the area of focus on the film plane. It determines the extent of focus in front of and behind the plane of critical focus (the point on which the lens is focused).[4] The smaller the lens aperture, the greater

the depth of field and this is particularly critical in the close up work where there is considerable depth, such as when photographing the teeth.

History of digital photography: Digital photography has been generally available since 1981. In 1991 "Autotrader" were the first mass market publication to move completely to digital recording of images. Now digital photography is used in professional fields on routine basis. Digital images are made up of picture elements 'pixels' comprising red, blue and green light each set at a level between 0 and 255. If all three colors are set at 255, white is the result while if all are set at 0, black is the result. There are 256 grey shades that result from all three colors being set at the same number. Varying the level of each of the three colors result in the gamut of 16.7 millions colours. Numerical value for each of these colours is stored in Charged Coupled Devices (CCD). This is made up of pixels, the number of which combined with the degree of compression, determines the quality of final output.

In the 1990s, a typical CCD would comprise of 640 x 480 pixels resulting in acceptable images from the snapshots, but lacking the quality needed for high quality clinical photography. But by 1999, the first mega pixel cameras (over 1,000,000 pixels per image) became available.[5]

The conventional photographic equipments produced good image quality, was very reliable, user friendly and relatively inexpensive. However, well recognized problem with conventional photographic techniques are cost of developing and processing films, the time required for processing and physical storage of all patients slides or prints.

Requisite equipments for image capture:

Digital cameras: Digital cameras are easy to use, in terms of both making and storing the photographic images. There is no reason to avoid recording potentially legally threatening clinical situations and storing them in digital form for documentation needs.

In choosing a camera for digital clinical photography the two main choices are between compact and single lens reflex (SLR) cameras. With the compact camera as an option, the clinician has to compromise with the over lighting, image size and working distance. Greater control can be achieved by SLR which allows changing lenses and attaching different type of flash.[6] The lens barrel is set to the predetermined position and the subject brought into focus by moving the camera closer to or further from the patient. With digital images this is not such a critical issue as they can be resized at a later stage to allow comparison with previous or subsequent images providing there is sufficient information on the image to guarantee quality, once cropped and resized. This is determined by the number of picture elements (pixels) on the charge-coupled device within the digital camera and whether the area of interest completely fills the recorded area.[7] Most modern digital cameras record 3 mega pixels or more, which is more than adequate for high quality clinical photography as it can easily be able to produced 8 x 10 inch prints of high quality.

Figure 1: -Fixing the focal distance ensures consistent magnification

The examples of compact camera available are Fujifilm Finepix S5600 - 5.2 megapixels, 10x optical zoom, Fujifilm Finepix S7000 - 6.4 megapixels, 6x optical zoom, Minolta Dimage A200 - 8 megapixels, 7x optical zoom. Nikon 5700 – 5.24 megapixels, 8x optical zoom. Examples of digital SLR camera bodies are Canon D350 – 8 megapixels (CMOS). Fuji S3 Pro – 6.17 megapixels, Nikon D200 – 10.2 Megapixels, Nikon D50 – 6.1 megapixels, Nikon D2X – 12 megapixels (CMOS).

For dental photography a range of useful aids are essential. They are flash, mirrors background, retractors and reflectors.

Background

Its purpose is to isolate and concentrate attention on the object being photographed. A non-reflective light blue background is recommended. A white background does not provide sufficient contrast with the subject. A black background could be used to minimize shadows, but it does not provide sufficient contrast for subjects with dark hair, causing part of the image to be lost in the background. A piece of light blue cloth or cardboard attached to the wall with thumbtacks provides a suitable background for photographs of the face.[4] Occasionally, a black card placed behind the maxillary incisors will be useful for highlighting the translucency. The simplest backdrops are colored cards, cloth such as black velvet, which absorbs all incident light.

