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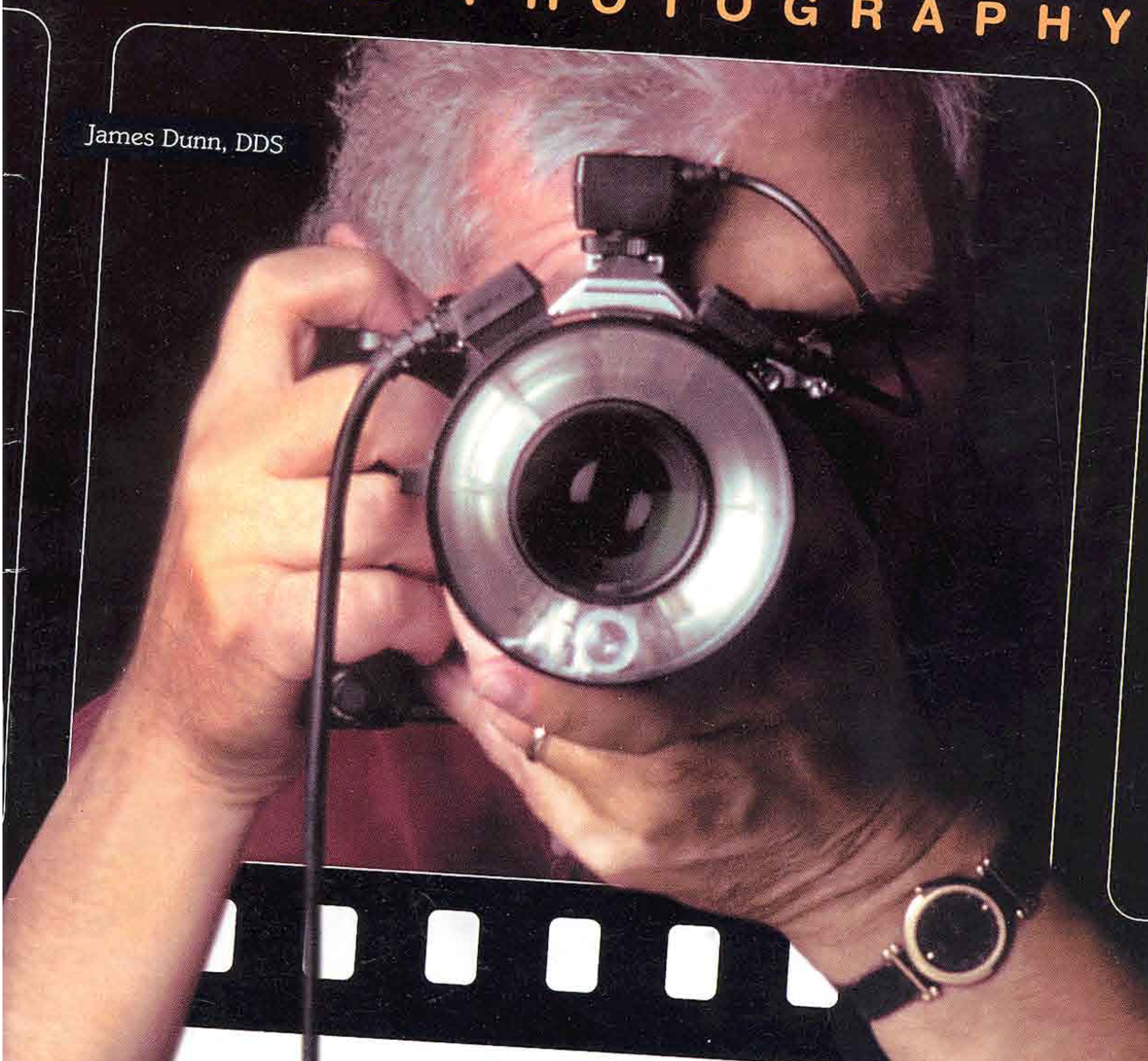
DENTAL PHOTOGRAPHY



James Dunn, DDS

OF THE CALIFORNIA DENTAL ASSOCIATION
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DEPARTMENTS

FEATURES

Change With the Leaves

Steven A. Gold, DDS

Autumn is upon us, and it is a reminder to many of the constant change in our environment. I grew up in Virginia, where in the distance, one can see the Blue Ridge Mountains gently rise and fall along the horizon. If we were there right now, we would be dazzled by an endless array of autumn colors as cooler temperatures and shorter days cause the dense summer foliage to give up its green. In a few weeks, this vibrant fall palette will be gone, yielding to the barren brown of trees and earth and the gray of winter skies.

Too often, change is viewed in negative light. To change, we must leave a place in which we are comfortable and move to one in which we are not. This can result in anxiety, uncertainty, and fear. Changes within the dental profession are no different than in other aspects of our lives. Practicing dentistry becomes a series of skills that improve with repetition. Changing the way we do something will typically cause a temporary lapse in the quality of our performance. This is why, I believe, most dentists do not readily embrace changes in the way they practice or in their profession.

I would like to offer a different perspective on change. Sometimes we consciously make changes in our lives that initially make things more difficult for us, but which ultimately lead us to better places. When we look at changes that have occurred in the dental profession in recent years, it is easy to see that many have had a profoundly positive influence on our patients and on us. Take, for instance, the discovery made in the late 1960s by Dr. Rafael Bowen. The new restorative material he developed, which we know as composite resin, and the technique of bonding that material to tooth forced dentists to change the way they practiced dentistry -- from restoring teeth, to treatment planning, to implementing preventive techniques. Few would argue against the fact that the addition of composite resin to our dental armamentarium has dramatically improved the quality of life of many thousands of patients worldwide.

A change that occurred even earlier in the last century was the introduction into everyday practice of safe and easily administered local anesthetics. Most of us have patients whom we have heard bemoan the days of their childhood visits to the dentist, when they often had dental treatment performed without anesthetic. Today we are able to render virtually painless dentistry. As a result, we are able to perform technically difficult procedures with greater ease because our patients are more comfortable. New generations of dental patients are growing up without ever experiencing the pain and suffering that their parents and grandparents did.

The list of improvements in dental technology over the last century could easily fill an entire issue of the Journal. Their common thread is that each required dentists to learn new information and acquire new skills and, at the same time, abandon the ways of the past.

Sometimes changes occur in our profession that may initially raise controversy or divide us. With mutual understanding, cooperation, and a willingness to change how we practice, these new concepts have also immensely benefited our patients and the profession. The 20th century saw a change in types of dental practitioners with the birth of dental specialties. We have seen vehement opposition to the recognition of new specialties in the dental profession by those who feel it will further fragment us or by those who fear personal loss of control or a diminished scope of practice. The development of dental specialties, however, has unquestionably raised the level of care we, as a profession, are able to provide our patients. I'm sure there are many practitioners amongst us who have gladly referred out a difficult case to a capable specialist because they could not or would not want to treat it.

On a similar note, we have seen the creation and development of dental hygiene as a viable allied dental health profession. Dental hygienists have taken their place alongside dentists, becoming prominent and important members of the dental team. This group of highly skilled and dedicated individuals has been responsible for elevating the periodontal health of our patients to substantially higher levels, allowing many of our patients to maintain most or all of their natural teeth for a lifetime. While the relationship between the dental and hygiene professions has been tenuous at times, the ability of both groups to work through their differences has and will continue to be of direct benefit to patients.

We also face changes that are beyond our control and, if unchallenged, may have a profoundly negative impact on us. Through a united effort of all dental professionals, we cannot only overcome these potentially damaging challenges, but also turn them into positive changes. The Chinese express this concept in their philosophy. One saying translates, "Where there is crisis, there is opportunity." Recall the AIDS dental "crisis" of the 1980s. When news of a potential transmission of the disease from a Florida dentist to several of his patients made its way into the headlines, we feared the public's trust in the safety of dental visits would be forever diminished. In response to this challenge, the dental profession rallied. New infection control standards were developed and quickly accepted and implemented. In fact, amongst the health care industry, dentistry became the model for the practice of these new standards. Fear or erosion of trust on the part of patients was replaced by a renewed sense of security and respect for the profession.

What will spawn the next great changes in the dental profession? What challenges must we face? Some are already on the table in front of us: the controversy over and challenge to the use of amalgam, a growing crisis in dental education, escalating debt of dental school graduates, even the restructuring of this association to meet the ever-changing needs of its members. I would argue that somewhere in all of these challenges lies opportunity for positive change.

Let us resolve not to view change as a negative experience but rather as an opportunity on which we may grasp and elevate our profession and ourselves. Change is a natural phenomenon and the more readily we accept this, the more likely it will be a positive experience. Even as autumn leaves change, fall, and fade into memories, we know that it is only nature's way of preparing us for the new color and new life that spring promises.

Dentists Find Ways to Balance Family Life, Career

By Janyce Hamilton

In California, half of all children have two working parents. Not surprisingly, as dentists become new moms and dads, few quit the profession to stay at home. Instead, the balancing act begins.

Just how well-suited is a dental career to juggling parenting? And, is there time leftover for a mate, let alone oneself?

"I went into dentistry thinking it would be more flexible," Ariane Terlet, DDS, Berkeley, Calif., begins. "Obviously, you can set your own schedule, but you are responsible to pay the bills. Ultimately, what determines how much work you do is the bottom line."

Judee Tippet-Whyte, DDS, of Stockton, Calif. (children ages 6, 9, and 13), thinks dentistry isn't much different than other careers when it comes to the balancing act.

"As your own boss, you're flexible to work as many hours as you want, but it's less flexible if a girlfriend plans a last-minute birthday lunch. You can't sneak away without disrupting the patient's schedule, who made arrangements for time off of work." Tippet-Whyte works four 10-hour days per week.

Cynthia Brattesani, DDS, San Francisco, finds dentistry ideal for parenting her 3-year-old as she was able to arrange her patient schedule to a comfortable three days a week.

But who does the cooking and cleaning in such a household?

"Whoever gets home first starts dinner," explains Terlet, who works full-time. As for housework, the babysitter does laundry, vacuums, and cleans the bathroom. "I won't give up my sleep to have a spotless house. We'd rather spend our free time with our children (ages 3, 12, and 13) instead of doing dusting that no one will see."

When her kids (age 10 and 13) are with their friends or dad on the weekends, Debra Finney, DDS, of Folsom, Calif., catches up on the housecleaning. And luckily, her new husband helps in all aspects of household duties and doesn't have strict culinary demands.

"McDonald's does more cooking than I'd like to admit. If it isn't microwaveable, it's not in our house," Finney says.

Finding time to sustain a marriage, and a scrap of time now and then for oneself is the ultimate challenge with a career and one or more children to raise.

In Parenting magazine, the August 2001 feature, "The Marriage Factor," listed tips for maintaining a love life. Among them:

- Make rest a priority. Less housework and phone time, more naps and use of answering machines.
- Work in time to work out. Even a daily walk clears the mind, and increases energy.
- Get away from the kids. Swap babysitting with a friend, use family or pay a sitter to have alone time.

Although most parents don't get to spend a day for themselves weekly, they probably should take an hour a day to "recharge the batteries." Going to the gym, meeting one's mate or friends for lunch, or reading dental journals at a café works. Realistically for many, however, commuting time is all they can "steal away" for themselves.

In addition to the logistics of day-to-day responsibilities, the working dentist occasionally has other issues to contend with -- such as illness.

When the flu strikes and there isn't another dentist to cover, appointments must be canceled. When a child gets ill suddenly, if someone isn't available to help out, desperate times call for desperate measures. Finney has brought her kids to the office. Terlet, too, has had to bring her kids to the office when they were sent home sick from school.

"Even though they are in back, patients are sometimes concerned they will catch whatever the kids have," Terlet explains. One patient of hers, disgruntled because her child's illness delayed his appointment, wrote a complaint letter.

"His letter began, 'I understand the plight of the working mother, however' but really he didn't have a clue."

"Remember to spend more time making a life than making a living," Terlet advises. "I have seen many people put their practices first, and you can't do that for too long or you won't have a family left by the time you want to interact with them."

New JADA Editor Named

Marjorie K. Jeffcoat, DMD, a renowned dental researcher, will be the next editor of the Journal of the American Dental Association. A 1976 graduate of the Harvard School of Dental Medicine and immediate past president of the International Association of Dental Research, Jeffcoat will be the first woman to hold the JADA editorship.

Jeffcoat was formerly chair of the Department of Periodontics at the University of Alabama School of Dentistry in Birmingham. She is set to begin working with current editor Lawrence H. Meskin, DDS, this month. He will officially step down on Dec. 31.

A widely published author, Jeffcoat most recently has been exploring the link between oral infection and systemic disease. She is a long-time member of the JADA Editorial Board and a frequent contributor to the publication.

New Books Offer Guidelines for Evidence-Based Medicine

The AMA Press in conjunction with the editors of the Journal of the American Medical Association have released two new books that provide clinicians with a solid foundation and quick reference for understanding and applying evidence-based medicine.

Users' Guides to the Medical Literature: A Manual for Evidence-Based Clinical Practice and Users' Guides to the Medical Literature: Essentials of Evidence-Based Practice were edited by the physicians who coined the term evidence-based medicine and include contributions from more than 50 of the most renowned evidence-based medicine educators and practitioners worldwide.

"The original medical literature has become part of the essential landscape of clinical practice," says Dr. Gordon Guyatt, professor of medicine and clinical epidemiology and biostatistics and medicine at McMaster University and co-editor of the Users' Guides. "The Users' Guides provide the compass that can first orient the clinician and ultimately provide an in-depth understanding of the topography."

These detailed, clinician-friendly guides offer tips, examples, and thorough explanations of the concepts necessary for clinicians who wish to use information in the medical literature to more effectively treat their patients and provide the tools necessary for a thorough understanding of the principles of evidence-based medicine.

"These resources put the practitioner in charge of the single biggest resource they have -- the medical literature," says Dr. Drummond Rennie, deputy editor of JAMA and co-editor of the Users' Guides. "The literature is already overwhelming and growing daily, getting control over the literature, and using it to help patients, presents the clinician with an apparently insuperable problem."

The Users' Guides to the Medical Literature: A Manual for Evidence-Based Clinical Practice covers what every practicing physician, resident, and student needs to know about reading and applying medical literature to improve the care of patients.

Users' Guides to the Medical Literature: Essentials of Evidence-Based Clinical Practice is a condensed version of the manual. The paperback-sized Essentials can fit easily into clinicians' pockets and offers a concise yet thorough introduction to evidence-based medicine.

To order a copy of either Users' Guides, call (800) 621-8335 or order online at http://www.amapress.com. Refer to order number OP427700 for the manual and order number OP740001 for Essentials.

New System Will Monitor U.S. Blood Supply

Health and Human Services Secretary Tommy G. Thompson recently announced that a new "real time" monitoring network is being launched to measure the blood supply in key local areas, regions, and nationwide.

The new system will receive daily reports from selected hospitals and will measure current demand as well as supply on hand, giving hospitals and blood suppliers a more useful picture of supplies and possible emerging problems.

"Our nation's blood supply network needs good, current information if it is to operate with maximum effectiveness," Thompson said. "This new system will be unlike anything we've had before in providing widely available, real-time information on both supply and demand for blood and blood products."

The system is to include 29 hospitals, which will provide their daily reports to the Department of Health and Human Services. Exact plans for compiling and sharing the information will be developed over the coming weeks as the information begins to be provided. Ultimately, the department plans to make the information available on a public Web site.

"The Web site will provide easy access to the information for all interested health care providers and blood collection agencies, and we hope it will also help raise awareness in the public of the always-important need for blood donation," Thompson said.

The new system is being implemented at a cost of about $350,000 per year.

Study Gives Glimpse of Human Painkiller System

A unique study that looked at chemical activity in the brains of human volunteers while they experienced sustained jaw pain and reported how they felt is providing new insights into the importance of the body's natural painkiller system -- and the reasons each person experiences pain differently.

The results confirm long-suspected connections between pain-dampening changes in brain chemistry and the senses and emotions experienced by people in pain. The findings may help researchers better understand prolonged pain and find more effective ways to relieve it.

Results from the brain imaging study were published in the July 13 issue of Science by National Institute of Dental and Craniofacial Research-supported researchers from the University of Michigan Health System and School of Dentistry. It is the first study to combine sustained, induced pain with simultaneous brain scan monitoring of a key neurochemical system and the self-reported pain ratings of human participants.

The research cements the critical role of the mu opioid system, in which naturally produced endorphins match up with receptors on the surface of brain cells and reduce or block the spread of pain messages from the body through the brain. The mu opioid receptor in particular has been found to be a major target for both the body's own painkillers, as well as for drugs such as heroin, morphine, methadone, synthetic pain medications and anesthetics, which also numb pain.

