

American Dental Association
Technical Report No. 1029

Guide to Digital Dental Photography and Imaging



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AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1029 FOR A GUIDE TO DIGITAL DENTAL PHOTOGRAPHY AND IMAGING

The Council on Dental Practice of the American Dental Association has approved American Dental Association Technical Report No. 1029 for a Guide to Digital Dental Photography and Imaging. Working Groups of the ADA Standards Committee on Dental Informatics (SCDI) formulate this and other technical reports and specifications for the application of information technology and other electronic technologies to dentistry's clinical and administrative operations. The ADA SCDI has representation from appropriate interests in the United States in the standardization of information technology and other electronic technologies used in dental practice. Approval of ADA Technical Report No. 1029 was confirmed by the ADA SCDI on April 12, 2004.

The ADA SCDI thanks Scott D. Benjamin, Advanced Integration & Mentoring, Inc., Hancock, NY, as chairman of Working Group 12.4 for Digital Photography for leading the development effort.

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FOREWORD

(This foreword does not form a part of the Dental Association Technical Report No. 1029 for a Guide to Digital Dental Photography and Imaging).

In 1992, there was interest in the standardization of clinical information systems related to electronic technology in the dental environment. After evaluating current informatics activities, a Task Group of the ANSI Accredited Standards Committee MD156 (ASC MD156) was created by the ADA to initiate the development of technical reports, guidelines, and standards on electronic technologies used in dental practice. In 1999, the ADA established the ADA Standards Committee on Dental Informatics (SCDI). The ADA SCDI is currently the group that reviews and approves proposed American National Standards (ANSI approved) and technical reports developed by the standards committee's working groups. The ADA became an ANSI accredited standards organization in 2000.

The scope of the ADA SCDI is:

"To promote patient care and oral health through the application of information technology to dentistry's clinical and administrative operations; to develop standards, specifications, technical reports, and guidelines for: components of a computerized dental clinical workstation; electronic technologies used in dental practice; and interoperability standards for different software and hardware products which provide a seamless information exchange throughout all facets of healthcare."

This technical report was prepared by SCDI Working Group 12.4 for Digital Photography. The SCDI Working Group 12.4 chairman is Scott D. Benjamin. SCDI Working Group 12.4 prepared this report at the request of SCDI Subcommittee 12 for Informatic Component Interoperability in Dentistry (Brent Dove, Chairman).

AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1029 FOR A GUIDE TO DIGITAL DENTAL PHOTOGRAPHY AND IMAGING

INTRODUCTION

Although in its infancy in dentistry, digital photography, digital imaging and its management is exploding at an extraordinary rate. At present, the use of digital photography in dentistry has no set nomenclature, procedure codes, standards or continuity. The focus of this Technical Report is to provide basic information on the use of digital photography in dentistry and to facilitate the appropriate selection of the necessary equipment. This report further seeks to foster the interoperability of digital images and the information contained therein, thereby helping concerned parties to achieve consistent communication. The information provided will address the digital imaging needs of the various dental specialties, the general dental practitioner, other health care providers, the patient and any interested third parties such as insurance carriers, prosthetic and pathology laboratories. These discussions take into consideration interoperability requirements to insure proper identification, exporting and importing of the image and database management of the image.

To capture a quality digital image is not enough—the image has to have proper and standardized labeling of what it contains (the structures that are visible in the image) and the necessary DICOM descriptors of what, how and when it was captured. Tables 1, 2, 3 gives the practitioner suggested views for the dentition, soft tissues and extraoral, respectively. These tables include details of the structures expected to be contained within the images in the primary view; the relationship (angles) of the camera to the structures; and the occlusal relationship in the image so that images can be compared to subsequent images of the same region, even if captured with different cameras by different clinicians. These tables will be expanded in the future to include the appropriate DICOM descriptors. The establishment of consistent procedural nomenclature for the image needs to be established to make images truly exportable from database to database.

Digital dental photography requires the combined knowledge and understanding of the terminology of dentistry, computer technology and photography. Appendix A is a comprehensive glossary of dental digital photography terminology for use as a reference to help users obtain an understanding and consistent use of some of the most common photography terms and definitions associated with digital photography and camera use in dentistry. The definitions of most of the technical terms contained within the text of this document can be located within this glossary. The glossary's terminology and definitions are further intended to be consistent with a master glossary of terms developed for the overall field of dental informatics.