Mirror: Long-handled, front-silvered, glass mirrors are the ideal tool for clinical photography, although they are significantly more expensive than rear-silvered or metal mirrors. Long handles are held by the photographer to allow complete control of the picture and to keeps assistants fingers out of the shot.[7]

Glass mirrors produce a far superior photograph compared to polished metal mirrors as there is much greater reflection of the light and they are more resistant to scratching. Silvering on the front side of the mirror prevents double images, which occur due to a second reflection from the glass surface when the silvering is on the back surface.

Prior to taking the photograph the mirror should either be warmed to prevent misting of the mirror when it is inserted into the patients' mouth or the patient should be instructed to hold their breath for 10 seconds or so.

The occlusal mirrors are available in three different sizes; however, the two smallest sizes are required in less than 10% of patients. During occlusal photography light is never reflected 100%, and there is a tendency for mirror photographs to be slightly underexposed. It is therefore worth using an aperture compensation to ensure good illumination of mirror shots. This adjustment can be usually made on both conventional and modern digital camera systems.[7]

Figure 2: - Long-handled mirrors are the best available

Flash: Our eyes and brain have an extraordinary ability to adjust to different lighting conditions**.** Cameras and films are less adaptable, particularly in mixed light. Indoor lighting is not bright enough and the quality of light is never appropriate for clinical photography. Thus we need the extra source of light in the form of flash. Electronic flash is ideal for providing a light source that is of such short duration that it is capable of 'freezing' any moment. Modern compact cameras have flash built into them with automatic exposure control making it difficult to produce a badly exposed photograph.[6]

The ring flash is an important tool for photographing cavities where the shadow of the directional flash would obscure important details. A ring flash provides virtually shadowless lighting, with the flash tube wrapped around the camera lens. There is a common misconception that all the medical photographs should be taken using a ring flash. This type of lighting is very flat and reduces modeling. It also causes large circular reflections, which are particularly noticeable on wet surfaces such as the eye. For this type of work, a hand-held flash is preferable: a powerful light source providing modeling and a single, small reflex.

Aperture size: Relative aperture size is denoted on a lens by f-numbers - the higher the number, the lesser the depth of field, and also lesser will be resolution.[4] Generally in clinical photography we need the maximum depth of field so our flash should be bright enough to allow us to use the smallest possible aperture. Smaller f-stops are preferred for close up dental photography (but not less than f-22).

Reflectors: Reflection is one of the methods used for modifying light. This refers to reflection of the key light, not reflections produced by the object being photographed. The resulting light is dependent on the type of surface used to reflect it. A variety of surfaces are used, ranging from a highly polished mirror to a textured or matte finish.

The colored reflectors are highly polished glossy surface, irrespective of its color it produce a specular (mirror like) reflection. Conversely, textured or matte colored reflectors will produce reflections that correspond to their color. For e.g. a glossy green card will produce a reflection that is specular and white, but a matte green card will produce a reflection that has greenish hue. Mirror reflectors are useful for capturing the texture and luster of enamel and porcelain surfaces. A diffuse specular reflection is created using a silver painted card[4]. The result is light that increases the overall color temperature, i.e. one that is bluer and tends to flood the scene with burst of diffuse bright light. This is used to soften or eliminate undesirable facial blemishes and wrinkles.

Retractors: Two sizes of double-ended retractor are prerequisite to obtain a set of high quality intra-oral photographs. The large ends of the larger retractor are used to obtain retraction for the anterior intra-oral shot. The assistant should hold both retractors pulling them both laterally and also forwards, which is the opposite to the natural instincts of the assistants when retracting. By pulling the lips forwards towards the photographer it makes it easier for the patient to bite together in occlusion and pulls the soft tissues away from the teeth. To allow optimal soft tissue retraction the assistant passively holds the large end of the large retractor on the opposite side.[7]

For both occlusal shots the assistant inserts the small ends of the small retractors under the respective lips and rotates them towards the midline pulling the lips forward, as well as laterally. This is essential to prevent obscuring the teeth with the lips. The direction of pull is away from the teeth, and upwards for maxillary shots and downwards for mandibular shots, thus ensuring a background of the reflected mucosa rather than stretched vermillion.