The study found that the onset and slow release of jaw muscle pain over 20 minutes caused a surge in the release of the chemicals. It also found that the flood of those chemicals coincided with a reduction in the amount of pain and pain-related emotions the volunteers said they felt. Specific brain regions, especially those already known to play a role in affective, or emotional, responses, and those known to help process signals from the body's sensory systems, had the biggest increase in the level of opioids when pain was introduced.

The research also revealed major variation among volunteers in the baseline and pain-induced levels of opioids.

"This result gives us new appreciation for the power of our brain's own anti-pain system, and shows how brain chemistry regulates sensory and emotional experiences," says lead author Jon-Kar Zubieta, MD, PhD, assistant professor of psychiatry and radiology at the University of Michigan Medical School and assistant research scientist in the Mental Health Research Institute.

Diet and Exercise Dramatically Delay Type 2 Diabetes

At least 10 million Americans at high risk for type 2 diabetes can sharply lower their chances of getting the disease with diet and exercise, according to the findings of a major clinical trial announced at the National Institutes of Health.

"In view of the rapidly rising rates of obesity and diabetes in America, this good news couldn't come at a better time," said Health and Human Services Secretary Tommy G. Thompson. "So many of our health problems can be avoided through diet, exercise, and making sure we take care of ourselves. By promoting healthy lifestyles, we can improve the quality of life for all Americans and reduce health care costs dramatically."

The same study found that treatment with the oral diabetes drug metformin (Glucophage) also reduces diabetes risk, though less dramatically, in people at high risk for type 2 diabetes.

Participants randomly assigned to intensive lifestyle intervention reduced their risk of getting type 2 diabetes by 58 percent. On average, this group maintained their physical activity at 30 minutes per day, usually with walking or other moderate intensity exercise, and lost 5-7 percent of their body weight. Participants randomized to treatment with metformin reduced their risk of getting type 2 diabetes by 31 percent.

The findings came from the Diabetes Prevention Program, a major clinical trial comparing diet and exercise to treatment with metformin in 3,234 people with impaired glucose tolerance, a condition that often precedes diabetes.

Honors

Jack S. Broussard, Jr., DDS, has been named University of California at Los Angeles Alumnus of the Year for 2001. Broussard, who is currently president of the California Dental Association, will formally receive the honor Nov. 3.

Ronald S. Mito, DDS, has received a $5,000 grant from the Foundation of the Pierre Fauchard Academy to support indigent care at the Wilson-Jennings-Bloomfield UCLA Venice Dental Center. Mito is a professor and associate dean at the UCLA School of Dentistry.

Glenn T. Clark, DDS, MS, has received the Pierre Robin Academic Award from the Academy of Dental Sleep Medicine. Clark is professor and section chair of oral medicine and oral facial pain at UCLA School of Dentistry. He is a clinical professor at the University of Southern California School of Dentistry, where he teaches the course in chronic orofacial pain.

Liviu Eftimie, DDS, has received a Certificate of Recognition for Volunteer Service in a Foreign Country from the American Dental Association.

Lee Nelson Wiggins, DDS, has received a Certificate of Recognition for Volunteer Service in a Foreign Country from the American Dental Association for service in Cambodia, China, and Ghana.

Joel M. White, DDS, MS, is the recently inducted president-elect of the Academy of Laser Dentistry. White is professor and chair of the Department of Restorative Dentistry at the University of California at San Francisco.

The University of Southern California School of Dentistry has been reorganized and has made several new appointments as follows:

Michael J. Mulvehill, III, DDS, is co-chair of the new Division of Primary Oral Health Care.

Mahvash Navazesh, DMD, leads the new Division of Diagnostic Sciences.

Roseann Mulligan, DDS, serves as chair of the new Division of Health Promotion, Disease Prevention, and Epidemiology.

Robert Gerald Keim, DDS, directs the new Office of Advanced Specialty Education.

CDA JOURNAL, VOL 29, Nº10

Using Photography in the Dental Office

James Dunn, DDS

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"A picture is worth a thousand words" and "seeing is believing" are more appropriate to dentistry today than ever before. We live in a visual world. We, and our patients, are immersed in images from television, movies, videos, the Internet, DVDs, and countless magazines. We make choices on what we buy, where we go, our entertainment, and even our appearance, from pictures. We can even produce our own high-quality photographs using technology that until recently was available only to professional photographers. We expect one-hour processing of our film prints and slides and instantly replay digital photos and movies. Many of our patients expect that we will use images when we communicate with them.

Dentistry has used 35 mm and Polaroid film for several decades to record pre- and post-treatment images. Most photographs have ended up in patients' charts, in articles for publications, or in teaching presentations. Some dentists gave prints and Polaroids to patients for education and personal marketing. A few dentists also created "smile galleries" for their own offices or to sell to other dentists to show patients how dental treatment can enhance their smiles.

The current emphasis on dental esthetics with technological advancements in tooth whitening, porcelain veneers, all-ceramic crowns, composites in anterior and posterior teeth, periodontal plastic surgery, and implants has created an increased need for photographs before and after treatment and to visually demonstrate to patients the available treatment options.

Other uses of images in dentistry are incorporation of images in patients files -- both paper and electronic, communicating with dental laboratories, referring to specialists, and one of the most important, communicating with patients on proposed treatment and after-treatment appearance.

Photography is also changing. High-resolution digital cameras are replacing film cameras. The dentist and his or her staff are now controlling not only image capture, but also the manipulation, printing, management, and transmission of imaging without the use of film. The "digital" office can capture images of patients and immediately send those images to the patient's records, a printer, or to a software program that allows the dentist to present an electronic case presentation -- while the patient is still in the office. This convenience, however, comes with a price of additional equipment and more importantly, additional time spent on image management.

Whether film-based or digital, the dental practice of the future will be taking and using more photographs. We hope this issue on imaging in dentistry is helpful as you use photography in your practice.

CDA JOURNAL, VOL 29, Nº10

Photography in Dentistry

Edward A. McLaren, DDS, and Doug A. Terry, DDS

ABSTRACT The use of photography is becoming a standard for today's modern dental practice. Dental imaging is critical for the sharing of visual information among the patient, dentist, and ceramist. This article covers the basics of camera, lens, and flash selection, and the use of camera flash systems. It will also provide guidelines for obtaining a good dental image.

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The use of photography, whether film-based or digital, is becoming a standard for today's modern dental practice. Dental imaging is critical for the sharing of visual information among the patient, dentist, and ceramist. Most people are visually oriented ("a picture is worth a thousand words"), which makes it significantly easier to use visual documentation to demonstrate problems and thus motivate patients to accept needed treatment. The ceramist who fabricates the porcelain restoration needs as much shade data as possible to be able to duplicate the shade of the adjacent natural teeth; photography is best-suited for providing this information. A dentist should also provide the ceramist with images of the finished work after cementation to give feedback, which allows the ceramist to learn and improve his or her techniques. Film-based and digital photography can be used to develop a smile portfolio of before-and-after cases that are useful in demonstrating to a patient what is possible. More importantly, the patient will get a sense of how good an esthetic dentist the practitioner is by viewing actual finished cases.

The process of choosing a camera and flash system can be confusing. Many different systems are available. Is a film-based or digital system more appropriate? This is a fundamental question frequently being asked today. The main advantage of digital photography is that the image can be viewed immediately. If the photographic variables were incorrect, the dentist would know it instantly and could correct them and retake the photo. It is important to understand that the basics of using a camera are the same for digital and film-based photography. The operator has to understand metering options, f-stop (aperture) settings, flash options and positioning, lens and magnification ratios, exposure bracketing, film selection, and composition. This might all seem very confusing and like a lot of work, but the basics of taking a good photograph are really quite simple. This article covers the basics of camera, lens, and flash selection, and the use of camera and flash systems. It will also give guidelines for obtaining a good dental image.

Camera Body Selection and Camera Settings

The selection of a camera body is really the least critical of all the elements of obtaining a good image. The standard for dental imaging has been the 35 mm format; many different manufacturers make cameras for this format. Depending on the features desired, a camera could cost as little as $200 or up to $7,500 for a high-end digital model (Figures 1 and 2). Durability, elaborate matrix-metering systems, extremely rapid auto-focusing systems, and fast multiple exposure options drive up the cost of a camera. Very few of these options are necessary for the type of imaging performed in dentistry. A high-end camera is appropriate for people planning to do action photography or imaging in variable lighting conditions. For dental imaging, all the features necessary for an excellent photograph can be obtained in camera bodies costing from $500 to $900.

The critical features a camera should have for dental imaging are through-the-lens (TTL) focusing, an exposure and flash-metering system, matrix metering, spot metering, exposure compensation that allows plus or minus three stops exposure value (EV) changes in 1/2-stop increments, aperture priority exposure settings, and manual exposure settings.

TTL vs. Manual Flash Exposure

Many high-end photographers use all manual exposure and flash settings to create exactly the effects they want, and the dental photographer may choose to do this. This may require a significant time commitment and trial and error experimentation to find the correct settings for each scene. Cameras and flashes with TTL features allow the user to shorten the learning curve and minimize the guesswork on the exposure settings. The camera flash (**Figure 3**) is set in the TTL mode; and when the exposure is made, the camera meters the scene and fires the electronic flash. The camera automatically adjusts the light output to expose the scene based on the exposure (aperture and shutter speed) and metering settings of the camera. For most dental photography, the camera should have TTL features and the flash set in a TTL exposure mode. Rule No. 1: Choose a camera that has TTL metering and manual exposure settings.

Spot and Matrix Metering

The camera should have both matrix- and spot-metering capabilities. Surprisingly, many cameras do not offer spot-metering options (sometimes center-weighted metering is said to be comparable, but it can give a significantly different exposure). Most dental images should be spot metered due to the high contrast nature of the area to be imaged (**Figure 4**). Essentially, in spot metering the camera is only metering the area within the small spot seen in the viewfinder; the exposure is based on this reading only. Dental images are generally of high-contrast scenes, that is, there are bright and dark areas. If the camera is set in matrix or center-weighted metering, a significantly larger area of the scene is metered. Matrix metering meters the whole scene as seen in the viewfinder, but it applies more weight to the center areas of the scene. If the scene has a lot of contrast, as do dental scenes, then the camera tries to balance out the exposure of the light and dark areas of the scene. Because the camera is trying to bring up the exposure of the dark areas, this almost always results in overexposure of the lighter areas of the scene, i.e., the teeth (**Figure 5**). Rule No. 2: For most dental scenes, the photographer should spot meter the part of the scene he or she wants correctly exposed.

For facial photography, matrix metering is OK as long as there is no significant contrast in the scene, such as a black background. If there is a background with a lot of contrast, an area of the face should be spot metered (**Figure 6**). Rule No. 3: Choose a camera that has spot- and matrix-metering capabilities.

Aperture Priority

Most dental images should be taken with the camera set to the aperture priority exposure setting (**Figure 7**). When the camera is set to aperture priority, the user selects the lens aperture (e.g., f-22) that will allow the proper amount of light through the lens for the correct exposure. The camera then adjusts the time of exposure to correctly expose a scene. When the camera flash is set to TTL, the shutter speed is set to sync with the flash; and the flash output then changes to correctly expose the scene based on the aperture setting, or f-stop setting, on the lens. The film speed will also affect the flash output and shutter speed and will be discussed later, along with lens and f-stop settings. Rule No. 4: Choose a camera that has an aperture priority setting because most dental images are done with the camera set in this mode.

Exposure Compensation

It is critical that a camera be selected that allows for exposure compensation. This is accomplished by changing the EV (exposure value) setting on the camera to either a plus or minus value (**Figure 8**). This allows for a photographic technique termed bracketing. By changing the EV to a positive or negative number, the camera will either overexpose or underexpose the scene by the amount of the setting. As an example, by changing the settings

FIGURE 1. Film-based camera body (Nikon N90S) with all the features necessary for dental photography, priced less than $600.

FIGURE 2. Digital camera body (Fuji FinePix S1 Pro), price approximately $3,000.

FIGURE 3. Electronic flash with manual and TTL settings. The flash is set in the TTL mode.

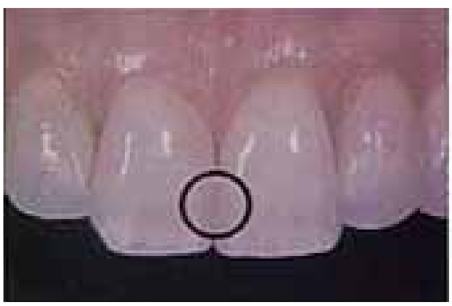


FIGURE 4. Image of natural teeth properly exposed looking through the viewfinder of the camera. The small round circle (spot) should be placed entirely over a tooth and the camera set in spot meter mode.

FIGURE 5. Image of natural teeth that are overexposed in the slide. This was due to the camera being set in the matrix-metering mode, which metered the whiter teeth and the darker background. The camera tried to bring up the exposure of the darker areas, thus overexposing the teeth.

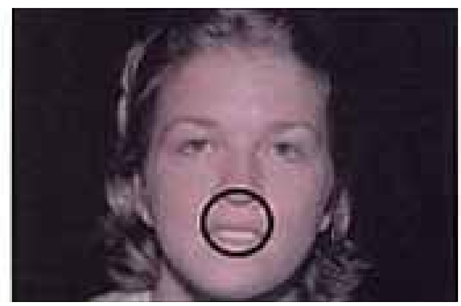
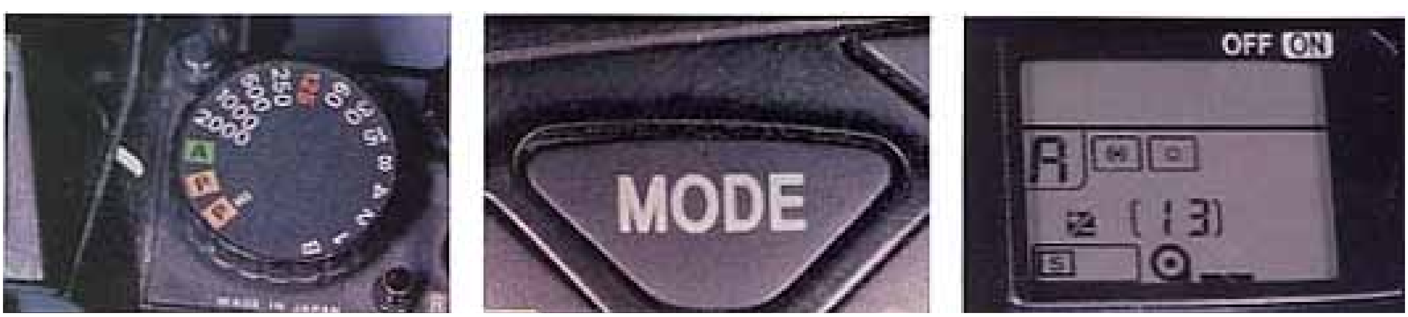


FIGURE 6. Full-face image properly exposed. Due to the high contrast in the scene, spot metering should be done on an area of the face. The figure illustrates where the spot in the viewfinder should be positioned on the face.



FIGURES 7 A, B, AND C. The aperture setting on some cameras will be a simple dial set to A or Ap as (a); or, in more sophisticated cameras, an exposure "mode" button (b) is pushed and the dial is adjusted until the LCD screen reads A or Ap (c).

to EV + 1, the camera overexposes the scene by one f-stop over no exposure compensation. For each full EV setting, there is either a doubling of the amount of light hitting the film plane, or a halving of the amount of light hitting the film plane, depending on whether the setting is plus or minus one. The term bracketing means to take an exposure slightly over- or underexposed relative to the main exposure (thus a minimum of three exposures are taken). This allows for errors in metering in the hopes that one of the photographs comes out correctly exposed. A camera that allows for EV adjustments in 1/3 or 1/5 f-stop increments is best. Rule No. 5: Make sure the camera allows for exposure compensation of up to plus and minus three stops.

Even with the camera set to TTL, spot metering and aperture priority, it is still important to bracket the exposures of each scene one stop over- and one stop under-exposed from the camera's metered settings. The camera should spot meter off the teeth, which is the area that should be correctly exposed. In situations where the teeth are darker than normal, the camera may try to lighten the scene more than is necessary, resulting in a slightly overexposed image. Conversely, extremely light teeth might be slightly underexposed. Bracketing will minimize this problem. For true aficionados, trial and error with manual settings will be the way to go. Rule No. 6: Bracket important images.