DIGITAL PHOTOGRAPHY

Digital photography means that the images are stored in a computerized file format often referred to as a digital image file. A digital image file comprises any computer file format that contains a graphical image instead of text or program data. Photographs and documents that have been scanned along with digital camera photographs end up as digital image files. There are basically two types of digital images—a bitmapped image and a vector based image.

A 'bitmapped' image contains information for placement of each and every pixel in the image. JPEG, PNG, GIF, TIFF and BMP are probably the most common type bitmapped digital image. JPEG, GIF and TIFF are readable in both PC and Mac format computers. All digital cameras and scanners produce

bitmapped digital images. Most 'paint' programs also produce bitmapped digital images. The other type of digital image is called a vector based image. This kind of image is produced in "paint or draw" and "illustration" programs. Such programs are not normally used in capturing photographic images but are used in manipulating or enhancing images after they have been captured. Vector images map the outlines of an image and fill in the areas inside the mapped areas with color. These file types are most often proprietary to the program that creates them as they are not usually displayable outside of the program that created them until they are converted into a bitmapped image.

The term DICOM is an acronym for Digital Imaging and Communications in Medicine and is a worldwide standard that provides a common language for formatting and exchanging medical and dental images and their associated information. A DICOM file (DCM) is a single compound file that contains both an image and text information about the image and allows for images to be captured and communicated in a common format across the entire healthcare industry. The DICOM standard permits devices and files, from conforming vendors, to "talk to each other" across an open system.

PHOTOGRAPHIC SYSTEMS

A camera is only a part of a photographic system. With conventional film systems, film acts as the capturing and storage medium for the image. Chemical processing and printing, or projecting the slide, complete the system with a printed picture, negative and/or slide the permanent storage of the image.

With digital photographic systems the camera and flash perform the same function, but place the image on the digital sensor instead of film when capturing the light image. The digital camera, however, also has software (sometimes referred to as firmware) that converts the image to a digital format. The picture or digital image is digitized by the sensor within the camera and is converted into a computerized image file (vs. the photochemical processing of film that is done in a photographic lab). The camera's software then places the file in a temporary storage media (such as a flash card) normally contained within the camera. At this point the digital images can be transferred (downloaded) into a computer where they can be displayed, edited, manipulated, e-mailed, printed or incorporated into any document almost instantly.

Film photographic capture process consists of the following path:

Subject → Lens → Film → Sent to photographic lab →
Chemical Processing (Developing) → Printed or mounted in slide →
Returned from lab → View Image

Digital photographic capture process consists of the following path:

Subject → Lens → Sensor → Digitized to File → Transfer to computer or printer →
→ View image

After the image file has been placed onto a computer's hard drive, it can be retrieved and viewed almost instantly at the viewer's discretion. The image file can be duplicated or placed on a long term storage device such as a CD or DVD for its safekeeping without any loss or degradation in the image's quality.

Once the digital image file has been created, the quality of the image is limited to the information that has been stored and, more importantly, the limitations of the displaying mechanism (monitor, projector, or printer). With all systems the final quality of the viewed image is dependent on the weakest link in the

system, which with still digital photography is almost always the monitor's resolution or the printer and paper quality. The weakest link with intraoral video cameras is presently the throughput (amount of information that is past in a period of time) allowed by the computer, usually limited by the video capture card resolution capabilities (commonly 640x480 or approximately 0.3 megapixels).

DENTAL DIGITAL PHOTOGRAPHY

Presently, digital dental photography is captured or recorded in one or a combination of ways with varying success and quality:

- Captured with a traditional film camera and then digitized into a computer file using a scanner;
- Using an intraoral camera connected to a video capture card, USB or an IEEE 1394 Port (firewire);
- Using a standard video (VCR) camera or camcorder and digitized by being processed by a video capture card or imported through an IEEE1394 port ;
- Capturing the image with a still "photographic style" digital camera and downloading the computerized files from the camera to a computer with various mechanisms;
- Using a web style camera that normally connects to the computer via USB port or IEEE 1394 Port;
- File transferring, where the images are being transferred from one computer to another.