Lighting Equipment: In most photographic lighting setups, the main or primary light is termed as the key light, while all others are secondary or fill lights. The first step is to choose the key light source according to the effect the photographer wishes to achieve. Once choose, the supplementary source can be added to complete the setup. For e.g. to show enamel or crown texture, the lighting setup should include 2 unidirectional flashes (one acting as the

key source and other as fill light) which will capture reflections with enhanced contrast.[4]

Figure 3: - The four sizes of retractors required

The primary factor in this technique is the use of umbrellas or a small "softbox" to modify the light source. A softbox is simply a box placed over the flash head that guides the light through a translucent panel in the front which functions as a diffuser. When light is shone through the softbox, a large diffuse light results. Softboxes come in several shapes and sizes, ranging from about 30x30 cm to 120x180 cm. Commercially available softboxes are usually lightweight, easy to attach to the flash head, and are often collapsible for transport and storage. Their sides are usually black on the outside and either matte silver or black on the inside.

Umbrellas for photography come in different sizes and colors and are used to diffuse or reflect the light. They usually attach to the studio flash unit with a bracket through which the umbrella is threaded to its straight handle. One of the most common photography umbrella styles is black on the outside and white on the inside. This type is designed to be positioned so the concave side of the umbrella points at the subject. As a result, the flash head is pointed away from the subject so it shines on the inside of the umbrella and soft, reflected light is bounced onto the subject. Other umbrellas have a silver or gold interior, which affects the color and reflectivity of their inside surfaces. These umbrellas are not designed to be shone through but rather to reflect light from the flash onto the subject.[8]

Another common type of umbrella is all white and translucent and is used to either reflect light or allow light to shine through to the subject. However, the translucency of the umbrella will lead to some reflecting light being lost.

Figure 4: - Diagram of a reflective umbrella positioned with the concave side of the umbrella pointed at the subject and the flash is shone on the inside of the umbrella.

Figure 5: - Diagram of a white umbrella positioned with the convex side pointed at the subject and the flash is shone through the umbrella imitating a softbox effect.

Professional flash heads usually come with a small reflector and an umbrella bracket, through which the arm of the umbrella is threaded and attached. Alternately, a collapsible softbox can be attached to most flash heads with an accessory bracket. The biggest difference is the shape of the highlight in the eyes.

Photographic setup for clinical photography:

As with all areas of photography, lighting is one of the key factors. Conventional lighting approaches using ring-flash or two studio flashes shining 45 degrees on each side of the face could result in the flattening of the depth of facial structures.

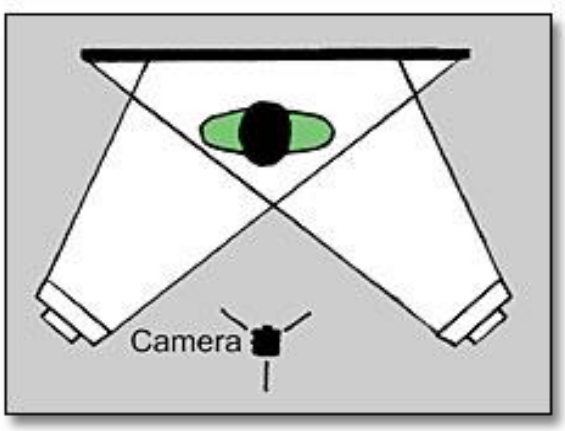

Figure 6: - Diagram demonstrating conventional lighting approaches using two studio flashes shining 45 degrees on each side of the face

The ring-flash does not have the power to evenly illuminate the subject, necessitating the use of large apertures and resulting in a shallow depth of field. Moreover the ring-flash might, from time to time, create a "red-eye" effect in the photograph.

