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DEPARTMENTS

FEATURES

When Good Ideas Go Bad

KERRY K. CARNEY, DDS

If good ideas had expiration dates, it would make life a lot easier. When good ideas go bad they take us by surprise and it is not usually a happy surprise, The following three good ideas seem to have reached their expiration dates.

Think back to how unfamiliar and disjointed dental school training seemed at first.

Deregulation is always a good idea. The electricity industry in the state of California is a case in point. In 1996, the California Legislature voted to deregulate the state utilities. Deregulation was supposed to produce competition among utilities and result in an array of choices and reduced utility costs for the consumer. By the summer of 1999, San Diego energy consumers had a preview of what was to become the California energy crisis. Dentists in Southern California experienced monthly utility bills that spiked to three times normal. What followed was a cascade of increasingly bad outcomes for the California consumer.

It is hard to admit when a good idea has gone bad. The usual reaction of those not immediately impacted is not to question the soundness of the idea. Bad outcomes are attributable to poor execution and extenuating circumstances. Eventually, rolling brownouts and soaring utility costs became common throughout the state. Dependable, low-cost electricity was not available. For dentists in the Bay Area, backup generators and procedure rescheduling became the norm. By the winter of 2000, we were all ready to agree in this case, deregulation was a good idea gone bad.

Term limits, what a great idea: Make it impossible for individuals to hold the same political office for an indefinite period of time. Throw the rascals out and make sure government offices are filled with people from outside the governmental establishment. Make sure each elected official knows his/her days are numbered. They would have to be nimble and responsive to their constituents' needs and desires. Term limits are a good idea until we find out the elected officials can never achieve the independence and longevity necessary to make the tough decisions.

Political power shifts to the lobbyist and PACs and those groups in turn finance ever-increasingly expensive election campaigns. What was supposed to produce new *everyman* candidates produces, instead, a game of musical chairs with candidates scrambling for assembly, senate, and county seats, according to how many years they have left and which seats are coming available. Term limits is an idea gone bad, but not bad enough for us to do anything more that tinker with it at this time.

Finally, there's problem-based learning in dental education. What a great idea: Make education more real. Hone the student's ability to research and discover on his/her own. Develop a skill students can use for the rest of their lives. Forget the lecture hall and its unnatural didactic model of learning. Let the complexities of case analysis draw on all the student's deductive reasoning to explore, learn, and apply principles in a real environment. How could this not be a great idea?

Problem-based learning has spawned dental classes made up of small learning groups comprising eight students and one facilitator. The facilitator does not act as a teacher because the problem should drive the learning experience. The student researches and critically thinks his/her way to the appropriate treatment plan. At this point, this is where the good idea starts to go bad.

Think back to how unfamiliar and disjointed dental school training seemed at first. What we do every day seems so familiar to us now. But it takes only the task of training of a brand-new assistant to remind us of the nonintuitive nature of our activities. A good friend confided that he did not understand for months into dental school that we were waxing up crowns. He had never seen a crown. He was totally unfamiliar with the concept of a crown. For a long time, he thought the hours we spent in lab waxing and carving were all just an exercise in morphology.

Imagine now, a student who has never seen a distal extension removable partial denture. A facilitator told me he gave up, took pity on a student who was grappling with just such a concept, and brought in an array of partial dentures so the students in the learning group could see them. Like fish trying to imagine fire, it was difficult for the students to knowledgably apply concepts so outside their experience. A sound grounding in the "how" of dentistry is necessary before the "why," and "when" can make much sense.

The small learning groups also wreak havoc with the student-faculty ratio. In a class of 80 students, one teacher must be replaced by 10 facilitators. Excellent faculty abandons the problem-based programs for schools with traditional teaching models where their experience and knowledge can be appreciated and utilized. There is so much material to cover in a dental education; it is very helpful to have those with experience give some indication of priority of importance.