Direct digital photography, which converts the images almost immediately into a digital file, has many beneficial advantages in dentistry, such as:

- Images can be visualized almost immediately;
- Allows for immediate retakes when needed;
- Can make 100% exact duplicates;
- Media can be reused meaning no additional cost of film or its chemical processing;
- Single media can hold many images;
- Ease of manipulation;
- Images can be easily stored and catalogued;
- Images can be instantly forwarded or transmitted to interested parties, such as: patients, labs, colleagues, insurance carriers, and web pages among others.

INTRAORAL CAMERAS

Intraoral video cameras have been used in dentistry since the 1980s. They were first designed to

display images on an analog (television) monitor. These images were saved initially only in printed form using a dye-sublimation printer, or to a VCR-style tape to be replayed on the television monitor. Beginning in the mid-1990s, the intraoral camera could be connected to a computer with a video capture card, sometimes referred to as a “frame grabber” due to its ability to “capture,” or save the image displayed on the monitor. The resolution for these captured images was limited to the capability of capture card. At 640x480 pixels, they were (and still are, for the most part) greatly inferior to 35mm film and the resolutions of handheld photographic-style digital cameras. Due to computer speed and storage limitations at that time, the images were compressed further before they were saved on these computers’ hard drives, causing even more degradation to the image.

Today some intraoral cameras are able to be connected directly to a computer’s CPU through its USB or firewire (IEEE 1394) ports. Although these connections should allow for higher resolutions, intraoral cameras still provide only 640x480 resolution, and most cameras still use video capture cards for acquiring images. With hardware improvements that allow increased processing and networking speeds, however, many of today’s image management programs allow the operator to save images without further compression.

Some advantages of intraoral cameras over handheld photographic-style digital cameras are a wand-shaped handpiece that allows easier and better access to most regions of the oral cavity; and the instantaneous image display on the monitor for immediate review.

STILL “PHOTOGRAPHIC-STYLE” DIGITAL CAMERA

Digital cameras have been the biggest innovation in photography in over 100 years. They give dentistry a myriad of benefits that cannot be obtained with a film camera. Today more digital cameras are being sold to consumers than film cameras. In 2003, the number of digital cameras sold has increased by 36%, while the number of film cameras purchased has decreased by 15%. This trend is expected to continue at increasing rates.

When the still photographic camera is compared to other types of cameras, the resolution (clarity) of almost all still digital cameras is superior to that of video and intraoral cameras. The newest high end professional digital still cameras for commercial photography have resolutions that even exceed film. Depending on the speed (ASA) of the film to which it is compared, a still digital camera with a resolution of 6 megapixels has the ability to capture an image that is a equivalent to that of 35 mm film. Remember, however, that capturing is only part of the photographic process and the displaying of the image is usually the limiting factor whether it is a film or digital image.

When selecting a digital photography system for a dental office, evaluation of the entire system, its processes and the related workflow is extremely important. The following questions are only some of the issues that need to be addressed in the selection and implementation process:

- What images are to captured?
- How may images are to captured at one time?
- What is the image quality needed or required?

- What type of illumination will be needed?
- What lens or magnification is needed of each image?
- How and what the images will be use for?
- Who will take images and under what circumstances?
- How images will be transferred or downloaded from the camera?
- What computer hardware and software will be required?
- How and where will the images be displayed?
- How images are to be manipulated, such as will you be doing cosmetic enhancements or shade matching?
- How and where images will be printed?
- How and when images will be printed and/or electronically transferred to third parties, such as pathology labs, prosthetic labs or insurance carriers?
- Where the camera will be stored
- How are the batteries to be maintained for the digital photographic system?

HOW DIGITAL CAMERAS WORK

A digital camera is very similar to a traditional film camera in the way photographs or images are taken (captured). The major difference in the process is what occurs inside the camera rather than what the operator does. When a digital camera is turned on in the capture mode, the sensor is charged and prepared for a picture to be taken. When the shutter button is pushed, the shutter opens and light enters the camera. The light image strikes the sensor instead of film. The light is measured electronically on the sensor and this information is sent to the internal memory of the camera, called the buffer. The image is then converted into the selected file format (such as JPEG, TIFF, BMP, or proprietary format). The completed image is then transferred to the camera's memory storage media.