Lens Selection and F-Stop Settings

For dental imaging, a macro lens of fixed focal length of 100 to 105 mm is ideal (**Figure 9**). The term macro means close-up, and lenses designated macro (Nikon uses the term "micro") have special optics that allow the focusing necessary for close-up imaging. The lens must have 1:1 to 1:10 magnification settings. At the 1:1 magnification setting, an object measuring 10 mm, such as a tooth, will measure 10 mm on a 35 mm slide. Conversely, at a 1:10 setting, the same 10 mm tooth would measure 1 mm on the 35 mm slide. The 1:1 setting is ideal for close-up imaging of teeth and will generally include the four maxillary incisors on the film plane. The 1:10 setting is used for full-face shots. Lenses in the 90 to 105 mm range are known as portrait lenses because they provide distortion-free images at the working distance of portraiture photography. Other lenses, e.g., 60 mm macro, can also have a 1:1 magnification setting but are not ideal for most dental imaging. Because of the wider angle of view, areas that are closer to the camera are distorted and appear unnaturally large. This is very uncomplimentary in portraiture photography since it makes noses appear larger than normal. At 1:1 settings, 60 mm lenses focus too close to the subject and thus cannot be used for intraoral mirror images. Rule No. 7: Choose a macro lens with a 90 to 105 mm focal length that allows 1:1 magnification settings. The macro lens should also allow for f-stop settings of minimum aperture (f-32).

Changing the f-stop settings on the lens changes the lens aperture (**Figure 10**). Opening or closing the aperture allows more or less light to reach the film plane. The f-stop number is a ratio of the focal length divided by the lens aperture diameter. Thus, when the lens is focused at 100 mm from the film plane and set at f-22, the aperture will be 4.5 mm. A larger f-stop setting results in a smaller aperture opening. Smaller apertures will give greater depth of field. Depth of field is the amount of the scene in front of and behind the focal plane that will be in focus in the image. For each change in f-stop, there is a doubling or halving the amount of light that reaches the film plane. For most close-up dental images, an f-stop setting of 22 is best. F-32 may not allow enough light to reach the film plane even with flash and would thus be underexposed. F-16 or f-11 would not have enough of the image in focus due to the smaller depth of field. For some mirror shots where no ambient light is present, it may be necessary to expose at f-16, which would allow more light in and thus ensure a proper exposure. For portraiture photography, f-5.6 or f-8 is best because the depth of field is adequate; and these f-stops allow enough light to reach the film plane for proper exposure. For images of greater than 1:1 magnification, extension tubes (**Figure 11**) -- which are essentially hollow tubes -- are added to the lens to increase its focal length. These are better than teleconverters, which are essentially magnification lenses. Lens elements decrease the amount of light hitting the film plane and create problems with exposure. Rule No. 8: Most dental photography is done at f-22, and facial images at f-8.

Flash/Lighting Systems

The proper illumination of a scene is one of the most critical aspects of imaging. Natural or studio lighting provides inadequate light for dental photographic situations, due to the small lens apertures and slower (less light-sensitive) film used. Thus, the only practical source of illumination is one of several types of electronic flashes. Electronic flashes for dental photography should have a color temperature of 5500K; most are manufactured with this color temperature, but one should ask to be sure. 5500K color temperature is said to be daylight-balanced, and flashes of this color temperature are to be used with film designated as daylight-balanced. The other main type of film is called tungsten-balanced, which is color-balanced for tungsten lighting. It has a color temperature of about 3200K. There are three basic types of flash systems for dental photography. The single-point source light; the dual-point source light, of which there are two kinds; and the ring light.

The single-point light source (**Figure 12**) is generally a small flash mounted on the side of the lens. This type of flash is good to show surface detail and contour. If this flash is used, it is best to take several images with different flash positions to give a complete picture of the contour and surface detail. Due do the fact that one light source is coming in at an angle, this type of illumination does not give an adequate representation of translucency or depth. To obtain photographic information about translucency and to minimize shadowing, a dual-point or ring flash is better.

The favored light source among dental photographers has been the ring light (**Figure 13**). This is the best light source for mirror exposures in the back of the mouth, due to the even illumination provided by the ring light. For anterior shots, it produces even and consistent (but not ideal) results. Because the light surrounds and is generally slightly in front of the lens, it eliminates all shadows. The specular or mirror-type reflection created by this type of flash tends to flatten out the image, giving a less-than-lifelike result. The results are acceptable, however; and this system is easiest to master and to train a dental auxiliary

FIGURES 8 A, B, AND C. Exposure compensation (EV) controls on a camera are generally labeled "+/-," either on a simple dial (a) or on a button (b). The dial is adjusted to + or - values to bracket the exposure. Cameras with LCD screens will display the numerical value of the desired exposure compensation in + or - values (c).

FIGURES 9A AND B. The 105 mm Micro-Nikkor lens from Nikon (a) and the 105mm Macro lens from Sigma (b). After market lenses by Sigma and Tamron yield dental images that are undetectable from either Nikon or Canon lenses, and they are half the cost.

FIGURES 10. Aperture adjustment setting on the barrel of the lens. Changing the setting (f-stop) opens and closes the internal diaphragm of the lens, allowing in more or less light.

FIGURE 11. Extension tube and teleconverter for increased magnification. The extension tube is a hollow tube, while the teleconverter is a magnifying lens.

FIGURE 12. Single-point source electronic flash.

FIGURE 13. Typical ring light electronic flash.

to use. A system already put together specifically for dentistry that is easy to use and gives consistently acceptable results is the Yashica Dental Eye III (**Figure** 14).

The ideal flash for anterior photography is the dual-point source flash, of which there are two kinds. Lens-mounted dual-point sources look similar to a ring flash (**Figure** 15), but due to the fact there are only two flashes (which are vertically aligned bars) on either side of the lens, there is no light coming from the top or bottom of the lens. This positioning allows for some subtle shadowing, which creates an image with more depth and lifelike effects.

The other type of dual-point source flash uses a special bracket that attaches to the camera body, which allows custom positioning of the flashes (**Figure** 16). Mastering the use of this type of flash system will yield professional photographic results (**Figure** 17). Generally the flashes are set away from the lens about 3 inches and slightly behind the lens, which gives the best images. With the light coming in at a slight angle, there is less specular reflection and some slight shadowing is created; this gives the greatest depth to the image. All of the color effects and crack lines can be seen from these images. Subtle color gradations and translucency levels are displayed best using this type of flash system. Camera manufacturers don't make this type of flash system; the dental photographer would have to purchase after-market brackets and put together a custom flash system to accomplish this type of photography. Rule No. 9: Dual-point light sources give the best image.

Film Selection

For dental imaging purposes, transparency (slide) film is best. Slide film generally tends to be more color-accurate than print film, and if prints are necessary it is easy to make them from slides. Slide film ends in the designation "chrome," e.g., Ektachrome or Kodachrome (**Figure** 18). Print film ends with the designation "color" (e.g., Kodacolor). Film is sometimes called slow or fast film, which is an indication how light-sensitive it is. Slower film needs more light for proper exposure, and one way to get more light on the film plane is for a longer or slower shutter speed, thus the designation slower film. Faster films require less light and thus use faster shutter speeds. The speed of the film is related to the number of light-sensitive silver halide grains in the film. The more grains, the faster the film and the less light that is necessary for proper exposure. The problem is the higher number of grains, the grainier the image becomes (i.e., detail is lost). For dental applications, a film with an ISO rating of 100 is ideal: It is fast enough to allow correct exposure with the equipment and camera settings previously discussed.

Professional film is best because the color accuracy of the film is better than that of consumer film. Color-neutral and low-contrast film is best-suited for accurate color reproduction in dentistry. Kodak EPN 100 (**Figure** 18) or EPP 100 produce the most color-accurate images with the correct contrast. Contrast is a measure of the differences of the light and dark areas of a scene. A normal-contrast film would image the contrast of a scene as it is, a high-contrast film would add contrast (i.e., make the lighter area of a scene whiter and the darker areas of a scene blacker). Kodak has recently started selling a film called Dental Photographic film, which is EPN repackaged. Twelve exposure rolls of the dental film cost the same as a 36-exposure roll of EPN, thus if one is taking several images, EPN is a better value. It is also extremely important that the film be processed at a high-quality professional processor. Even with all the correct camera parameters and correct film, if it is processed incorrectly, the final result will be poor (**Figure** 19). Rule No. 10: Choose a professional film of neutral color balance and normal contrast.

Mirrors and Retractors

Mirrors are required for occlusal and buccal views in the posterior region. Front-surface-reflection mirrors are best for dental images because they don't create a dual image, which a rear-surface-reflection mirror can give. Glass mirrors generally give a better image than polished metal mirrors. The polished metal reflects less light than the glass mirror does and seems to slightly distort the image. Retractors come in two varieties, either metal or plastic (**Figure** 20). The larger plastic retractors give slightly better retraction than the metal ones, but the metal retractors will last significantly longer because the plastic ones become brittle and fracture after repeated sterilization. Retractor choice is a personal preference because there is no clear advantage for either one in terms of cheek retraction. The important point for dental photography is to retract the cheeks away from the teeth and photograph the teeth with no cheeks, lips, or retractors showing in the photograph (**Figure** 21).

Discussion and Summary

Dental imaging is critical to the success of a modern dental practice. The basics of using a camera for dental imaging are the same for film-based and digital formats. Neither system compensates for errors in exposure; the main advantage of a digital camera is that the image can be viewed immediately so exposure adjustments can be made. Although it is possible to import both film-based and digital images into a computer and digitally manipulate them to correct exposure problems, it is significantly easier to learn the use of the camera and obtain the correct exposure initially.

The camera body is the least critical element in obtaining a good dental image. Very expensive cameras and lenses are not necessary to obtain a good image. The flash system, lenses, film, exposure, and proper processing are critically to making the most of dental photography.

FIGURE 14. The Yashica Dental Eye III

FIGURE 15. Dual-point source light with the light sources mounted at the front of the lens (Nikon SB 29).

FIGURE 16. Custom dual-point light source system that allows individual positioning of the flashes. The best images are obtained with this system.

FIGURE 17. Image of all-ceramic crowns on the maxillary anterior teeth done with the dual-point flash system.

FIGURE 18. Professional Kodak Ektachrome EPN 100 film

FIGURE 19. Image that was exposed properly but underdeveloped. When this happens, the slide will appear darker and slightly bluer than ideal. It is important to note that underexposing the image will create the same effect.

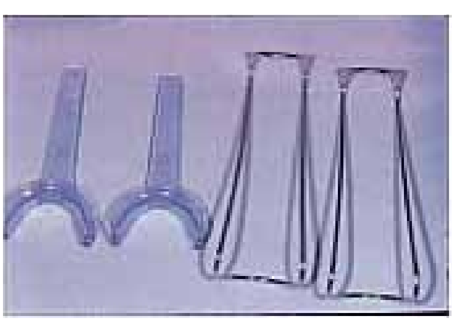


FIGURE 20. Plastic and metal cheek retractors. Either type is acceptable.

FIGURE 21. This image demonstrates the correct use of retractors, which pull and separate the cheeks away from the teeth and gingiva.

Digital Photography Technology Offers Unique Capabilities, Advantages, and Challenges to Dental Practices

James Dunn, DDS, and Gerald Beckler

ABSTRACT Digital photography technology has both advanced substantially in the past few years and decreased in price. Today, high-resolution cameras offer an attractive option to dentists ready to incorporate digital photography into their practices. This article begins with a technical explanation of how digital photography works as the basis for understanding how it compares and contrasts with film photography, as well as how it offers unique benefits to dental practices. It describes how digital camera design affects image characteristics such as resolution and color fidelity and provides dentists with suggested camera features they should consider. The article explores issues associated with the display and storage of images. It then provides guidelines to help dentists determine whether they are ready to adopt digital photography, including a discussion about the advantages of digital photography as well as suggested ways digital photography will affect office workflows and productivity.

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Digital photography is a technology that intrigues many dentists. However, like all technology, it raises as many questions as it suggests answers. Is digital photography a fad, or is does it offer lasting advantages to dentists? Does it provide benefits over film? How difficult is the technology to master? How expensive is it? Does it carry any hidden costs?

Digital photography is not new. The charged-coupled device, or CCD, which is the component within digital cameras that detects light photons, was invented in the late 1960s by Bell Laboratories.1 Imaging companies soon went to work to refine CCDs for use in digital photography. By the mid-1980s, exponential improvements in both the speed and resolution of CCD technology had been achieved. For example, Eastman Kodak Company's first CCD sensor had a resolution of 675 picture elements, or pixels. By 1986, Kodak had developed a 1.4-megapixel sensor.2 Today, current Kodak sensors offer up to 6-megapixel resolution.

Early applications of this technology, however, were primarily aimed at industrial and scientific applications. Before manufacturers could mass-produce lower-cost digital cameras, they had to face a number of challenges. CCDs, like computer chips, must be manufactured under carefully controlled, "clean room" conditions. Such standards greatly increase manufacturing costs. Nonetheless, by the late 1990s, both consumers and professional photographers could select from dozens of digital camera types and brands, ranging from inexpensive point-and-shoot snapshot models to high-end cameras offering resolutions approaching that of film.

Today, available cameras also include some choices that fall in the middle of the spectrum. These cameras offer a resolution of 2 million to 3 million pixels plus amenities such as automatic focus and flash. At the same time, they are priced low enough to be incorporated into a dental practice.

FIGURE 1. CCD chip in single-lens reflex digital camera.

These cameras are generating considerable interest in dentistry today.

What is Digital Photography?

In an important way, digital photography is no different than film photography. Both technologies record photons of light that enter through the camera lens.

The primary difference is the capture medium. Film records light chemically: Photons strike silver-halide crystals that have been suspended in gelatin on a piece of acetate. When the exposed film is developed, the molecules of silver that were struck by light form the image.

In digital photography, an electronic sensor records the light. These silicon chips, generally smaller than a postage stamp, are made up of photosensitive diodes. When light strikes the sensor, it generates electron charges. The charges are recorded as digital information in the camera's memory card, which in turn can be converted into an image for viewing or printing.

There are two types of sensors used in digital cameras: CCD and CMOS (complementary metal oxide semiconductor). CCDs are the most widely available type of sensor in higher-quality digital cameras.

Generally, today's digital cameras produce image files that are useable by common, off-the-shelf software. For example, many cameras produce JPEG format files, which can be displayed by tools bundled with Windows or Macintosh operating software as well as software designed specifically for dentistry.

As with film cameras, better digital cameras will feature high-quality mechanics and, perhaps more importantly, high-quality lenses. However, the component most important to a digital camera's image quality is the CCD itself.

The first measure of CCD quality is resolution, or the ability of the camera to resolve detail. CCD resolution is expressed in pixels: the more pixels, the higher the resolution. The number of pixels is commonly given as either the number of rows and columns of pixels on the CCD (for example, 1,000 x 1,200) or the product generated by multiplying the rows and columns (1.2 million pixels or 1.2-megapixel resolution).

Manufacturers can also use software to boost resolution over the raw resolution capabilities of the CCD. This will be provided in the camera specifications as interpolated data.

Generally, higher-resolution CCDs must be physically larger than lower-resolution CCDs; this accounts for the higher production costs associated with very high-resolution digital cameras. It makes sense, therefore, for dentists, as well as other professional and nonprofessional photographers, to invest in cameras that provide adequate resolution.

The dentist needs to consider how the images will be used. For example, most home computer screens have monitors that display at a resolution of 800 x 600. They cannot display images at a resolution greater than that. So if a camera is to be used exclusively to capture images for on-screen display (without enlargement), it would not be necessary to invest in a CCD with more than 0.5-megapixel resolution.

Most dentists, however, will want to do more with images than display them on a computer screen. Many will want to produce photographic quality prints of their images. Dentists who plan to use their images for treatment planning or lab communication need sufficient resolution to capture detailed oral form. For this reason, cameras with less than 2-megapixel resolution should not be considered.

Dentists who plan to use their images in publications or who lecture may need even higher-resolution cameras.

In addition to affecting image quality, image resolution also affects image file size. Simply put, the higher the resolution, the more detail that is captured, which creates larger data files. Some cameras let the photographer choose from several different resolutions. For images that are intended for more-demanding applications, the photographer can select a higher resolution. If the primary consideration is conserving space on the camera memory card, the dentist or assistant can shoot at a lower resolution.

After an image is captured, dentists can manage file size through compression. Compression algorithms enable software to remove some of the raw data from the image file and store that information mathematically instead. These types of algorithms are referred to as "lossy compression" tools because some raw data is lost when the image is compressed. Generally, images that have been compressed in this fashion will lose some quality. The advantage is that smaller file sizes can be transmitted faster. Compressed images can be accessed more quickly from computer and network hard drives and take up less storage space.