Set up for clinical photography: Position the subject about five feet in front of the background and directly in front of the camera (to avoid any undesirable shadows from the subject onto the background). First, mount a powerful flash head on a sturdy light stand and attach a reflector and umbrella (or softbox) to it. The light stand is positioned at a high angle directly off to the side about 20-40 degrees, depending on which angle flatters the subject more. To judge the angles, turn on the flash head's modeling light and look at the scene from the camera angle. If a reflective umbrella is used to reflect the main light source, such as one that is black on the outside and white on the inside, the flash needs to be reflected into the umbrella and let it bounce back onto the subject.[8]

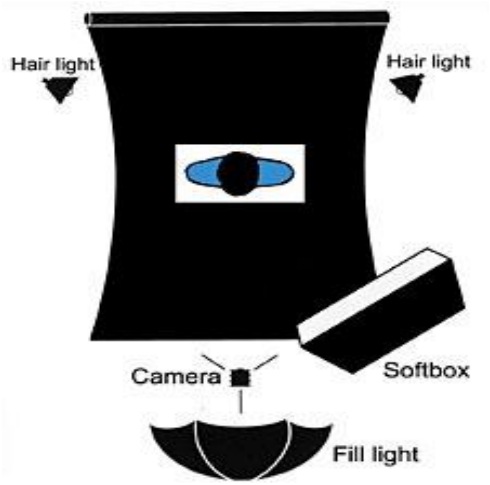

Figure 7: - Diagram of lighting setup for clinical photography.

It is difficult to produce satisfactory photographs of patients other than infants and children in prone or supine position. Such photographs require a greater working distance than achieved with the patient lying in the bed even if taken while standing on chair or stepladder. A short working distance means using an extreme wide angle lens, which will result in unacceptable distortion.

Babies before they can sit or stand can be photographed on physiotherapy mats, or several layers of blankets covered in a white sheet on the floor. Not only is this safer (they have nowhere to fall), but from a standing position a full length view can be achieved without distortion. The assistance of parent or helper is needed to position the child for lateral view and to gently extend his/her legs to show the full length.[6]

Dentofacial frontal view – It useful for detailed analysis of the lips in relation to the teeth.

This type of photograph is taken with either studio or compact flashes. The flash are placed at 45˚ and equidistant from the patient. The flashes should be covered with soft boxes or fabric diffusers to mellow the light output intensity.

Relaxed lips convey the amount of incisal exposure are rest, while contracted lips, during varying degrees of smiling convey tooth and gingival exposure.

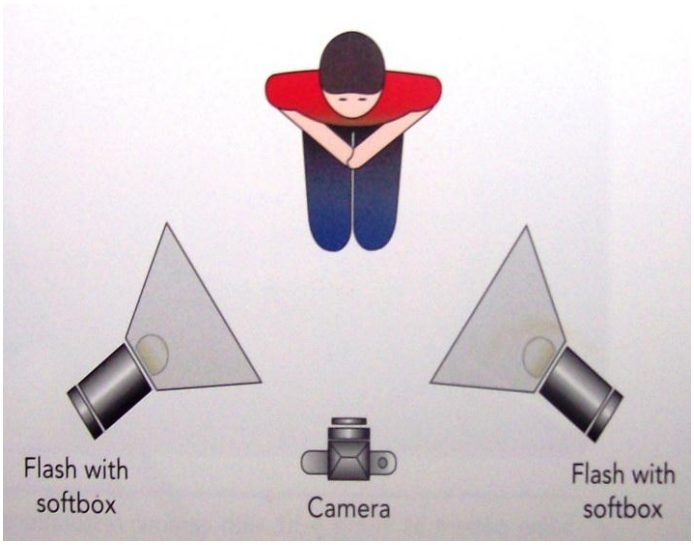

Figure 8: - Set up for dentofacial frontal view.