Some cameras require this process to be completed before the next picture can be taken, though some higher end cameras have an internal buffer large enough to allow multiple pictures to be taken as the previous images are processed. This capability is called burst shooting.

DIGITAL SENSORS AND SENSITIVITY

The image-capturing device in most digital cameras is either a Charged-Coupled-Device (referred to as a CCD) or a Complimentary Metal Oxide Semiconductor (referred to as CMOS) sensor. CCD sensors are the most commonly used sensor. They have more sensitivity to light and a better image quality than CMOS sensors, but they are more expensive to manufacture and use a process that consumes as much as 100 times the power than the equivalent CMOS sensor. CMOS sensors have transistors

located next to each pixel, so the pixels have to be spaced farther apart, meaning there are less pixels per inch. This causes more “noise” in the raw image. Due to the fact CMOS sensors are less expensive and consume significantly less power, they are used in the very high end professional cameras, where these factors are critical. Such cameras may have sensor resolutions as high as 14 megapixels, which far exceeds the present needs of the dental professional.

The digital sensor is made up of millions of tiny photosensitive diodes called photoelements; each of which captures a single pixel that records the amount of light that hits it. Each pixel only records the amount of light that hits it, not the color. To record color, a red, green or blue filter is placed over the individual sensor. When filtered light hits the sensor, the individual pixels convert the amount of light hitting them into an electronic signal by accumulating an electrical charge. The charge is measured and converted to a digital number, which is originally stored as an analog signal that is converted into a digital signal by a component called an analog to digital (A-D) converter.

Film's sensitivity to light is measured by its film speed with an ISO or ASA rating, which normally ranges from 25 (the least sensitive to light) to 400 (the most sensitive to light). As film speed increases, images become grainier or appear “fuzzy.” The shutter speed can be increased, or aperture opening decreased to possibly get an overall improved image in some situations. Increasing the ASA or ISO on a digital camera increases sensitivity of the sensor, but this also increases noise, which decreases resolution.

To increase the sensitivity of the sensor the bite depth of each pixel is increased to more accurately record the amount of light hitting it. An 8 bit image has 256 colors, a 16 bit image has 32,000 colors and a 24 bit image has 16.7 million colors. The higher the number of colors the more information the computer can use during the interpolation of the image.

The actual image and color is determined by averaging the pixels with the others in the area. The information is read one line at time into the camera's internal memory. As the information is passed it goes through internal filters to correct white balance, color and aliasing. The higher the bit depth the more vibrant and possibly accurate the color in the image; however, higher bit depth images will create larger files, requiring more storage space. The uncompressed image can then be compressed, if the operator desires, through either lossy or lossless compression, or transferred uncompressed to the camera's storage media or the computer.

RESOLUTION

Resolution is a measurement of the quantity of information captured by a digital camera or scanner. Generally, the more pixels that capture the image; the better the resolution. Though the number of pixels is just one dimension of resolution and image quality, it is the most often used for image evaluation. Dynamic range, or the difference between the highest and lowest light levels recorded, and bit depth – the number of tones captured – are other very important factors in accurately recording images.

Printers usually measure resolution in terms of dots per inch (dpi). When printing images, the larger the printed image, the higher the resolution requirements for the captured image. An image printed at a resolution of 300 dpi that is 3-in. × 5-in. requires an image resolution of 900 x1500, or 1.35 megapixels. An 8-in. x 10-in. printed image at 300 dpi would require an image of 2400 x 3000, or 7.2 megapixels, to

achieve the same quality. Therefore, greater resolutions are necessary to print larger high quality images.

The goal and desire of most clinicians is not to print images but to view and enhance them on computer screens. Computer monitor and projector display resolutions are quite low in comparison to printers. Most computer projectors and dental management programs have their display resolution set at 1024 x 768, which means the maximum image that could be displayed at full screen size at this setting is only 786k, or approximately $\frac{3}{4}$ of a megapixel. This means that in a 1-1 pixel relationship with no cropping or digital zooming of the image, a monitor or projector set at 1024 x 768 would not be able to display all the information captured by a simple one (1) megapixel camera. A high end monitor and display adapter with a resolution of 1600 x1200 still has a maximum resolution of only 1.92 megapixels.