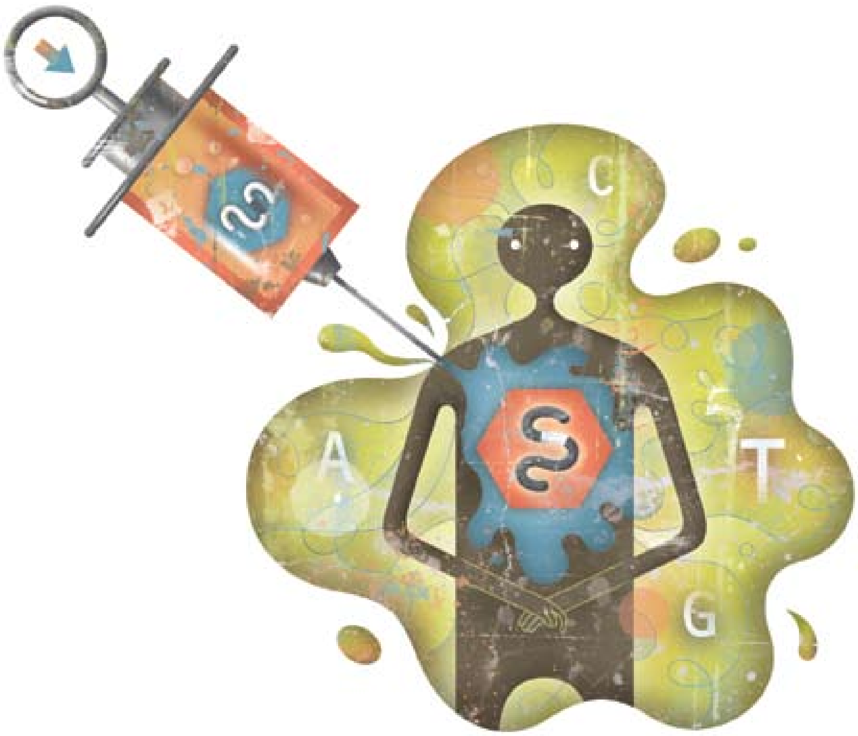
Problem-based learning as the dominant model for dental training is a good idea gone bad. It will always have an important role to play in the more conventional lecture-based model. In the form of case presentation, problem-based learning is how we all continue to learn every day.

The goal is still to provide dental students with the best education within a limited timeframe and to sharpen their heuristic skills, and better prepare them for a life of continued learning. Achieving that is an ever-changing challenge.

It is important to recognize when a good idea goes bad and try another good idea. The practice of review, re-evaluation, and change should not be limited to energy, politics, or dental pedagogy. We need to constantly check the expiration dates on our ideas and practices. Change is what makes us able to adapt, cope, and thrive. It is what makes us active participants instead of innocent bystanders. ■■■■

Address comments, letters, and questions to the editor at kerry.carney@cda.org.

CDA JOURNAL, VOL 37, Nº3



Matt Mullin

Gene Therapy Shows Promise Against Periodontal Disease

University of Michigan researchers have been able to demonstrate that the development of periodontal disease can be stopped using gene therapy.

This finding, which shows there is promise that the gene delivery approach may be a remedy for longtime conditions such as a periodontal disease, is a first, said William Giannobile, DDS, DMSc, principal investigator with the study and a professor at the university's school of dentistry.

"Gene therapy has not been used in nonlife threatening disease. (Periodontal disease) is more disabling than life threatening," said Giannobile, who also directs the Michigan Center for Oral Health Research and has an appointment in the U-M College of Engineering. "This

CONTINUES ON 152

Dentist Anesthesiologists Needed to Calm Fear of Dental Procedures

Authors, in an retrospective study that appeared in *Anesthesia Progress*, a quarterly publication of the American Dental Society of Anesthesiology, recently explored the relationship between dentist anesthesiologists and general practice dental residents and their patients who were deeply or moderately sedated as part of their dental procedure.

Also known as moderate or deep sedation, monitored anesthesia care was reviewed in 100 randomly selected cases. The authors found five instances of morbidity (e.g., nausea, vomiting), and these morbidities were minor and either self-limiting or easily controllable. The result was sedation was found overall to be effective and safe. An important factor in these successful treatments was the presence of a dentist anesthesiologist who collaborated with second-year general practice dental resident in administering sedation care.