In some cases, it makes sense to store both compressed and uncompressed versions of the same image. The compressed version can be used for applications in which the images are e-mailed. The uncompressed version can be stored for applications such as production of photographic-quality prints.

A second important measure of camera quality is color resolution. Typically, each pixel on a CCD is sensitized to either red, green, or blue light. Additionally, each pixel can record only a given amount of data. This value is expressed in bits. In an 8-bit camera, each pixel can record 8 bits of data. Cameras of this color resolution are capable of recording 16.7 million colors, which is considered full-color resolution. This level of color resolution meets the needs of most dental practices. The higher the color resolution, the higher the cost.

While color resolution governs the sophistication of the camera from an image-capture standpoint, how that color will be displayed or printed later is another matter. Color management is a topic with a number of interesting technical challenges. For color to be displayed or printed, the camera's original digitized color data must first be interpreted by the display or print device. Then that device must use its own internal mechanics to replicate the color. If the device is unable to interpret the original color data, or if the device is not properly calibrated, the image color will not be a faithful rendition of the original image.

As with other aspects of digital photography, higher-end cameras offer more-sophisticated color management capabilities. These include the ability to work with color management software templates that ensure printers, computer monitors, and other devices interpret the camera's color data accurately. For example, a graphics industry group known as the International Color Consortium has specified software templates, commonly called ICC device profiles, that camera and printer manufacturers can use to standardize the way their products manage color data. Higher-end cameras bundle ICC profile software with their hardware to ensure the files they output will be read accurately by other devices.

More About Digital Cameras

In addition to resolution and color resolution, dentists should evaluate other characteristics of available digital cameras.

The mechanics of digital cameras are similar in many ways to those of conventional film cameras. Many digital cameras offer such familiar features as autofocus, autozoom, and autoflash. The image itself is captured by depressing a shutter button, just as in film cameras.

Digital cameras, like film cameras, are also generally classified as either consumer or professional cameras. An intermediate class, sometimes called "pro-sumer" cameras, combine features from both categories.

Like all technology products, the differences between these various categories come down to price, features, and performance. For example, higher-end cameras tend to be single lens reflex cameras. With these cameras, lenses can be interchanged to support photography at different focal lengths. They also generally support the use of external close-up flash and similar accessories.

Professional cameras generally use larger sensors and support higher-color-resolution image capture. The images they capture will be higher-resolution, which means they can be enlarged for displaying, for example, in lectures.

Most dentists, however, will find it is possible to purchase consumer or pro-sumer digital cameras with sufficient resolution and color resolution to support general dental photography applications.

When shopping for digital cameras, dentists should look for several camera features in particular. Perhaps the most specialized is a flash system that will give adequate light for oral structure during close-up photography. Before purchasing a camera system, the dentist should make sure an adequate close-up lighting system is available for the specific camera being considered for use in the dental office. Point lights and modified-ring and ring lights are available for many cameras used in dental photography. If this is not the case, the dentist should research the camera before buying it to make sure a suitable flash attachment is available.

Another important feature is a close-up or macro lens for photographing patient smiles and individual teeth without distortion. Consumer cameras may require add-on (diopter) close-up lenses, while true macro lens are available for single-lens-reflex cameras.

Proper color balance is important to record accurate tooth and soft-tissue color.

Some cameras are able to detect an ambient lighting source and adjust accordingly. For example, they might apply a different color balance algorithm to the digital image if the ambient light is tungsten rather than fluorescent, daylight, or electronic flash.

Digital cameras tend to be more demanding on batteries than film cameras, so dentists should be prepared to have adequate disposable batteries, or use rechargeables. Newer rechargeable batteries have greater capacity than earlier NiCad rechargeable (NiMH) systems.

Digital cameras also differ from film cameras in one other respect: They typically include on-board software and hardware functions that enable the user to manage captured image files. For example, digital cameras typically have ports that let users connect them via cable to computers and use memory cards that can be read by a computer.

FIGURE 2A AND B. Single-lens reflex digital cameras for dental use.

FIGURE 3A AND B. Consumer cameras modified for dental use.

FIGURE 4. Digital image close up of natural incisors.

FIGURE 5. Digital dental portrait.

Displaying the Digital Image

With silver-halide photography, images are a physical entity created through a chemical process.

With digital photography, images are not physical but a record of electronic signals. Displaying them requires software, which converts the signals into digital information; display devices and printers interpret this information to create visible images. This lends digital photography flexibility: A single image can be displayed in a variety of ways, using a variety of media; in most cases this display can be accomplished instantaneously.

Typically, most dentists will display their digital images on computer screens, both to discuss cases with patients and during record-keeping procedures. The minimum requirements to accomplish this are a computer with sufficient video-display hardware and imaging software. Today's operating systems typically include imaging utilities that enable the user to perform simple functions such as displaying and cropping digital images.

Some digital cameras also feature liquid crystal display (LCD) windows on the camera body, enabling the picture-taker to review the image immediately after capture.

For printing, most dental practices will require color inkjet printers. This class of printer is reasonably priced, yet delivers a level of quality sufficient for most dental applications. Using a medical-grade glossy paper is also advisable. This type of paper improves the quality of the image and provides a suitably professional "look and feel" to prints.

Storing Digital Images

Because digital images are electronic files, storing them is a computerized function. Most dental practices should plan to store their digital images in an image database (software) that resides on a computer or network server.

FIGURE 6A. Film.

FIGURE 6B. Digital camera memory cards.

This helps keep the images organized for straightforward retrieval. Image databases that are tailored for dental applications provide features that most dentists will find indispensable, such as the ability to merge images with non-image case information.

Storing images does require planning, particularly due to the size of image files. A typical uncompressed JPEG image captured by a 2-megapixel, 8-bit camera is likely to be 500 megabytes in size. Higher-resolution cameras will have much larger files. If a dentist plans to capture 12 views of each patient (by following, for example, the American Academy of Cosmetic Dentistry guidelines for cosmetic dentistry photography), memory will be used up quickly. Dentists should estimate how much storage space they will need to accommodate their images based on planned use and install large enough computer or network hard drives to ensure adequate storage.

Switching to Digital: Why and When

One of the lessons dentists learn very quickly is that just because a technology exists doesn't mean it is the right technology for every dental office. The individual dentist must still decide whether digital photography will fit his or her practice.

The advantages of digital photography fall into two categories. First, there are the qualities it shares with conventional photography over the alternative, no imaging at all. Using any sort of photography in the dental office can be beneficial. For example, filed identification photographs of patients for staff recognition on return visits is a great relationship-builder. "Before and after" photographs that document restorations and cosmetic procedures make great patient mementos. When patients share them with family and friends, it generates word-of-mouth referrals for the practice.

Many dentists create "wall of fame" or "smile gallery" collages in their offices to help show patients the quality of dental care available.

Communication with dental laboratories is enhanced by photography. Images convey far more information about tooth color, texture, and shape than written descriptions, shade tabs, and casts alone. Better information enables laboratories to create indirect tooth-colored restorations that more precisely match patients' natural tooth shade. The result is happier patients and, again, a chance for more patient referrals.

Reviewing patients' photographs along with other diagnostic records can enhance treatment and planning. Photographs also document the treatment process if questions were to arise concerning the patient.

Each of these benefits is the benefit of photography in general.

Advantages of Digital Photography	Advantages of Film Photography
Images can be displayed and printed immediately	Images are high resolution, even if captured using a less-expensive camera
Images can be stored electronically directly after capture and integrated with on-line patient management databases	Camera equipment is available off the shelf
Images can be incorporated directly into electronic presentations (e.g., PowerPoint slide shows)	Processing of film images is handled externally (i.e., by photo processor)
Digital imaging systems help make practices appear "high tech" and modern	Initial equipment costs are lower
Images can be printed selectively, helping dentist to control image printing costs	Can be used by dentists who do not wish to computerize their offices
Does not require dentist to own specialized equipment to view or print images	

Digital vs. Film

Digital photography also offers some advantages relative to 35 mm photography. A primary benefit is its immediacy: Dentists can view images as soon as they are captured to determine whether they are of adequate quality. If a picture is not good enough, it can immediately be retaken. This can virtually eliminate the possibility that a patient might have to be reappointed to redocument a case.

Digital images can also be shared immediately. One application for this might be a referral, where a dentist wishes to consult with another specialist, or a laboratory technician. The dentist can simply e-mail the image to the third party.

A third advantage of digital imaging is that digital photographs can be added to patient files immediately after capture. This can eliminate the possibility of errors in properly labeling and filing image records.

Finally, accessing digital photography is relatively easy, because with image management software, the process is computerized. Once the images are associated with patient records, they can be called up, viewed, and printed with the click of a mouse button. Assuming the images are properly stored the first time, the likelihood of their being misplaced or misfiled later is virtually nil.

These are powerful advantages. At the same time, digital photography requires procedures and management that conventional photography does not. With conventional photography, the work of processing images is essentially outsourced to a commercial photo processor. The office staff packages rolls of film, drops them off, and after receiving the processed film, files or distributes them.

Digital photography can require more time for image management. An analogy is word processing, which began as a replacement for typewriters but soon added capabilities to allow fancy formatting. Creating documents became more complicated and time-consuming, because people who once would have been merely typists became layout designers as well.

A similar phenomenon happens with digital photography. Checking an image to see if it is properly framed and focused provides real-time quality control; it also takes time. Downloading images from the camera or camera memory card to a computer also requires time, as do operations like cropping photographs, adjusting color balance, and properly storing the files in the photo management software.

In most practices, it will be the dental staff who do most of the photography; the staff will therefore need to be trained in the basics of photography as well as the use of the digital camera itself. Incorporating digital photography will change office workflows; the dentist and staff need to plan for those changes as much as possible and periodically review them to ensure they have not become detrimental to office productivity.

When to Switch

When considering digital photography, dentists should consider a number of factors.

First, in most cases, the practice itself should have a computerized management system. The maximum benefit of digital photography cannot be achieved in an office that relies on paper recordkeeping. The sites best-suited for adopting digital photography are already equipped with up-to-date computer hardware, including at least one system with a multi-gigabyte hard drive. A network is even better, as it will allow images to be accessed from anywhere in the office. E-mail is another important component, as it will enable the digital images to be shared with third parties and patients electronically.

The practice should also evaluate its image display and printing capabilities. At least one digital camera for dentists is sold as a "kit" that includes a color inkjet printer and image management database software. Dentists who purchase standalone digital cameras will need to research available printers and software as well, to ensure they have the means to store, access, and print their images after capture.

Assuming the office is ready, from a technological standpoint, for digital photography, the next step is to determine whether the benefits are sufficiently important to justify the transition. Dentists can start by considering whether they would like to be able to display photographs immediately, share photographs electronically, and store them electronically. If these applications are sufficiently attractive, then digital photography is probably a good choice for that practice.

Conclusion

Electronic or digital photography technology has progressed substantially in the past few years. Digital cameras are quickly becoming an important photographic tool for dentists. Taking time to understand the technology and plan for the way it will change practice workflows and affect the office infrastructure will help ensure the transition to digital will be both pleasant and financially beneficial.

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CDA JOURNAL, VOL 29, Nº10

Enhancing Interprofessional Communication Through Digital Photography

Anthony G. Gallegos, DDS

ABSTRACT Dentistry has enjoyed more technological advancements in the past 10 years than in the previous 50. A majority of that technology has become common in today's dental practice. Intraoral cameras, digital radiography, air abrasion, CAD/CAM dental units, and various laser systems are many of the technologies that are headlined at dental conventions not only in North America but throughout the world. Dental offices are rapidly becoming digital and must communicate digitally not because dentistry demands it to but because the technology available to many other professions, businesses, and consumers (patients) demands it. One such digital technology, digital intraoral photography, can enhance communication between dentists and dental ceramists. This article will explain a simple and inexpensive approach to approaching the esthetic dilemma of restoring teeth in the esthetic zone.

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Today's dental clinician has a myriad of esthetic materials at his or her disposal. Yet, regardless of the material chosen for crown and bridge prosthetics, many dental offices fill out laboratory prescriptions with minimal instructions such as, "Make PFM #9 shade A2." The laboratory ceramist is left in a quandary as to how to fabricate an esthetic restoration with only generic instructions. The lab ceramist makes a plain-looking crown, despite the ceramic restoration chosen, that replicates the generic shade tab as closely as possible. Upon looking at the crown at the insertion appointment, the dentist and team are usually less than excited about the result. The dental office had a certain level of expectation of the prosthetic result and probably a mental vision of what the definitive prosthesis would look like.

The goal of any communication is for the sender to articulate his or her message clearly so that the receiver understands the message. It would be ideal if the message generates in the receiver the same mental picture that the sender visualized internally and then transmitted externally. Historically, in their efforts to achieve success beyond generic-looking restorations, dentists have utilized everything from crude drawings, commonly known as shade mapping, to intraoral photography for communication with ceramists. Drawings have improved results, but they can be misinterpreted depending on the artistic qualities of the person drawing the picture.

On the other hand, many clinicians have attempted to use traditional film-based modalities to communicate their ideas to ceramists. This requires specialized cameras and attachments for close-up and intraoral images. The learning curve is high, and the technology not readily usable by the entire dental team. Exposure and composition errors are not caught until the film has been processed, which is usually after the operative site has been altered. In addition, the desire to use an entire roll of film before processing can delay submission for developing. Also, traditional film, both print and transparency (slide), can yield color shifts that vary among manufacturers and depending on the type of film used (daylight, low light, chrome, portrait, etc.)[1] These color shifts and the entire developing process can give a hue to the final photo that is too red, blue, or green. Slide film also requires specific projection equipment and a darkened environment to view the photographic results.

For all of these reasons, the photographic depiction of a tooth's value and chroma can be different from the actual clinical situation. To address these issues, the current state of the art for esthetic clinicians is a combination of photographs, drawings, prescriptions, diagnostic models and wax-ups, photo atlases, and even photo clippings from magazines that the patient may have brought to the office.[2]

Recent advances in digital cameras, imaging software, and printer capabilities are allowing the esthetic clinician the opportunity to address some of the toughest shade-matching challenges. Previous digital attempts have given less-than-acceptable results since camera electronics and computer printer technology were inadequate. Secondly, expensive investments were necessary to create images that approached print photographic in quality. Today, however, digital cameras are capable of images that are "megapixels" in size, and some of them are being outfitted with macro capabilities and flash units that make their extra- and intraoral use acceptable for dentistry. A variety of manufacturers offer single-lens reflex cameras with interchangeable lenses and macro-flash capabilities. Without this macro-flash capability, intraoral shots tend to wash out. The overall investment can range from just less than $1,000 to $2,400 depending on the make of camera, its accessories, software, and printer. A conventional film-based camera may be a smaller initial investment; however, there are the additional costs of film processing, print duplication, and archiving.

Digital cameras offer the advantage of viewing an image immediately, thus allowing the clinician an opportunity to check its composition and exposure. Ink jet and dye sublimation printers can give a photographic quality result, and the user can choose which images to print instead of developing an entire roll of film. The print of the digital image can then be sent with the case to the laboratory without a delay for processing film. A new digital breed of clinicians and laboratory ceramists are also communicating with each other electronically because digitized images can be sent via e-mail.

The American Dental Association has adopted recent guidelines for the development of electronic image standards.[3] This digital imaging and communications in medicine, or DICOM, standard allows a common language to be used throughout the dental and medical fields.

One software developer thus far (Dicom Imaging, Inc., Blaine, Wash.) has a software suite for use in the dental industry. The suite consists of an image capture and storage system, a tooth-bleaching simulator, a cosmetic simulation module, an electronic digital X-ray viewer, and an electronic laboratory prescription module. Other companies are also developing their own versions of digital capturing and storage software, and consumer software suites can also be used for the dental office. It is not difficult to predict that the next evolution of office procedure will include an electronic patient chart that includes digitally captured images.

Case Examples

Several cases will be used to illustrate how digital photos and electronic sharing of images can facilitate communication between the clinician and ceramist.

Case 1

Laboratories often receive simplified prescriptions and stone models that are green, purple, blue, pink, yellow, etc., and constructed from impressions. If the prescription calls for any one of the available all-ceramic restorations, the vitality of the definitive restorations will be compromised because the stone model lacks the reflective and refractive optical properties of natural dentin. Communication of shape, dimension, and shade is important. One often overlooked visual aspect of teeth is incisal translucency (Figures 1, 2, and 3).

The restorations depicted exhibit a naturalness that permits the definitive restorations to show vitality and esthetic characteristics. The definitive restorations look natural and blend with the adjacent natural dentition. The other vital aspect is value -- the degree of grayness a tooth has. Lastly, minimal attention is given to surface anatomy and glossy

FIGURE 1. The definitive restoration can have its optical properties affected in the laboratory setting with the use of various model stone colors. This can also influence the actual clinical result. Communicating the dentin color to the laboratory technician is important when dealing with all-ceramic restorations.