However, because most digital cameras have a digital zoom lens, and dental clinicians typically desire to enlarge images, these guidelines recommend utilization of a digital camera with a minimum of 2 megapixels, or preferably 4 megapixels. This level of megapixels allows for the enhancements and still produces a high quality image. It is best to capture and save all images at high resolution and remove or crop the unwanted areas when viewing as this will maintain a high quality image. When an image is resized, pixels are removed or added throughout the entire image. When an image is cropped pieces (pixels) are removed only from the area removed (trimmed). Digital images consume a large amount of hard disk space; however, the cost of storage is insignificant when looking at the overall system.

IMAGE ILLUMINATION AND FLASH

The properties of the digital sensor and the coordination and relationship of the illumination techniques are one the most important issues in obtaining a quality image. There is wide variation in the quality, consistency and accuracy of colors captured by all cameras; this is especially true with digital cameras. As mentioned above, proper display of the image is extremely important, but if an image is not accurately captured it cannot be consistently displayed or transferred. Color is captured in digital photography with the use of red, green and blue (RGB) filters on the individual pixel. The pixel only records the amount of light that stimulates it, making the coordination of consistent illumination and the digital sensor paramount in obtaining accurate color image files.

Some of the basic factors that relate to the consistency in the illumination and color accuracy used in dental photography are:

- The intensity (brightness) of the light source;
- The color temperature of the light source;
- The amount (intensity and temperature) of natural/room light;
- The distance of the light source to the subject;
- The angle of the light source to image and sensor;
- The distance of the camera (sensor) to the subject;

- The properties of the filters on the sensors;
- The software processing of the data;
- The ability to control any or all of the factors.

There are basically two types of flash units used routinely in dental photography. The on-board point flash that is incorporated into and is an integral part of the camera, and an external flash that is often a ring light that circles the lens, or a boot flash that slides into a bracket on the top of the camera. Each of these types of flashes has its advantages and disadvantages. Due to the need for illumination in all dental images, the use of a light meter that measures the natural light and recommends the aperture and shutter speed has little value and the best images are obtained with automatic or predetermined settings for each type of exposure.

With a point flash, the light source is from a single point and most of the light is on the same vector. This can create a "hot spot" or reflection caused by a direct bounce back effect of the flash off the subject (teeth). A point flash is usually located above, or to the right, or left of the lens. This separation of the light source from the lens also can create uneven light or shadow, especially with close up or macro focus exposures.

This is a particular problem with the pop-up style of flash that moves the light source even further from the lens. The closer the flash is to the lens of the camera, the less shadowing will occur. The farther the camera is away from the subject or object, the lighting will become more uneven and shadowing becomes a factor. The major benefit of an on-board flash is that the camera manufacturer has the ability to calibrate the sensor, the acquisition processing software and the flash for correct (auto) white balance at the desired distance, enabling the user to obtain a consistent, correct and accurate image. Another benefit of the on-board flash is that it uses power from the camera, meaning that there is only a single set of batteries that have to be charged and maintained.

An external ring flash illuminates with a circle of light around the lens, creating even light from many points (vectors), which reduces shadows and helps insure proper illumination. However, a disadvantage of external flashes is that they are not calibrated by the manufacturer of the camera to match its filtering system, sensor, white balance, or acquisition processing software. This often creates an image that is not properly illuminated or that is not color accurate. Another concern with an external flash is that there is a second set of batteries that has to be maintained and charged.

FLASH COMPENSATION & DEGRADATION

Flash output compensation allows the camera to be preset to adjust the value of flash power output. Some digital cameras allow this value to be set using the EV (exposure value) range, while others simply have a high, normal and low setting. Regardless of the type of flash used, it is extremely important that the same settings and distances are used once the system has been calibrated, because light intensity and value change with distance, affecting image quality. The use of a distance guide attached to the camera can help insure proper distancing and correct illumination of the subject so that similar consistent images can be captured at any time. A flash's output will gradually degrade as the batteries discharge. A flash with weak batteries will give off inconsistent illumination and affect the quality of the captured image.