Dentofacial Lateral view: this type of view is useful for detailed analysis of the lips in relation to teeth. The inclination of the incisors can be assessed in regard to phonetics. Two identical flash with fabric diffusers units are used; first is placed directly opposite to lips, while second is directed opposite toward the chosen color card backdrop.

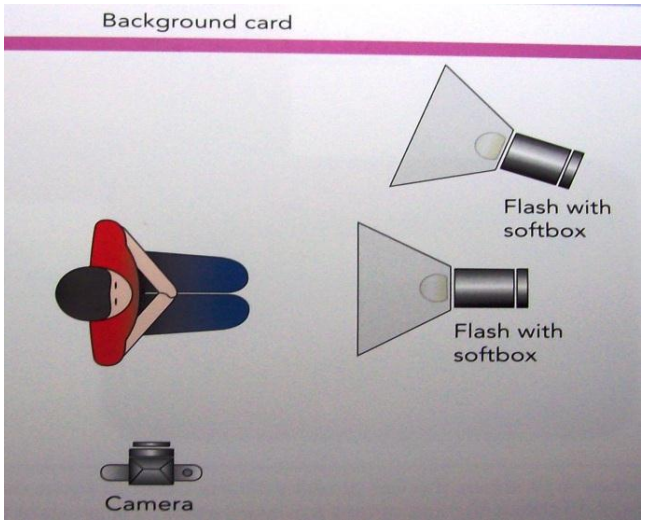

Figure 8: - Set up for dentofacial lateral view

Set up for clinical procedures: It is best recorded using uniform, bilateral illumination. This is applicable for most intraoral protocols since this relatively simple lighting set up expedites photographic documentation during what may be protracted treatment session. Two compact flashes with fabric diffusers are places equidistant from and at 45 degrees angles to the patient in the horizontal plane.

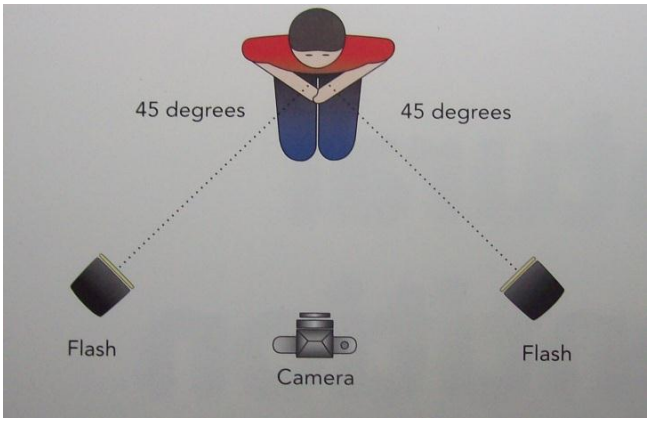

Figure 9: - Set up for the clinical procedures

Set up for anterior prosthesis: This set up is useful for highlighting defective prosthsis margins, clinical procedures, tooth preparation margins, gingival texture, occlusal view and capturing porosity and cracks in ceramic restorations. Assessment of pre-operative clinical status of prostheses is essential prior to treatment planning. The best way to photograph defective or under or over contoured crowns is to aim a compact flash with a fabric diffuser directly at the offending discrepancy. For restorations in maxillary arch, this is achieved by placing the illumination inferior to the patient in vertical plane and the setup is reversed for the mandibular arch where the illumination is placed superior to the patient in the vertical plane. The flash position needs to be angled according to tooth alignment to ensure the desired result.[4]