FIGURE 2. The preoperative condition shows a loss of function. There are existing ceramo-metal restorations on the maxillary left central incisor and first bicuspid.

FIGURE 3. The definitive restorations exhibit a naturalness to them that blends value, chroma, and surface anatomy. The incisal translucency and characterizations further add to the natural look.

FIGURE 4. The preoperative photo shows a Class IV fracture of the disto-incisal corner of the maxillary left central incisor.

FIGURE 5. Prior to prepping the patient, the clinician should take a digital photograph with the shade guide adjacent to the teeth in question. This is done prior to prepping to avoid the teeth desiccating and a color shift occurring.

FIGURE 6. Some of the flash elements of the ring flash were obscured to aid with the visualization of the hypocalcification pattern . The tooth has been prepped for a partial-coverage all-ceramic restoration. The margins have been placed at the gingival crest.

FIGURE 7. The definitive restoration depicts vitality and blends with the adjacent dentition. The ceramist was able to create a restoration that matched the adjacent dentition primarily because it was similar in value and surface gloss.

characteristics. In the author's numerous conversations with laboratory ceramists, it is generally agreed that these last two characteristics of value and surface anatomy/glaze are key elements. In fact, a dentist could give the wrong shade tab chroma intensity, yet give the correct value and surface anatomy/glaze and the resultant restoration will blend with the adjacent dentition quite well. The case shown in this example required a cooperative analysis by dentist and lab ceramist. Facial analysis using a Trubyte Tooth Indicator (Dentsply International) requested a central incisor with tooth dimensions of 8.75 mm wide by 11 mm long. The preoperative condition depicted a 1:1 width to height ratio. The lab ceramist uses the digital photos to plan the case and examine the effect the final dimensions would have on the overall restorative/esthetic result.

Case 2

The second case (Figures 4 through 7) depicts the typical dilemma of matching a single anterior tooth. In this case, the young female patient had a unique hypocalcified pattern on the adjacent central incisor. Some of the light elements of the camera's macro flash ring were obstructed to aid the visualization of the subtle calcification pattern. It would be difficult for the clinician to communicate this pattern to the ceramist in any method other than photographic. Having the patient present at the laboratory for custom shading would most likely tax the creative abilities and patience of the ceramist. In addition, to go to the lab, the patient would have to coordinate her schedule with the laboratory technician's. A laboratory more than 500 miles from the dental office was chosen to test this technology. Very simplified instructions were given to the ceramic designer: Make Empress Veneer Shade 120/110.

FIGURE 8. The preoperative condition shows missing lateral incisors and disproportioned space to accomplish an esthetic result.

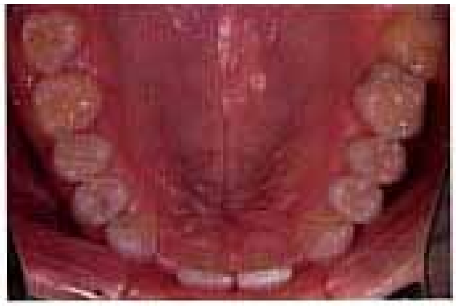

FIGURE 9. The maxillary occlusal view.

FIGURE 10. The completed case. Two all-ceramic three-unit bridges were fabricated. Treatment required ovate pontic preparation in the lateral position and provisional stabilization. Abutment teeth were prepared to allow for dimensionally proportional teeth.

The resultant restoration (**Figure 7**) shows the artistry of a gifted technician despite a lack of information in the laboratory prescription. The photographic print sent to the laboratory aided the ceramist in understanding the unique anatomical variations within the adjacent teeth. The case was successful not only because of the excellent customization by the ceramist but also because the definitive restoration matches the adjacent teeth in their value and surface anatomy and glazing characteristics. The ceramist indicated that the shade matching could not have been this exact without the digital picture of the adjacent dentition.

Case 3

This case shows how proportionally placed restorations can aid the natural look of the final result (Figures 8 through 10). In the presented case, the patient had congenitally missing lateral incisors; and an orthodontist had attempted to lateralize the cuspids. The digital images allowed simultaneous viewing of the various aspects of the case while the clinician and the ceramist were in separate locations. Software allowed the two individuals to connect to each other's computers and carry on a phone conversation while being miles apart. They were each able to use the mouse connected to the individual computers, and the cursor movements could be seen by the other person. The case was successful due to the use of digitized images that allowed for the proper facial and dental analysis by the clinician and ceramic designer simultaneously. The clinician and ceramist were able to co-design the case. From here the ceramist was able to render a three-dimensional, fully contoured wax-up. In this regard, the dentist had become team leader (general contractor) and the subcontractor(s) could easily communicate, contribute, and design a possible outcome for the patient to view for approval. The patient approved of the final design before the teeth were ever touched with a dental handpiece. The dentist, patient, and ceramic designer could all see and approve the desired outcome. This allowed the dentist to provide the correct amount of tooth reduction. The patient's provisional restorations were constructed from this same mock-up, and the lab could complete the definitive restorations from the mock-up, the various digital views from different angles, and digital images of the shade tabs that reflected the patient's true natural state.

Conclusion

With the use of one of the dental-ready digital cameras, DICOM-compliant software, and a photo-quality printer, the esthetic clinician is now capable of accurately communicating to the dental laboratory the unique esthetic challenges and desires of any case. One of the most difficult esthetic challenges, the shade matching of the single central incisor, can be consistently and reliably be performed. All that was lacking was the ability to successfully communicate the actual clinical environment from clinician to ceramic designer. This article explored case examples that illustrate the successful use of this new technology for dentistry.

A recent trend of shade communication and color mapping is the use of digital scanning technology to optically capture an image. It uses color-corrected lighting and a capture device that digitally assigns tooth shading based on widely accepted shade and stump guides. This form of communication will prove invaluable for every esthetic clinician. Unfortunately, at this time, the investment in this latest technology is too expensive for the majority of dental practices. Despite this problem, such technology represents the future of shade communication. Similar to computer technology that costs thousands this year and whose future financial investment will be smaller in the years to come, this technology will lead to the dental clinician to wanting to provide the most precise communication. It is hoped that it will become more affordable for a majority of dental practices and laboratories.

While the above may represent the future, today's esthetic clinician can now accurately communicate shade, shape, and function to the dental laboratory to yield beautiful results that rival nature with a modest investment. The future of digital communication remains wide open for everyone from the general dentist wanting to aid the dental pathologist to the dentist wishing to consult with other dental specialists.

Acknowledgements

The author would like to acknowledge the ceramic efforts of Matt Roberts, CDT, in Case One; Kent Hallmeyer, CDT, of Frontier Dental Laboratory in Case Two; and Mike Cash, CDT, of Glidewell Laboratories in Case Three.

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Image Management in Dentistry

David Gane, DDS, BSc

ABSTRACT Dentistry has seen a significant increase in the number of digital imaging technologies that have become commercially available during the past year. Computers, digital still cameras, scanners, intraoral cameras, digital X-ray systems, and their associated imaging software are all positioned at the top of the list of technologies that dentists plan to purchase within the next 12 months. This article provides an overview of the principles of image management in the dental office with an emphasis on hardware and software requirements as well as practical applications that a properly implemented image management system can afford the modern dental office.

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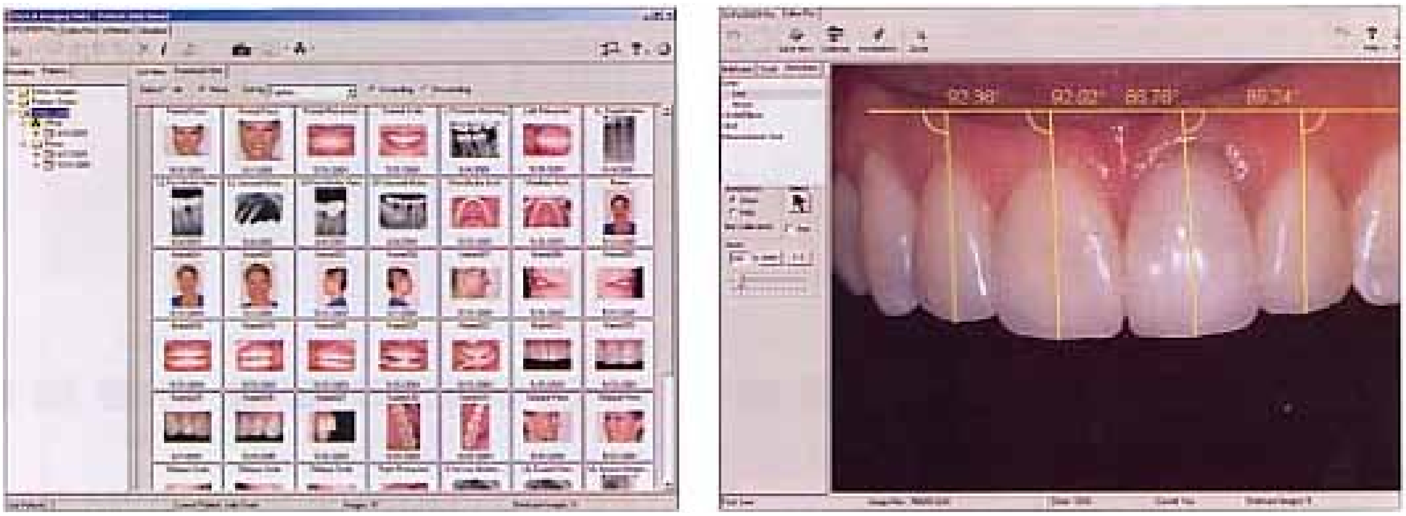
Ever since Roentgen's accidental but momentous discovery of X-rays in 1896, innovative imaging technologies have continued to advance and dramatically improve health care. This is especially true in dentistry, which has seen a significant increase in the number of digital imaging technologies that have become commercially available during the past year. Computers, digital still cameras, scanners, intraoral cameras, digital X-ray systems, and their associated imaging software are all positioned at the top of the list of technologies that dentists plan to purchase within the next 12 months. One reason for this growing popularity of imaging technologies is that they are within the budget of most dentists. Another is that they are easy to use, and they also afford tremendous efficiencies and positive returns to those who invest in them. If we consider this trend toward the use of digital imaging systems combined with the emerging statistics that dentists are computerizing their operatories3,4 and using the Internet5,6 in ever greater numbers, a compelling case for adopting digital imaging starts to emerge. This article provides an overview of the principles of image management in the dental office after capture through final output with an emphasis on hardware and software requirements as well as practical applications that a properly implemented image management system can afford the modern dental office.



FIGURES 1A AND B. Image management software provides much of the power and convenience of digital imaging and is routinely used to acquire images from a variety of hardware devices as well as to store, retrieve, edit, print, and share the digital images (Images courtesy of Dicom Imaging Systems, Inc.).

FIGURES 2A AND B. The original image (left) is clear with an uncompressed file size of 510 Kb. The image on the right shows the visible lossy effect of aggressive JPEG compression, but the file is only 28 Kb.

Digital Images and Their Management

Just like their film-based counterparts (possibly more so), the striking high-resolution digital pictures generated by digital imaging systems are essential and critical elements of a patient's dental record. These images have proven to be invaluable resources to the dentist for diagnosis, treatment planning, and case presentation. Furthermore, these images are fundamental to optimizing communication with patients, labs, and insurance companies. This sounds very powerful and impressive, but what is a digital image really? The word digital refers to the binary language of computers, bits and bytes. (The use of the numbers 0 and 1 are known as bits, and a byte is eight bits). The computer sees all data, including image files, as binary information. So a digital image is no more than a set of numbers stored as a digital file that a computer can recognize and perform operations on with the help of imaging software. The sheer volume of images that can be acquired in a dental practice can be overwhelming. Managing images from capture to output with the appropriate software ensures that images are stored away carefully by patient name and date so they can be conveniently accessed when needed.

Software

Image management software is essential to maximize the power and convenience of digital imaging. It is routinely used to acquire, store, retrieve, edit, print, and share digital images. A

FIGURES 3. Cosmetic imaging affords the opportunity to explore different treatment options and to communicate them to patients in a way never before possible.

patient's images are stored in an electronic filing cabinet (image database), along with important information about the image and the patient. While ease of use, specific functionality, and cost vary among different products, the principle is almost always the same.

Images are located by performing a search or browsing though a collection of small images, known as thumbnails, on the computer screen. Once found, an image may be viewed at full size, presented in a slide show format, transferred across a network or the Internet, or printed, alone or as part of an image group. Prices for image management software can vary dramatically. Products offering sophisticated features such as direct digital capture from multiple devices, measurement functionality, annotation, color correction capabilities, etc., have somewhat higher prices. The following points should be considered when evaluating image management software applications for the dental office:

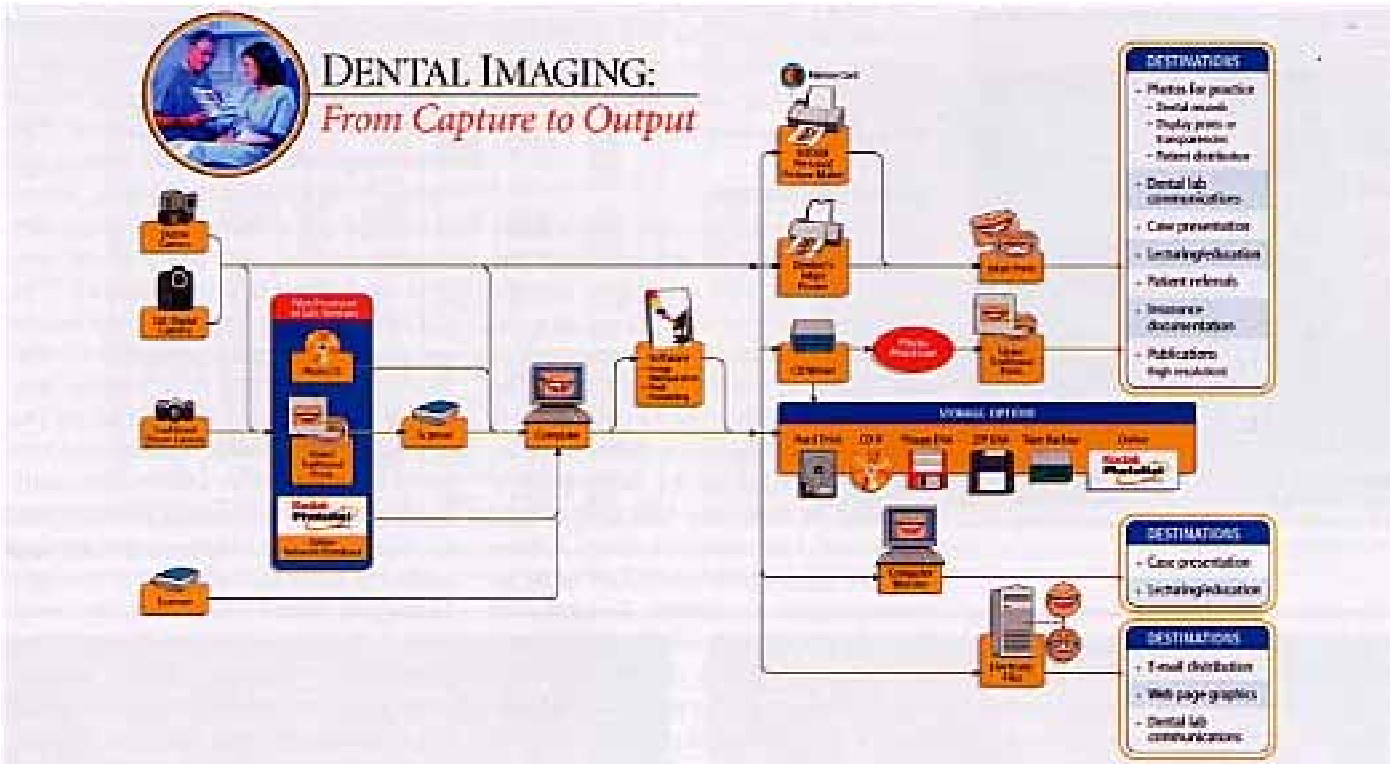
- Image acquisition: Image management software should permit easy transfer of images from the dentist's image input devices into the patient file in one easy step.
- Image viewing: Much of a dentist's time with the software will be spent viewing images on screen. The viewing function should enable the user to readily pan and zoom an image as well as view multiple images at once, alone or in a slide-show format.
- Browsing/searching: The image management software should allow the user to organize images in a logical and easy-to-use fashion. The user should be able to locate images by patient, visit date, or image type.
- Printing: The print reports should be versatile. The software should be able to place images on paper in a custom fashion, and there should be a print preview function.
- Database synchronization: A user will often have databases in different places that need to be "synchronized." Image management software should have that capability.
- Software integration: The software being considered should work well with the most current operating systems, e.g., Windows 2000, NT, etc. It is also likely that a dentist will want to use image management in conjunction with practice management software. The image management software should integrate well with other software applications.
- Image editing: The better image management products allow the user to perform certain tasks without switching programs. Such features may include the ability to add notes and comments, color correction, cropping, rotating, resizing, automated measurement, and annotations.