WHITE BALANCE

White balance is a term given to the color correction system that deals with differing ambient lighting conditions. Most digital cameras feature automatic white balance, meaning that the camera looks at the overall color of the image and calculates the white balance. Most digital cameras allow overriding the automatic white balance. One can choose the white balance manually, or set a custom white balance, which simply means calibrating from a known white reference and then using it to correct all images until it is reset. Typically all dental images require additional illumination, thus, ambient lighting conditions are somewhat irrelevant. Properly adjusting the camera's white balance with the on-board flash for the desired distance will drastically affect the color of dental images and will often create a color accurate image file.

APERTURE

The aperture is an adjustable diaphragm of overlapping blades that can be thought of like the iris of the eye. It controls how much light enters the camera and is also referred to as the *f*-stop. The aperture setting has a direct effect on depth of field and the required shutter speed of the exposure. The value of the *f*-stop represents a ratio of the equivalent focal length of a lens to the diameter of its entrance opening. The smaller the *f*-number, the larger the opening of the aperture. For example, *f*/2 means that the opening is half the diameter of the lens, while an aperture of *f*/22 means that the aperture is 1/22 the diameter of the lens.

DEPTH OF FIELD

Depth of field refers to how much of the image is in focus both in front and behind the main focus point of the image. It is primarily affected by the subject, distance and aperture. In dental images, with the closeness of the subject at fixed distances, the depth of field is relatively small and the only control is the aperture, which is normally automatically set by the camera. A large aperture (smaller *f*-stop) will have a shallow depth of field, meaning that anything behind or in front of the main focus point will be blurred and out of focus. A smaller aperture (larger *f*-stop, e.g. *f*/22) will have an increased depth of field, meaning that objects within a certain distance both in front or behind the main focus point will also appear sharp and in focus (hopefully containing an entire arch or quadrant when needed).

LENS

Digital sensors are quite small in size in comparison to 35 mm film, which is why digital cameras normally have lenses that are specially designed for them and are not removable or interchangeable. Some of the more expensive digital cameras have compensated for this, but at a considerable optical expense.

The focal length of a lens is measured in millimeters from the center of the lens to the film or digital sensor; different lenses have different focal lengths. Some lenses have fixed focal lengths, however, most digital lenses have zoom capabilities and can change focal length. Zooming in increases the focal length and zooming out reduces the focal length. The shorter focal length, the wider the angle of view; the longer focal length, the more magnification it produces and the narrower angle of view.

The ratio that relates the lenses that are used on film camera to most digital lenses is approximately a 1:1.6 ratio. This means that a 100 mm lens on a digital camera produces an image equivalent to that produced by a 160 mm lens on a film camera, making close-up views larger with digital cameras. It also makes wide angle images more difficult. This means that a practitioner's existing lenses might fit a

digital camera, but the framing and distancing of the subject may be unacceptable to acquire the desired image. Remember, in dentistry a close-up view is usually more desirable than wide angle views.

Most digital cameras with non-removable lens have a zoom capability that may be either an optical or digital zoom or, more commonly, both. An optical zoom functions by changing the focal length of the lens with no loss or decrease in resolution. When an optical zoom lens reaches maximum optical magnification, many digital cameras will “increase magnification” with “digital zoom”. With digital zoom, the camera enlarges the center of the image and crops away the edges, thus decreasing the image resolution. An image manipulating software program can achieve the same effect as the digital zoom. The clinician is best advised to make full use of the optical zoom and to use the digital zoom only when needed and to help simplify the editing process. Having a zoom lens that increases magnification in incremental levels allows the practitioner to record the amount of magnification used to capture an image, making it easier to recreate the image capture in the future.

Most digital cameras have an autofocus feature that will automatically focus the lens on a specific area within the subject area, simplifying the capturing process. Some, but not all, digital cameras permit the focus to be set manually, giving the photographer complete control of the focusing process.