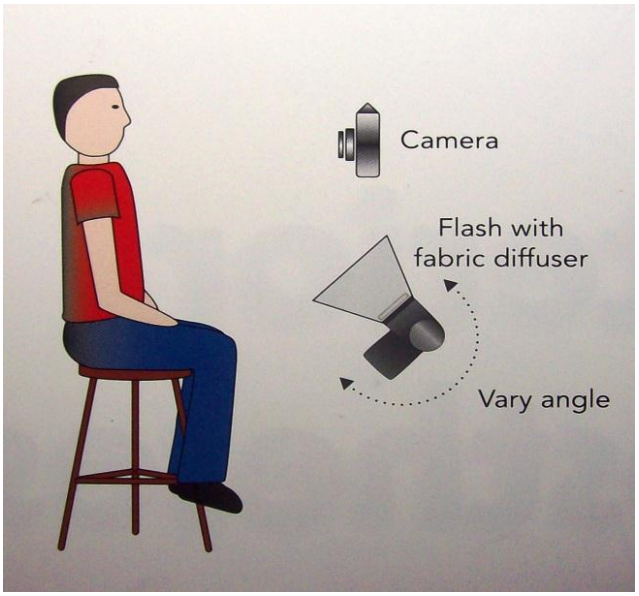

Figure 10: - Set up for recording anterior prosthesis

The buccal introral shots serve a very important function giving details of malocclusion. The patient should be told to close in centric relation for this photograph. If taken perpendicular to the tangent of the arch of premolar/molar are it can offer a greater deal of information as to the severity of malocclusion, the need for treatment and the difficulty of the proposed treatment. The upper and lower occlusal views can be used in assessing the space required for the particular case.[9]

Commercial SLR digital cameras when combined with the appropriate calibration protocols showed potential for use in the color replication process of clinical dentistry. The correct equipment is required for high quality clinical photographs, which include a camera with a macro-facility (ability to produce 1: 1 images) and, ideally, a ring flash, an appropriate background, suitable lighting and well trained assistants. Correct camera orientation is important, with extra-oral photographs taken in portrait mode and intra-oral photographs taken in landscape mode. To allow direct comparison of photographs taken at different time's consistent magnification of images is required. To aid this with conventional equipment a label can be placed on the barrel of the lens indicating the required lens setting (focal length) for each of the standard views.[7]

Recent Developments in Clinical Photography:

Kyocera Yashica are to be congratulated for their new model Dental Eye III (Figure 1), which contains many improvements over the Dental Eye II, which itself was a very popular camera in medical and dental circles. The first obvious improvement is the fact that the camera is smaller and substantially lighter than its predecessor.

Figure 11: - Dental Eye III by YASHICA

This system comprising of a clinical camera, specialized retractors, and a new occlusal mirror. The main advantage is the camera is smaller and lighter than its pre-decessor and the aperture control is placed on top of the camera body, and thus is directly viewable by the photographer.

The beauty of the Dental Eye, particularly in a multiuser situation, is the fact that few adjustments are required during use. A drawback of its predecessor was the fact that the exposure compensation switch (only required for mirror shots) was placed underneath the lens and thus was obscured from the direct field of view of the photographer or assistant. On the Dental Eye III, the aperture control is placed on top of the camera body, and thus is directly viewable by the photographer and assistant, both of whom can check whether it has been activated or not. An LCD panel, which is accessible and easy to read, is provided on top of the camera giving an indication of the number of frames that have been used[10].

Figure 12: - LCD and aperture control easy to read

Summary

Dental photography is a powerful and indispensable tool for the treatment plan presentation and patient education. Good photographic presentations and effective communication can immediately simplify the explanation of obscure dental terms, demonstrate or justify the need for treatment and enable clinician and their auxiliaries to present to patients completed cases that are visual testimonies to their professional capabilities. Digital cameras are easy to use, in terms of both making and storing the photographic images. Digital photography has greatly increased the ease of documenting treatment, which can be significant in not only a clinical sense but also a legal sense.

Familiarity with equipment and adherence to simple protocols can make all the difference between success and failure in clinical photography. A systematic approach is essential. This should extend beyond the photography itself to the handling and storage of photographs. Considerable attention should also be paid to legal and ethical issues before undertaking any clinical photography.

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