Image Compression

A full-screen 256-color image takes about 1 megabyte of storage, about the same amount as a complete text or Tolstoy's novel "War and Peace." Color images can consume massive amounts of disk space and memory; they can also be slow to transmit over computer networks. Data compression technology allows large files to be temporarily squeezed so that they take less storage space and transmission time. Before they are used, compressed files must be decompressed. In general, compression works because most raw data files contain redundancy that can be "squeezed out." Lossless compression systems allow a file to be compressed and later decompressed without any loss of data; the decompressed file will be an identical copy of the original file. A popular example of a lossless compression system is WinZIP (DOS/Windows). On the other hand, a lossy system can usually achieve better file compression, but the compressed file isn't always identical to the original. This is tolerable in many types of image files. A popular example of a lossy system employed by many software developers and vendors is JPEG (Joint Photographic Experts Group).

The Dicom Standard

The Digital Imaging and Communications in Medicine (Dicom) standard as it relates to dentistry is the result of efforts by the American Dental Association Task Group on Dental Informatics and manufacturers to develop a common "language" for formatting and exchanging images and image information throughout the profession.6 The emerging Dicom standard will allow dental images to be captured and communicated in a common format, allowing for more efficient exchange of images and related information with the ultimate goal of total interconnectivity among dental and medical images and image-generating devices.7 This promises to contain costs and to improve the quality of care. Dicom equipment in an office might include digital intraoral and extraoral radiographic systems, image management software, and secondary capture devices such as intraoral cameras and digital still cameras. The Dicom standard has now been implemented in an increasing number of dental imaging products from various vendors. This adoption of Dicom by the dental industry is opening new opportunities for dentistry to increase the quality and cost-effectiveness of patient care.



FIGURES 4. This flow diagram shows a typical work flow for acquiring color images via digital camera and scanner and the potential storage and output solutions (Used with permission of Eastman Kodak).

There is more to image management software than initially meets the eye. Managing dental images requires easy-to-use, high-quality software. Many practice management software applications do offer varying degrees of imaging functionality, but specialized image management software usually affords greater functionality, usability, and value. A dentist may also wish to consider cosmetic imaging software to provide compelling treatment simulations.

Cosmetic Imaging Software

Cosmetic imaging software (sometimes termed “computer imaging” software) can be used to simulate the results of esthetic and restorative dental procedures. During a case presentation or even during a routine re-care appointment, a patient is able to easily see proposed cosmetic or restorative treatments, such as tooth whitening, prior to committing to a procedure. Cosmetic imaging also allows dentists and their staff to explore different treatment options and to communicate them with their patients in a way never before possible. Using cosmetic imaging software, a dentist or staff member can visually demonstrate what is -- and is not -- feasible. With a clear understanding of patient expectations, any misconceptions can be dealt with prior to treatment. Software options for patient imaging range from inexpensive, general-purpose products to more costly specialized dental simulation programs complete with libraries of teeth to facilitate the imaging process.

One should keep in mind when evaluating options that except for tooth whitening simulations, imaging is generally not performed in front of the patient. The least-expensive image-editing programs available are intended for consumers, photographers, or graphic artists and can be difficult to use for the average dental staff member. Also, these off-the-shelf programs typically do not incorporate image management. Those who can afford the investment are encouraged to consider software that has been developed specifically for dental imaging. The tools and interfaces of these programs are designed to simulate dental treatments in a quick and easy fashion.

Hardware

Prior to purchasing a capture device and software -- i.e., digital camera, scanner, intraoral camera, digital X-ray system, etc. -- one should consider a computer configuration for the clinical workstation. Imaging imposes heavy demands upon a systems resources, both memory and storage. Whether a system be used as a standalone or configured as

FIGURES 5A AND B. Easy-to-use image management software puts the power of the images at the dentist's disposal.

part of a local area network, the following should be considered when a system is chosen:

- Hard drive: Images files are large files. The bigger the hard drive, the more images that can be stored there. In most cases, 30 Gb of storage will be sufficient.
- CPU: The CPU or processor should meet the specifications of the software that will be used. A speed of 800 Mhz is fine for most clinical imaging applications; the user should get the fastest processor he or she can afford.
- RAM: Random access memory is the computer's virtual workspace. One should get at least 128 Mb. One can never have too much RAM.
- Printer: A variety of printers are available at different levels of quality and price. Kodak has recently introduced a low-cost digital ink jet printer ideally suited for both high-resolution paper and X-ray film prints.
- Backup: It is important that images are backed up diligently. On a single imaging station, the high capacity and low cost of digital audio tapes makes them an excellent choice. In a network scenario, mirrored hard drives, coupled with a tape backup system, are optimal for uninterrupted access to image data.
- Network card: If computers will be linked in a local area network, a network card will be needed for each computer in the network.
- CD-RW drive (re-writeable): These devices can be external or internal to a computer and are invaluable for moving transferring large amounts of data to a remote location as well as archiving and backing up image data.
- Video card: To capture still video frames into a computer from an intraoral camera will require a video frame grabber card. These inexpensive cards are readily available from software vendors.
- Display: When one is selecting a monitor, the main considerations are screen size (measured diagonally), dot pitch, and refresh rate. Recently there have been major advances in display technology. Cathode ray tube are rapidly being replaced by digital displays. Digital displays offer many advantages over traditional CRT designs in that they can reduce eye fatigue, occupy less desk space, provide a perceived increase in color saturation, and are coming down in price dramatically. Still, the observer's position relative to the screen greatly influences perceived color rendering. Rather than getting buried in technical aspects, the user should buy the monitor that looks best to him or her.

When one is evaluating a computer system for imaging, expandability is probably the most important consideration. A computer will definitely need to "grow" as the dentist's understanding and demands of imaging technology grows. There are many good Web sites where a dentist can custom-configure a computer.

Networking

A computer network provides the framework and backbone for achieving complete practice integration, thereby enabling information and images to be accessible throughout the dental office and even at remote locations such as satellite offices and from home.8

Local area networks are available in many forms. The most basic is a peer-to-peer-type network As the name implies, all computers in a peer-to-peer-type network are equal. Each computer can access the files and resources of the other, but as a general rule these types of networks are not ideal for imaging applications due to their inability to protect data from unauthorized access as well as the potential for sharing violations and data corruption. It takes a much higher level of sophistication to provide a secured network. This generally means dedicating a computer to act as a "server" for the system to manage the network and image-backup procedures. Realistically, every practice will have its own unique scenario, and the dentist would be wise to consult with a qualified networking professional.

Putting Images to Work

One of the issues that all sophisticated imaging technology dental consumers have to deal with is justifying the cost of purchasing and implementation a new digital imaging system for the office. Digital photography, digital X-ray, intraoral cameras, and computers are all exemplary in their ability to return their investment many times over. In addition, a number of imaging applications provide the ability for the practice to send their images to growing list of insurance companies as electronic attachments to pre-authorizations and claim forms. This affords the practice and insurance company added efficiencies and cost savings that translate into faster claims processing and higher acceptance rates of proposed treatment plans. Images can also easily be shared with lab technicians, specialists, colleagues, and even patients.

Looking Forward

The future of image management will rely heavily on the Internet. As image cameras and X-ray systems become less expensive and more useable and as Internet usage increases and becomes more reliable, companies will soon charge a nominal fee to participate in services such as such as cosmetic imaging, high quality printing, image archive and backup, and differential diagnosis using color and radiographic images. These services will be limited only by the imagination of the service provider. Data centers, service bureaus, image security, and encryption will be the buzzwords of the near future.

Since the introduction of the first radiograph, clinicians have relied upon imaging as an indispensable adjunct to diagnosis and treatment planning. It is no wonder that digital imaging products and image management software make up one of the fastest growing markets in dentistry and are positioned high on the shopping lists of dentists worldwide. When one considers that modern systems are affordable, are easy to use, and dramatically improve patient care and profitability, the question is no longer should one buy into digital imaging but when.

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Photography and the Operating Microscope in Dentistry

Cary Behle, DDS

ABSTRACT Operating microscopes have been used in various medical surgical procedures for many decades, but they have only significantly been in use in dentistry during the past 10 years. While microscope use in dentistry started mainly in endodontics and spread rapidly to periodontics and oral surgery, restorative dentists have recently been discovering the advantages of microscope. These advantages include tremendously increased visibility and lighting, much improved ergonomics and posture, enhanced ability to utilize assistants, and, because of these factors, a significant improvement in diagnosis and treatment results. The increased visibility has also prompted the adoption of various photographic devices to the operating microscope, from traditional 35 mm photography to video and digital media, both still and motion. The purpose of this article is to discuss and demonstrate some of the photographic options that can readily be adapted to this new instrument of modern dental practice.

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Many articles have been written in dental journals discussing the benefits and techniques of the surgical or operating microscope.1-11 The goal of all dental restorative procedures is to create a bacteria-free seal, however the resolving power, or ability to distinguish images, of the unaided human eye is 0.2 mm or 200 microns.3 The generally accepted ideal margin of a restoration is about 25 microns, which is well beyond the resolving power of the human eye to see. At least 25 bacteria placed end to end could pass through an opening of that size, which is the average film thickness of most restorative cements used today (**FIGURES 1 AND 2**). If a dentist can see something, he or she can better diagnose and treat it. Increased visualization, combined with much more relaxed ergonomics, makes for better treatment results, which benefit the dentist, assistant, and patient alike (**FIGURE 3**).

Photography and the Microscope

Intraoral cameras are very effective for patient education and documentation. Photography through the microscope is just as easy but with vastly improved image quality and a choice of magnifications. By using digital cameras or video along with the microscope, the dentist can have instant use of photos for patient education (**FIGURE 4 AND 5**).

Dental treatment utilizing the microscope is the main reason for having one, however the dentist can also easily take photos through them as he or she works. These photos can have many applications within dental practice. They

FIGURE 1. The microscope is invaluable during the seating of indirect restorations, in this case a porcelain onlay on a mandibular molar. The dentist can easily see that the cement excess is continuous and equal and clean it up rapidly.

FIGURE 2. The final margin of the onlay seated in Figure 1 shows a properly fitted margin and good seal.

FIGURE 3. The dentist and assistant working through the microscope. Notice the upright posture and improved ergonomics. The assistant can see everything the dentist sees, so the dentist becomes much more efficient and therefore faster. Notice the bagging of the microscope and camera for a disinfected procedure.

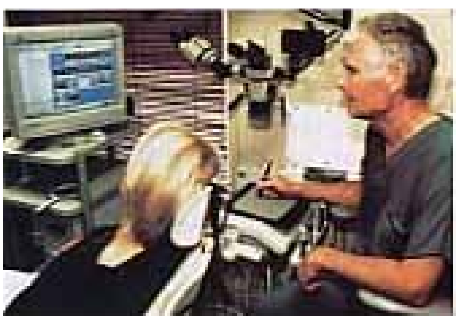

FIGURE 4. The dentist can easily show a patient details of her teeth to determine correct treatment, or before-and-after photos at the end of an appointment, to build value in the service. A library of images can be saved for future patient education examples.

FIGURE 5. A full smile should be visible at the lowest magnification (2x) for diagnosis and treatment planning with the patient, as well as comparison of before-and-after photos. All the esthetic parameters can be visualized and photographed except the full-face photo.

FIGURE 6. In preparing tooth #14 for an all-ceramic onlay, a distal category IV crack was discovered. Magnification 12x.

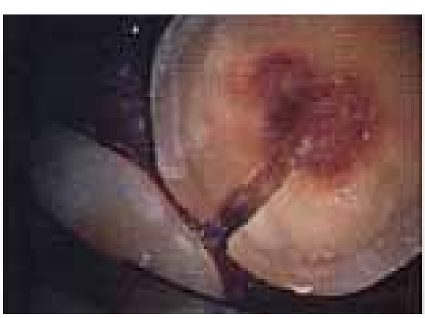

FIGURE 7. The crack was traced out with a #330 bur to under the gingival margin. This would be very difficult to do without the operating microscope.

FIGURE 8. The crack was traced another 1.0 mm and then etched, primed and bonded with a fifth-generation bonding agent (Prime and Bond NT, Dentsply, Caulk), which contains acetone for the most penetration, then filled in and built up with flowable composite. The margin can now be refined for an impression.

FIGURE 9. A broken abutment tooth #13 under a bridge can be shown from both direct and indirect (mirror) shot. The patient can better understand the choices presented to her, and specialists can be consulted quickly via the Internet.

FIGURE 10. A photo at about 4x magnification showing a poorly matched implant crown and exposed implant abutment. Documentation and demonstration to the patient can be performed instantly with a digital camera mounted on the microscope and the images downloaded to a computer. Photos can be e-mailed to specialists for opinions and discussion.

FIGURE 11. At about 2:1 magnification ratio, the exposed implant abutment in photo #9 and tissue morphology can easily be seen.

FIGURE 12. An example of a small occlusal amalgam that has eventually caused multiple fractures in the remaining tooth structure. The tooth should be restored with an onlay rather than an intracoronal composite. Magnification 8x. Detail shown to patient will explain the reason for a more-extensive restoration. The photo can also be used as documentation for insurance, since this level of detail would not be visible on an X-ray.

FIGURE 13. Crack visible at base of lingual cusp tooth #5. Magnification 8x. Another example of a need for onlay coverage. The crack must be traced out and bonded before fracture can occur possibly subgingivally. Higher magnification would be used for this repair and preparation.

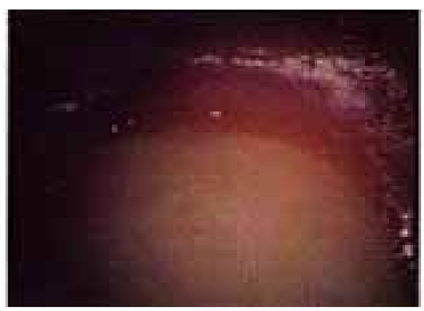

FIGURE 14. Cracks in a veneer can easily be seen at about 16x under the microscope. The patient can be shown something he would never be able to see with the naked eye. The resulting photo can be stored in the patient's chart as a documentation of the situation. The patient can better make a decision about whether to "watch" this or redo the veneer.

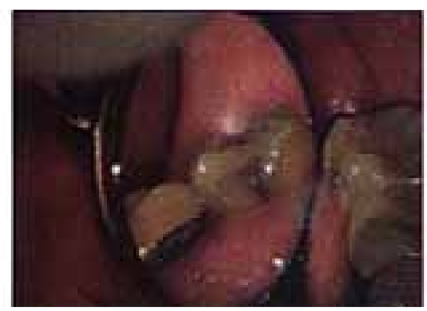

FIGURE 15. A crack under an onlay is completely visible using a mirror. Decay is evident under the crack. This photo is good documentation for an insurance company because this detail would not be visible on an X-ray.

can be used to build value for dental services by showing the patient what was accomplished during the visit (FIGURES 6, 7 AND 8). Problems or concerns can also easily be shown (FIGURES 9, 10 AND 11). Insurance company documentation can be provided (FIGURES 12 AND 13), and photos can be stored in a patient's chart for reference to observe changes over time (FIGURES 14 AND 15). In addition, a dentist can build a patient education library very easily, as well as accumulate photos for lecturing or illustrating articles. Dental assistants become much more valuable by being able to see the work in process from the same perspective as the dentist, and impressions can be examined easily and accurately at chairside (FIGURES 16).

Information can be provided to specialists to help guide their treatment, and those specialists can be contacted by e-mail for help in diagnosis and treatment planning (FIGURES 17, 18 AND 19). Digital cameras with computer download capability allow the use of the Internet for sending photos worldwide, and patient records and photos can be transmitted instantly. The office can e-mail before-and-after photos to patients before they have even arrived home from their appointments.

Photos through the microscope can also be used for marketing to other patients, answering questions on-line, and posting on a Web site. A series of photos can be e-mailed to a dental laboratory along with instructions typed onto an on-line lab slip (FIGURE 20). Full-smile images as well as shade tab comparisons and close-ups of teeth to be matched make lab communication easy and instantaneous (FIGURE 21). All of these benefits of photography are part of the digital revolution that is changing the technology of the dental office and the way dentists communicate with people.