LCD VIEWER/TTL/VIEW FINDER

When viewing or “framing” the subject area before capturing the image, there are three basic mechanisms the clinician can use. The most accurate way to select the image is by viewing the subject through the lens (TTL) that captures the image. This process is accomplished in one of two ways. The first employs mirrors, which reflect the image through an eyepiece held to the eye. This technique is often referred to as single lens reflex (SLR). Standard on most 35 mm film cameras, it also is found on some digital cameras. The TTL technology used in most digital cameras is an LCD display, which is a small display screen usually located on the back of the camera and shows in “real time” the image that is hitting the sensor. The LCD screen also is used by the digital camera to display the captured images that have been stored in the camera's on-board memory. An operator using the LCD display does not have to hold the camera to his eye to properly align the subject, permitting him to properly capture the image without invading the patient's space. This screen is also valuable in showing the immediate playback of an image once it is captured, allowing the operator to verify that the desired image was captured and properly framed. The limitation of LCD screens is that they are usually too small to verify proper focusing and color accuracy, and consume large amounts of battery power.

The other mechanism for viewing or framing the image before capturing is a viewfinder, which has the operator looking through an eyepiece on the camera that has a separate lens that is parallel to the primary capture lens. This technique can be very problematic with the close-up images that dental photography requires, because the offset angle of the viewfinder is not viewing the exact area the sensor is capturing. The primary benefits of viewfinders are that they are inexpensive and require no battery power.

REMOVABLE MEMORY

High resolution digital images are large files that can be difficult to manage. The storage card (media) in a digital camera is its “film” that holds the images taken with the camera. Most digital cameras have some form of removable media to store files temporarily within the camera before they are transferred (downloaded) to a computer. While temporary storage is important, the advantages and differences in

the various formats are not very significant in dental digital photography. Almost every type (or format) presently available has media available with enough capacity to hold a complete set of images from any patient encounter. Some of temporary storage media formats presently available are:

- PCMCIA / PC card;
- Flash memory card Type I;
- Flash memory card Type II;
- High capacity removable hard drive;
- SSFDC (solid state floppy disk card);
- Stick-type memory flash memory;
- SD (secure digital card).

For simplicity and convenience in file management, all the images should be downloaded into the computer's image management system after each patient encounter. If this is not possible, the clinician should consider utilizing multiple removable cards for the camera to insure the camera has the necessary storage space available when needed.

TRANSFER MECHANISM

After the images have been captured and stored within the digital camera there are several mechanisms for transferring the images to the computer or printer to be utilized. Some examples of these transfer mechanisms are:

- Auto-connect through USB or "Firewire" IEEE 1394 port;
- Docking station;
- Media card reader;
- PCMCIA /PC card adapter;
- Floppy disk adapter;
- Serial port connection.

An auto-connect feature allows the camera to connect to the computer's USB or "Firewire" (IEEE 1394) ports and be recognized as if it was just another drive on the computer. It allows a "drag and drop" or a "cut and paste" type of mechanism to move or transfer the images from the camera storage medium to the computer without the need for any special software. The cabling used for these connections uses a standard USB or IEEE 1394 connection on the computer end, but normally has a smaller device specific connection on the camera end.

Some cameras include a docking station as a part of its system, with software that allows the user to automatically (or semi-automatically) copy or transfer images from the camera's storage media to the computer or printer with a one-step procedure. The software usually allows the user to configure it to transfer images to a specified location on the computer or network and to remove (erase) images from the camera's media after transfer, making the camera immediately ready for use with the next patient. An advantage of most docking stations is that they are always connected to the computer and ready for use without requiring the user to attach any cables or manipulate the media card when transferring images. Another major advantage of a docking station is that, when properly located, it provides an ideal location for storing the camera when not in use; and most docking stations will automatically recharge the camera's batteries while it is in place.

One of the most common image transfer mechanisms is the use of card readers or adapters, which read (and can write to) the removable media of the cameras. While many adapters can only utilize one type of media, many other card readers are configured to use multiple types of media that are presently available, with each format or type appearing as a different device (or drive) on the computer. To use these card readers or adapters, the clinician must physically remove the media from the camera and place it in the device. While in the adapter and reader the computer recognizes the media as if it is a drive on the computer. The media must be erased and replaced in the camera before it can be used again.

A serial port connection is slower than the other transfer mechanisms and requires device specific software. It is rarely used with modern computer operating systems and newer camera models.