Types of Cameras for the Microscope

The digital revolution is flowing throughout our lives in ways not envisioned even a few years ago. It is also rewriting the future of photography and will be the focus of this article. However, there are still many uses for film photography, such as slide images used for lecturing; but event that is changing as more and more lecturers switch to the digital format for their entire presentations. At this point, film still has an advantage over digital in the amount of detail recorded, or resolution; but this gap is closing every day. A high-end single-lens reflex camera with superb lens optics using ISO 100 film and tripod stability can capture detail equivalent to a 40-megapixel sensor.12 The top digital sensors today using either CCD (charge-coupled device) or CMOS (complementary metal-oxide sensor) technology are in the range of 3.3 to 4.2 megapixels. Therefore film resolution currently has a tenfold advantage over digital, but that higher resolution may not be necessary in dental applications. The difference would only be apparent upon extreme enlargement of the image, comparable to a 35 mm image being enlarged to poster size, 20 by 30 inches or more. There is almost no use in dentistry for this resolution, except as a reception room display. Therefore, for all practical purposes, digital images are suitable for use in the modern dental office and with the microscope.

Film-Based Cameras

The most common format and film size is 35 mm using an SLR camera body attached to a beam splitter on the microscope (**Figure 22**). This splits the light beam passing through toward the operator binoculars to a separate attachment for one or two cameras or a camera and assistant binoculars. Each microscope manufacturer would have to provide a proper mounting system for each type of camera. The microscope light alone is not sufficient when using ISO 100 film, so a ring flash is attached to the microscope lens, as in a standard clinical camera. Exposure is arrived at by trial and error testing for each set up. Polaroid cameras could be used if proper attachments were available, or Polaroid camera backs can be purchased to fit 35 mm camera bodies. The only advantage with Polaroid film is instant prints, which can also easily be accomplished with digital cameras and printers.

Video Cameras

Video cameras (**Figure 22**) use CCD or CMOS sensors. The difference is in the output, either analog to a regular TV or digital to a computer. Intraoral cameras were all initially analog since it is less expensive technology, and a television was fine for showing patients what was needed. Digital output is much greater in resolution, as are computer monitors when compared with television. With output to a computer, the resulting motion files can be stored digitally but require very large amounts of hard drive space. These files are generally now downloaded to CDs. With analog output, a simple VCR can be used. The main question that should be asked about video is: Does one need motion to demonstrate what is desired, or are still images better? Generally speaking, motion recording or live video is useful in teaching situations but not to a dental patient. Some dentists use a video monitor for visualization by the assistant rather than an assistant binocular, but this does not allow the assistant to utilize the four-handed assisting techniques properly.

Digital Still Cameras

All digital 35 mm-style still cameras also use CCD or CMOS sensors. The output is generally shown on a built-in screen or, with a plug-in wire, to a TV screen. There is constant full motion output when the camera is on, just like with a video camera. The difference is that the motion is not being recorded; only single frames are recorded and only when the "shutter" is released. Therefore, a simple digital camera can also be used for live feedback in teaching situations or for assistant visualization. The resulting still picture files are much smaller than video and easy to store in a computer. Some cameras will download directly to a computer, others load images on an electronic storage card that is then fed into a card reader to download (**Figure 23**). Some video cameras are also able to "capture" still images; however, because of their design, the resulting images are generally inferior to that of still-picture-only cameras. Because of the increased sensitivity of digital sensors (generally comparable to a range of ISO 100 to 1600 film), flash is not necessary; the normal fiberoptic light output of the microscope is sufficient. Another advantage of digital cameras is that white balance can be used to maximize the true color under different lighting systems. Each camera and light will require calibration to optimize the exposure. Different microscope manufacturers offer a variety of attachments for all types of cameras and would be able to assist in calibration (**Figure 24**).

Output from the camera can be printed out directly from the memory card to some printers or from any computer where the images are stored or networked. The two main types of printers available are the ink jet and the dye sublimate process. The ink jet is the most common computer printer. Today, the color ones that are specific for photos are almost as good as film-based prints. Different kinds of papers can be used as well as different sizes, from 3 1/2 by 5 inches up to 20 inches by up to 20 feet. Most printers will output up to 8 1/2 by 11 inches. Costs for ink jet photo printers range from $100 up to $800 or more, but very good ones can be obtained in the range of $250 to $500. Dye sublimate printers have been the main printers used with the intraoral cameras the past 10 years. Their quality is generally better, but the better ink jet models are now very close. Dye sublimate printers will range from $250 up to $5,000 or more. The main disadvantage is that almost all of the printers that cost less than $5,000 can print on only one special kind of 4-by-6-inch paper.

Learning Curve and Costs

For a dentist who has never used

FIGURE 16. The dentist can easily examine his or her impression under the microscope and also send the photo to the laboratory with others via e-mail.

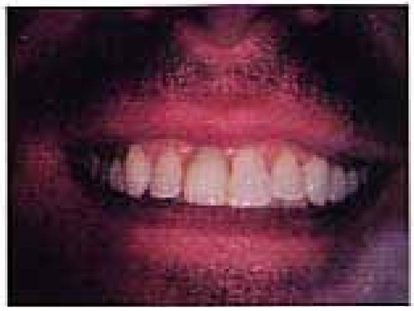

FIGURE 17. A full-smile photo taken through the microscope at 2x showing the mismatched shade and size of temporary bonded bridge pontic #8 over the implant site. This can be e-mailed to the lab for correction or done chairside. A periodontist or oral surgeon can be directed as to any tissue changes that may be necessary.

FIGURE 18. A full-arch-retracted photo can be used as a before or after documentation as well as for obtaining the opinions of a periodontist and/or orthodontist about the esthetic and functional improvements that can be made.

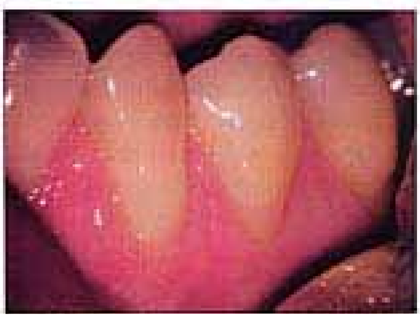

FIGURE 19. At about 1:1 magnification ratio (8x power), the receded tissue and exposed roots can show the patient and the periodontist exactly what is going on. Consultations with specialists can be carried out without the patient leaving the dental chair.

FIGURE 20. A photo of a silicone matrix preparation guide made from a laboratory wax-up of the final result desired. This helps the dentist considerably in the preparation of the teeth to achieve ideal equal thickness of porcelain. This photo can be sent to the lab to help the technician understand what the original position of the teeth was and why preps were done a certain way.

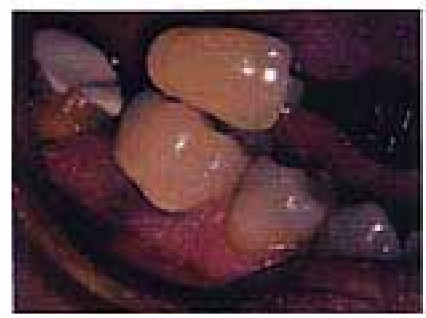

FIGURE 21. Shade-taking can be done as usual, and then several views of the adjacent teeth and shade tabs for comparison can be e-mailed to the laboratory. The actual color is likely not accurate, just as with all types of film, however comparisons can be made to help the technician. No film image, digital image on a computer monitor, or print done from a digital file is totally accurate with true colors seen by the eye.

FIGURE 22. A microscope with a 35 mm film camera and a video camera attached to the same side of a beam splitter (photo courtesy of Gary Carr, DDS).

FIGURE 23. A "Compact Flash" solid state memory card is loaded into a card reader for downloading into a computer.

FIGURE 24. A microscope with a digital still camera (Nikon Coolpix 950) attached to a beam splitter. The display can be used to compose the photo, or better, output to a television visible to both patient and doctor. Power supply is by AC adapter cord directly into the camera so no batteries are necessary (photo courtesy of Gary Carr DDS).

magnification before, it is best to start with low- to medium-powered loupes and a headlight to get some experience. Using a mouth mirror is extremely important with a microscope, and it is best to practice that with lower magnification first. The author started with 2.5x loupes and a headlight in 1986 and worked up to 4.8x and 6x loupes. The transition to a microscope in 1999 was very easy, and the device was fully integrated into the practice in a few weeks. The author recommends attending a hands-on course in the use of a microscope first, and then obtaining a mentor who uses one and can help with actual clinical cases.

Costs for a microscope will range from about $5,000 to $8,000 for an entry-level model up to deluxe models in the range of $40,000 to $50,000 with motors, balance gimbals, and zoom lenses. A very good quality microscope with assistant binoculars (recommended by the author) and a camera will be $20,000 to $30,000. Some can be mounted on a ceiling track and used in two different rooms or can be used on mobile stands, although a lack of floor space may make this inconvenient.

Conclusion

Use of the operating microscope in dentistry is growing. As more dentists realize the tremendous benefit of visualization of four, five or six different magnifications at a turn of a knob, unobstructed high-intensity lighting, relaxed upright ergonomics, and an increase in assistant utilization and speed, prices will decline and more models will become available. However, at this time, the benefits far outweigh the costs involved. Photography through the microscope is as natural as looking at the operating field. It requires almost no additional effort, and no change in position. The resulting images are superior to intraoral cameras and offer magnification unavailable with the clinical close-up cameras. The use of the resulting photographs, particularly in digital form, expand patient education and acceptance of treatment, as well as communication with laboratories and specialists.

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Portrait Photography for the Dentist

Cary Behle, DDS

ABSTRACT The increase in popularity of esthetic dentistry and the dential profession's enthusiasm for providing these services are leading to a new paradigm of dental practice. The design of a dental office must now relate to visual and esthetic values rather than just to treating disease or maintaining health. Photography has always been important in dentistry, mostly as documentation and more recently for patient education. Patients' high esthetic expectations put great demands on professional providers. It is the duty of the dentist who provides esthetic services to become schooled in the goals of beauty for a person's entire face, not just the teeth. Portrait photography heightens a dentist's and patient's value of the mouth as the center of beauty in the face. It helps educate the patient and dentist alike, is important for the education of other patients, creates value, markets the dentist's services, enhances the image of the office, and helps in the evaluation and planning for cosmetic treatment. This paper describes the basics of portrait photography and a simple two-light and reflector arrangement that can be used in most offices.

Although public interest in good-looking teeth and a great smile has consistently been high,[1] the dental profession's ability to satisfy this demand has been increasingly rapidly, thanks to a multitude of new materials and techniques. A recent USA Today survey[2] found that when people were asked "If you could change your facial features, what would you change?" the largest percentage of responses had to do with the mouth (27 percent). The nose came in at a distant 13 percent. As physicians of the mouth, dentists are in the position to positively affect people's self-esteem. Esthetic dentistry has finally become a mode of practice that is accepted by patients and dentists alike. However, this mode of practice requires a very different office layout, armamentaria, and way of communicating from the traditional dental practice. Since appearance and beauty are entirely visual, photography is perhaps the most important tool an esthetic dentist can use. Most dental photography of the past was for documentation and lecture-illustration purposes.[3] More recently -- with easier to use cameras and film, video, or digital output -- patient-education use has expanded phenomenally; and this has resulted in a significant improvement in the willingness of patients to accept

FIGURE 1. A typical dental clinical camera with a ring-light strobe surrounding the end of the lens. This is as close as a flash can get to the lens. Perfect for intraoral work, it is terrible for portraits. It is sure to produce red eye.

FIGURE 2. A clinical "macro" camera with ring light used for close-up clinical photography.

FIGURE 3. A PC connection found on cameras that will allow attachment of a PC cord to fire a remote strobe and deactivate the on-camera flash.

FIGURE 4. Picture taken with on-camera flash and 35 mm lens. Notice the distorted facial features: a larger nose and changed facial proportions.

FIGURE 5. Same picture as Figure 4 with an 80 mm lens. Notice the normal proportions and perspective.

FIGURE 6. A "before" portrait taken with the camera in Figure 1. Notice the red eye, effect, which is the reflection of light off the subject's retina due to flash being close to the lens.

FIGURE 7. An "after" picture taken with the camera in Figure 6. The red eye is still visible.

finer dentistry, a large percentage of which is discretionary. Now that esthetic restorative dentists have rightfully taken their place next to orthodontists, oral and maxillofacial surgeons, periodontists, endodontists, implant dentists, and plastic surgeons as "cosmetic experts," they must use the proper tools to diagnose, educate, and treat. Dental photography must now move into the realm of professional photographers and utilize "glamour" photography and portraiture as the main tool for either a "smile makeover" or a single central crown.

All that is needed is a camera, some type of lighting, and a space in the office to take the photos.

Cameras, Lenses, and Film

This discussion will be limited to 35 mm cameras, since that is by far the most popular format in use today. Professional photographers utilize mostly the bigger "medium format" cameras and film for portraiture, as they often enlarge prints to 16 x 20 inches or larger and need the detail provided by a larger film. There are many sizes of cameras and film that fit into this category, but most produce images that are five to 10 times larger than a 35 mm transparency. For the vast majority of dental uses, 35 mm transparencies, negatives, or digital backs will produce all the detail necessary for enlargements up to 8 x 10 or 11 x 14 inches.

FIGURE 8. A standard 35 mm camera with a hot shoe-mounted flash on top of the camera. This is not enough separation of flash and lens and will still produce red eye.

FIGURE 9. Same camera as Figure 8 but with flash positioned straight up and an extender and white reflector. This will eliminate red eye and give a softer, more diffuse light.

FIGURE 10. Same camera and flash as in Figure 8, but with an extension cord attached to the camera hot shoe and the flash. This enables the photographer to hold the flash in any position desired. In this case, 45 degrees to the side and 45 degrees above the subject will create Rembrandt lighting.

FIGURE 11. Portrait-type lighting setup that can be used in close spaces. Macro photography brackets with dual flashes attached and small soft boxes over the flash output. This will soften the harsh light of flashes being too close to the subject, and eliminate "red-eye."

The camera body itself is only used for film transportation and lens attachment, so it can be of the most simple, and therefore cheapest, type. It is not even necessary to have a light meter in it, although it is almost impossible to find a camera body without one. It is very helpful to have a motor drive, or winder, to advance the film; and these are almost universally included. The same camera and lens as the clinical camera can be used (Figures 1 and 2), but it is the author's experience that a separate, simple setup is better for portraits. This way, a different film can be used. Ideally, the camera body should have a PC connection for external light sources (**Figure 3**). PC in this case does not refer to a personal computer, but rather to a universal connector in photography for external light sources. The flash on the intraoral camera needs to be turned off and a PC connection available to achieve the proper lighting. Unfortunately, most clinical cameras today have neither of these features. A simple, cheap, or even used camera body can be purchased for this use.

The best lenses to obtain proper perspective of peoples' faces with 35 mm cameras are in the 80 to 120 mm focal length range. The normal "macro" lens used for clinical photography is 105 mm, so this can be used if the camera has a PC connection, or if the lens is removable. Zoom lenses are not necessary, as an 80 to 120 mm focal length requires a certain distance from the subject, usually 8 to 12 feet, and focusing is done by moving forward or backward. A used lens in this range can be purchased inexpensively. An 80 mm lens will require 6 to 8 feet and an 120 mm lens will require about 10 to 12 feet of room from the subject, depending on the amount of the head-and-shoulder area to be included in the image. An ideal focal length is probably 100 to 105 mm. Smaller focal lengths (35 to 80 mm) will result in distorted facial images by having a perspective too close to the subject (Photos 4 and 5). Longer focal lengths (greater than 120 mm) will result in much more space than necessary between photographer and subject and not change the perspective significantly.

Film options are numerous. The kind used depends on the intended purpose of the image. Most clinical photography is done with transparencies (slides, or positive images) because they are the truest and most vivid in color and the least expensive. With slides, there is only one original. With prints, the original (negative) must be printed to achieve a secondary image, with subsequent changes in color or loss of detail possible. The author's experience is that most dental offices give the portraits to patients and use them in the office as displays on the wall or in albums. Print film is best for this use. There are specific professional films available for portrait work that are optimized for capturing the skin tones of humans. The photo lab that produces the print can also manipulate the final prints in many ways to achieve the appearance wanted. One example of a professional print film is Porta 160 from Eastman Kodak. The number 160 stands for the speed of the film (ISO 160). Many professionals shoot this film at ISO 100 to reduce contrast even further.

Digital cameras and camera backs are becoming more popular. The advantages are the lack of film and processing costs, the easy manipulation of the image via printer or computer software, the instant visualization of the image for possible improvement, and the printing capability via many different photo printers.

FIGURE 12. A two-light portrait of the same patient as Figures 6 and 7, utilizing a main light, hair light, reflector, and soft-focus filter.

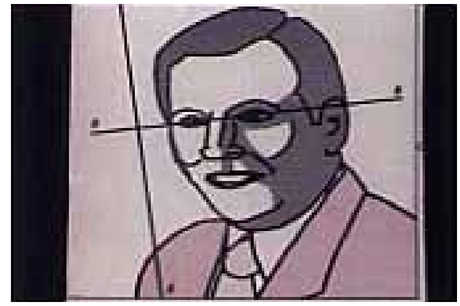

FIGURE 13. Diagram of "short" lighting, that is, light illuminating the short side of the face, or the part that is less visible than the "broad" side facing the camera. Notice the lighted triangle on the subject's left cheek. This is caused by the shadow of the nose and the direction of the lighting. Also notice the posing: turning of the shoulders towards the main light and a slight tilting of the head.

FIGURE 14. Permanently wall-mounted studio strobe with a cone-shaped reflector and white light diffuser over the end of the reflector.

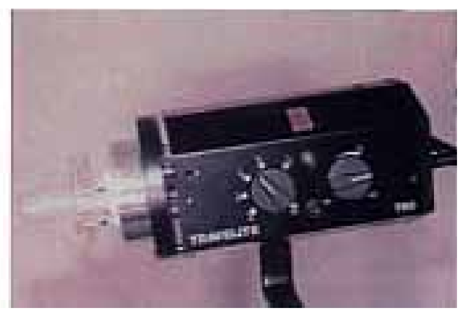

FIGURE 15. Typical studio strobe with an incandescent modeling light inside a circular strobe bulb and adjustable dials for intensity of both strobe and modeling light. In this way, the light can be positioned correctly and the intensity adjusted to get the proper exposure without moving the light.

Portrait Lighting

Lighting is where the difference between clinical documentation and creative photography really shows. The photographer relies totally on artificial light and therefore starts with an empty studio, a totally blank slate. Almost all of the variations visible in magazine advertising photographs are due to lighting and the creativeness of the photographer. Posing and set design are also important, but in straight portraiture, the lighting is everything.

In modern still photography, lighting is accomplished with strobes (electronic flash tubes). Motion picture or video lighting requires that a light source be on all the time; this is the reason such a source is called a "hot light." This is not necessarily desirable in still photography. Strobes that are very close to the lens opening, as is the case with the ring lights used in clinical intraoral photography (Figures 1 and 2) or point-and-shoot cameras, result in "red eye" (Figures 6, 7 and 8). This is the reflection of the strobe light off the subject's retina directly back into the camera. If the strobe is moved (Figures 9 and 10) at least 1 foot away from the camera lens, this reflection will generally not occur. If the lighting is directly in front of the subject, the resulting picture will have a flat, two-dimensional look (Figures 6, 7 and 11), since there are no shadows to define the depth of the subject or the third dimension. Therefore, moving the lighting off to the side will give more "depth" or "definition" to the subject (**Figure 12**). This is why professional wedding photographers hold a strobe in their other hand, or use extenders to raise the flash higher (Figures 10 and 11).

Likewise, moving the lighting above the subject (like normal sunlight) is much more natural than below (like the Frankenstein flashlight-under-the-chin look). The famous Dutch portrait painter Rembrandt used lighting above the subject in his painted portraits, so this has come to be called "Rembrandt lighting." The generally accepted position of this type of lighting is 45 degrees from straight ahead of the subject, and 45 degrees above the level with the subject. This type of lighting is also called "closed-loop" or "triangle" lighting, because of the highlight triangle formed on the cheek in the shadow side of the face, from the shadow of the nose (**Figure 13**). Generally the posing is such that the face is turned slightly toward the light source so the shadow side of the face is toward the camera.4 The shadow of the nose should not be touching the eye, or it will appear smaller than the other eye. This type of lighting also makes the subject appear thinner since the lighted side of the face is narrower than the shadow side. The author's experience is that most patients like this light setup, which can also be called "thin" lighting.

The Main Light

The light used in the Rembrandt position is called the main light, and it can be regarded as a replacement for the sun. This light could be a strobe (flash) that would be attached to the camera by a cord and held there by hand (**Figure 10**) or any type of strobe that is mounted permanently in that position and then to the camera (**Figure 14**). "Studio" strobes come in a variety of sizes and strengths and are surprisingly inexpensive (Figures 15 and 16). Soft-boxes (**Figure 17**), umbrellas, and other diffusers of light soften this light source, which can be rather harsh or too revealing of facial discrepancies (Figures 6 and 7). A softening, haze, or diffusion filter on the camera lens also gives an attractive effect (**Figure 12**). Many subjects will immediately look at facial wrinkles in a photo rather than at the teeth. A soft-box on the strobe used with a soft-focus filter works as a "wrinkle remover."

The "classic portrait" is composed of three lights: a main light, a fill light positioned on the opposite side of the main light to fill in the shadows created by the main light, and an accent or hair light positioned behind and above the subject to give some "depth" to the image and separate the subject from the background (**Figure 18**).5

The Fill Light or Reflector

The author has found that a reflector placed close to the subject on the side opposite the main light, either below the subject (**Figure 18**) or anywhere from there to vertical, works perfectly as a fill light. Fill lights generally should be less intense than the main light in order to fill the shadows without eliminating them, and therefore leave the appearance of depth in the portrait. Setting the lights for different intensities utilizes the lighting ratio.6,7 A reflector will bounce back most, but not all, of the main light. The distance to the subject is also greater, and therefore the light is of less intensity by about the right amount, usually 1 f-stop. This eliminates the need to buy another strobe and set it correctly. Therefore the classic portrait setup consists of only two lights and a reflector (**Figure 18**).

The Hair Light

To make an image more vital, the hair light is necessary. This light is generally positioned behind the subject and above, but it can be positioned directly behind and hidden by the subject's body. The subject should be at least 3 to 4 feet away from this light and the background. A longer distance is better. The average amount of space that is needed for proper portrait photography from the background to the camera is 10 to 15 feet or more. Proper photography cannot be done with less room than this. Therefore, in a dental office, photography is best set up at the

FIGURE 16. Inexpensive light-bulb-type strobe in a porcelain electrical socket. This operates in such a mode as to fire when another flash goes off, such as an on-camera flash. It's output cannot be adjusted, and it must be physically moved closer or farther from the subject to get the right exposure.

FIGURE 17. A medium-size soft box attached to strobe in Figure 15. These can be bought in many different sizes and shapes, and can be fixed or collapsible. The purpose is to soften or diffuse the light on the subject to achieve more even, nondirectional light that is not harsh.

FIGURE 18. A two-light portrait setup with a reflector below the subject's head, taking the place of a third, or "fill," light. The lights are a main light with a soft box and a hair light with a direction snoot. Notice the black background, posing stool, and position of subject's shoulders facing the main light, with her head rotated to look at the camera.

FIGURE 19. A snoot attached to the light in Figure 15. This directs the light to a narrow area, which is helpful for the hair lighting.

FIGURE 20. High-key lighting. Notice that the subject's face is darker than the background. This requires a background light and difficult exposure settings. Many photographers prefer this type of background for more full-body photos to highlight different clothing colors or body poses.

FIGURE 21. Low-key lighting. Notice that the subject's face is lighter than the background. This does not require a background light and is more dramatic, isolating the subject and focusing attention on the face and, therefore, the smile.

end of a hallway or another suitable room. Dental operatories generally do not have this amount of available space. The hair light is a strobe similar to the main light and of the same strength; but, instead of a soft-box, it should have some sort of concentrating or focusing attachment such as a “snoot” (**Figure 19**) and should be permanently mounted on the wall in the proper position.

Backgrounds

There are two main types of lighting for portraits: high-key and low-key. High-key is where the subject’s face is darker than the background (**Figure 20**), and in low-key lighting, the face is lighter than the background (**Figure 21**) This can be done with a backdrop that is not lighted separately with a background light but only illuminated by the main light, or it can be controlled by lighting with different colored gel filters on a plain white background. The latter would require another light and make the setup a little more complicated. For someone who is just beginng to do portraits, it may be best to eliminate this light and use different-colored background papers or cloths. These can be purchased in photography stores in a multitude of colors, patterns, and sizes. High-key lighting definitely requires a background light, and it is difficult to set the exposure correctly. The author prefers low-key lighting in which the subject’s face is highlighted. Favorite colors are dark blue or black. Other primary colors are generally not flattering. Gray is neutral for all skin tones but tends not to be as dramatic (**Figure 22**).

The Subject and Posing

There are unlimited poses appropriate for portrait photography, and they are best learned from a photography book about portraiture;4,9 but generally the subject is seated or standing. A simple starting position is to have the subject turn the shoulders towards the main light, facing about halfway between directly at the light and directly at the camera, and

FIGURE 22. Gray backgrounds are neutral for all skin types and hair colors but may not be as dramatic or flattering to many. In this case, no Rembrandt lighting was used, but rather two equal intensity main lights positioned on either side of the camera and diffused with white umbrella reflectors.

FIGURE 23. A typical incident light meter/flash meter used to determine exposure in many different types of lighting conditions, natural and artificial. For studio work, this will read the intensity of strobes and allow proper setting of cameras and lights.

FIGURE 24. Subject with only a main light, which is in the Rembrandt position

FIGURE 25. Subject with only a hair light behind and above.

FIGURE 26. Main and hair lights used together.

FIGURE 27. Main light, hair light, white reflector under subject’s chin, and soft focus filter. Notice how the reflector fills in the shadows of the face compared to Figure 26.

FIGURE 28. Typical close up portrait taken with a two-light Rembrandt setup and reflector.

FIGURE 29. Similar lighting setup as Figure 28 but utilizing head, shoulders, and arms as well as a chair for a posing prop.

FIGURE 30. Typical portrait setup as described in the text. A main light with softbox is on the upper left. A hair light with focusing snoot is on upper right. A reflector is attached to swinging arm on right wall, positioned under the model's left side. The model is sitting on a photo stool and leaning on a posing table, both of which can be purchased in a photography supply store for about $175 total. The black background is painted on the wall in a matte finish. The computer and printer on countertop are for input and output.

leaning forward slightly (**Figure 13**). The best strobes have built-in modeling lights (**Figure 15**), which are incandescent bulbs that help the photographer determine how the strobe light will fall on the subject. The subject should turn his or her head toward the camera until the shadow of the nose falls just short of the eye on the shadow side. The ear on the lighted side should not show, or just barely. Tilting the head slightly toward the camera helps. The author generally prefers to light the right side of the subject; the main light will therefore be on the left of the camera. The reflector can be mounted on the opposite wall, mounted on a tripod stand, or held by an assistant. It is positioned at 90 degrees from the main light, on the shadow side of the subject, and at head level or lower. The photographer should be able to see the reflected light fill in the shadows from the modeling light as he or she moves the reflector around. It can be raised or lowered or positioned closer to the main light or further away depending on the effect seen. The hair light should then be directed at the back of the subject's head with a snoot or some sort of narrowing of the light beam. A modeling light will assist in positioning. Different attachments can be procured at a photography supply store, along with strobes, reflectors, and other supplies.

The Proper Exposure

Once the lights are aligned and the subject positioned, it is necessary to set the camera to the proper exposure. This is accomplished with a flash/light meter that can be bought for about $200, or borrowed or rented8 (**Figure 23**). It might also be advisable to procure a professional photographer to help with determining the setup and exposure. Salespeople at a professional photo store should also be able to help. With a flash meter, the ISO number of the film used is entered, the f-stop (F 8 is average; it allows enough depth of field for the head, but allows background to be slightly blurred.) is entered, and a reading is taken of the intensity of the flash at the subject position. Ideally, the strobes are adjustable for output and can be modified accordingly. If not, the only way to vary the intensity of the light is to move the main light and hair light closer or farther from the subject to get the proper exposure.

Once the exposure is set and everything is in position, there is no reason for a flash meter. Test photos should be taken, developed, and evaluated, and modifications made if necessary. Everything is then done the same every time, and the portraits will be perfect.

Putting It All Together

Figures 24 though 29 show the effect of single and combination lights. The subject with only a main light in the Rembrandt position is shown in **Figure 24**. The hair light only is demonstrated in **Figure 25**. It is coming from above and behind, essentially the opposite position from the main light. **Figure 26** shows the effect of both of these lights together. Adding a white reflector under the subject's chin, as well as a soft-focus filter on the camera lens, results in the effect seen in **Figure 27**. Typical portrait photographs taken with this simple two-light setup are demonstrated in Figures 28 and 29. **Figure 30** shows a portrait set up in a dental office.

Conclusion

Modern esthetic restorative dentistry requires treatment planning the entire face of a patient. This can involve the services of an orthodontist, oral and maxillofacial surgeon, periodontist, endodontist, implant dentist, and plastic surgeon. Full-face portrait photography is essential. Professional quality "glamour" photography, rather than clinical documentation, adds value for the patient, enhances the image of the doctor's practice, and shows the artistic side of esthetic dentistry, not just the science.

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The Lazy Way to a Healthy Life

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I think we can all agree that scientists as a group are not a fun bunch of guys. Yet, when you get to know them better, like, for example when they are hitting on you for a research grant, they can demonstrate a unique sense of humor.

Now and again to ease the strain of the day-in and day-out heavy-duty scientific thinking that occupies most of their time, scientists gather together in bull sessions where even the most serious-minded let down their hair with hilarious results. You may not appreciate the levity because you are not one of them, but to a scientist, this is the WD-40, the Prozac and mother's milk that makes the serious bulk of their lives bearable.

Basically, their approach is this: Take an established scientific fact, an axiom carved in stone, and question its validity. This is easy, as there is no shortage of scientific facts. The more solid the evidence and the longer it has been accepted as gospel, the more fun it is to question. Witness the flip-flop on the danger of cholesterol in eggs, the healthful benefits of red wine, the fatal aspects of jogging, etc.

On balance, most scientific facts are bad news to the lay public.

Fact: A body in free-fall from a 90-story building will obtain a terminal velocity of 120 mph. Fact: The impact of that body on pavement has been proven to be 100 percent fatal. "Proven? Ha!" say the scientists while in their fun mode. "We will publish studies that show otherwise."

And the public will eat this up. Japanese scientists are just now recovering from the paroxysm of joy they shared upon their announcement that chocolate was good for you and, indeed, was a major benefit to teeth.

All over the scientific world, white-coated parties wearing serious frowny expressions while laughing up a storm on the inside are busy debunking the old standards. If a grant from Bill Gates or General Motors is not available, no problem—publish a book. Recent best sellers listed by the *New York Times* include *Biofeedback and How to Stop It, Optional Body Functions, Ego Gratification Through Violence and Guilt Without Sex*.

Which brings us to the latest revelation from German scientists.

From Munich via Reuters comes the announcement that all us couch potatoes have been waiting for: Professor Peter Axt, who teaches at a college in Fulda, has co-authored a newly published study, "On the Joy of Laziness." Professor Axt, you will remember, gained a measure of fame a few years ago with his revelation that Adolph Hitler and Charlie Chaplin were one and the same person. "You'll notice that you never saw them together," he pointed out. "The trademark mustache was the giveaway."

Axt's new book prescribes aimless sloth as the antidote to professional stress and the secret to a long life. The professor has put considerable thought into his pronouncements. For example, he claims, "Research shows that people who run long distances into their 50s are using up energy they need for other purposes." Now that I can run no more than 10 yards without initiating cardiac arrest, I think he may be onto something.

"People who would rather laze in a hammock instead of running a marathon or who take a midday nap instead of playing squash have a better chance of living into old age," he goes on. Even in spite of the fact that being tossed out of a hammock on your head is a real and present danger, I am sure he is right.

The appeal to an apathetic public is not lost on Professor Axt who recommends, "Waste half your free time. Just enjoy lazing around." Listen carefully. In the background you can hear Teutonic chuckling. At this very moment in Florence, Italy, scientists are compiling a list of the aphrodisiac qualities of pasta while denouncing Axt's advice as the Italian equivalent of "poppycock" and in direct opposition to their "Use It or Lose It" edict.

Personally, I buy into the German professor's study completely, believing that, as Jules Renard said, "Laziness is nothing more than the habit of resting before you get tired." Unfortunately, as Ben Franklin observed, laziness travels so slowly, poverty soon overtakes it.

What I do wish is that scientists would cease indulging themselves in these bouts of ill-conceived pleasure. You don't see dentists behaving this way.