IMAGE OR FILE COMPRESSION

Image or file compression utilizes mathematical techniques to reduce the amount of digital data (file size) required to store individual digital images. There are numerous algorithms (formulas) that can be used to achieve lossless (such as TIFF LZW) and lossy (such as JPEG) image compression. The degree of compression, which can cause losses and distortion of the image quality, usually can be user-specified depending on the ultimate quality needed. Some of the considerations of image file compression are:

- It can make large files smaller and more manageable;
- Lossless compression causes no image degradation;
- Lossy compression allows for image degradation;
- More compression results in poorer images;
- Less compression results in better images;
- JPEG (Joint Photographic Experts Group or JPG format) allows for variable compression.

Lossless file compression schemes make a file smaller without degrading the image – after compression and decompression (restoring), an image is numerically identical to the original image pixel-by-pixel. Thus, lossless compression is said to be non-destructive to image data when used. The

amount of lossless compression is dependent on image detail, noise, resolution, and bit depth. It is the ideal type of compression to use in health care because of the integrity of the images.

With lossy file compression and decompression, the image will be degraded relative to the original image. Lossy compression allows for much higher compression ratios. The resulting degradation, which is dependent on the amount of compression and viewing conditions, may or may not be apparent to the viewer. This compression scheme reduces the size of a file size by throwing away “unnecessary” data, but degrades it in the process; it cannot be restored to its original quality. The commonly used JPEG (JPG) image format is a lossy compression method, therefore causing degradation in the image. However, the JPEG format allows the operator to control the amount of compression, thus controlling the amount of degradation of the image. Consideration needs to be made for the value of file size (speed and disk space) versus the need for image quality.

BATTERIES AND POWER MANAGEMENT

In the selection of a digital photographic system, power consumption and management are areas of major concern because all processes in the digital realm are dependent on electrical energy. Digital cameras and their flash attachments require consistent dependable energy for the capture, display and transfer processes to perform dependably and accurately. The LCD display, flash, and transfer processes, particularly, require a significant amount of energy.

Most cameras have the capability to execute their various processes using power from batteries and/ or AC adapter. Batteries have to be replaced or recharged regularly, making battery management a potential problem that needs to be addressed as part of the office workflow. An AC adapter creates the dilemma of needing to be plugged into an outlet, making cable or cord handling problematic in the clinical environment. One of the best power management systems is a camera with a docking station, which recharges the batteries whenever the camera is placed in the cradle and uses AC power to transfer the images to the computer. Using a docking station may insure the camera’s batteries are always charged and the camera is ready to be used. A docking station will not recharge the batteries in an external flash, so attention still needs to be focused in that area if an external flash is used.

DIGITAL IMAGE MANAGEMENT

Digital image management can be divided into two separate areas, database management (cataloging or storing and retrieving the images) and image manipulation. Most consumer-oriented digital camera systems will contain image database and manipulation programs that work well for the home user for downloading or transferring images from the camera to the computer, but are normally not sophisticated enough for most dental applications. Many practice management software systems will also handle basic image database management. Dental specific image manipulation software programs allow the operator to simulate treatment options for patients, such as whitening, diastema closure, bonding, and prosthetic procedures. Most dental image manipulation software programs perform both management and manipulation.

Shade matching systems may be strictly software programs, or may require use of system specific cameras or capturing devices. These programs analyze the information within a digital image and compare it to known values to produce a map of the shades within the image. This information can be of particular value to dental laboratories and technicians in prosthetic cases and to quantify changes in the dentition for bleaching procedures.

SUMMARY

Digital photography, like many of the newer electronic technologies, offers significant benefits to dental practices. The key to successful utilization is to incorporate the technology into the practice in a way that makes efficient use of its capabilities without adding unnecessary administrative overhead. The inherent efficiencies of digital photography make it extremely beneficial, however, the practitioner needs a basic understanding of computer technology and standard photography for proper utilization. Proper selection and implementation of the appropriate photography and computer equipment, combined with the necessary training and correct workflow patterns, makes incorporating digital photography images into the patient's clinical record an easily obtainable goal. Training and utilizing the correct staff members to acquire and manipulate the images can make the process cost effective and beneficial to both the practice and the patient.

With increased standardization and use of the DICOM Standard, the ability to share images throughout the healthcare industry will increase efficiency and quality of patient care. The improvement in the standard of care is the goal of all dental procedures and modalities that are performed in dental health care.