While 15 percent to 30 percent of the U.S. population experiences dental fear, particularly special needs and phobic patients, very few general dentists have training or experience in advanced anesthesiology techniques used to address this fear and to minimize pain, according to a press release.

While the American Dental Association has not recognized dental anesthesiology as an official specialty of dentistry in the United States, the Commission on Dental Accreditation, which is associated with the ADA, is trying to address this gap between the lack of experience and knowledge of dentists and the increasing needs of those afraid of undergoing dental procedures. The CODA now includes dental anesthesiology residency programs as part of its accreditation process. Guidelines for using sedation methods and for teaching these methods to students and dentists have been adopted by the ADA.

To read the entire article, go to allenpress.com/pdf/ANPR55.4-3006-55-4-116.pdf.

Dental Erosion — Destructive and Quiet — on the Upswing

Although the topic of dental erosion has not been widely studied in the United States, it, unfortunately, is on the rise.

According to a study at the University of Texas Health Science Center in San Antonio, researchers discovered a 30 percent prevalence rate of dental erosion among U.S. children between the ages of 10 and 14.

Bennett T. Amaechi, MS, PhD, associate professor of community dentistry at the UT Health Science Center, led colleagues in the San Antonio portion of the nation's first population-based, multicenter study of dental erosion. Nine hundred middle school students participated in the 2004 and 2005 studies at the University of California, San Francisco, Indiana University, and the UT Health Science Center in San Antonio.

On the dearth of dental erosion not being widely analyzed, Amaechi said "This study is important because it confirms our suspicions of the high prevalence of dental erosion in this country and, more importantly, brings awareness to dental practitioners and patients of its prevalence, causes, prevention, and treatment."

Dental erosion, he said, is caused by acids found in products being consumed at a higher rate than ever in the United States. Among the culprits are certain fruit drinks, soft and sports drinks, beer salts, herbal teas, and candy imported from Mexico (Lucas brand) that are particularly popular among children in San Antonio and South Texas.

"When consumed in excess, these products can easily strip the enamel from the teeth, leaving the teeth more brittle and sensitive to pain," Amaechi said.

AGD Teams With Colgate-Palmolive

The AGD and Colgate-Palmolive recently announced its year-long partnership to provide continuing dental education to its members. The goal of this collaboration is to increase awareness between the link between overall health and oral health.

"The AGD understands the importance of ensuring quality educational courses to enhance and develop our members understanding and knowledge of oral health topics that will ultimately benefit their patients as well as the public," said Paula S. Jones, DDS, FAGD, AGD president. "This partnership with Colgate represents a collaborative effort to provide this profession, dental patients, and the public with the resources and education necessary to provide proper oral health."

An estimated 90 percent of all systemic diseases have oral manifestations. Studies have indicated a relationship exists between strokes, heart disease, preterm, and low birthweight babies and periodontal disease.

This year, Colgate will sponsor up to nine courses that all AGD constituents and their local members can participate in while earning continuing education credits. What's more, during the 2009 AGD Annual Meeting & Exhibits in Baltimore held July 8-12, member general dentists and their teams can partake in an educational course specifically designed to boost the attendee's understanding and knowledge of this connection.

"We are pleased to partner with the AGD to provide educational courses that will enhance the general dentistry profession and help further develop an understanding of this oral health topic," said Fotinos Panagakos, DMD, PhD, director of Professional Relations, Colgate-Palmolive. "The AGD has displayed its commitment to providing its members and the dental profession with ex cellent continuing dental education programs and resources, and we are pleased to be part of this initiative."

Increase in the Use of Mini-Dental Implants but Questions Remain

There is nothing "mini" in the lively debate in the implant dentistry community over the proper use of mini-dental implants.

On one hand, supporters urge broader use of the less-costly and quicker procedure; meanwhile, the other camp backs a more conventional approach until studies are published on long-term outcomes.

In a press release by the American Academy of Implant Dentistry, there also are concerns whether general dentists who adopt mini-implants receive sufficient implant training. Though mini-implant companies provide weekend training sessions, the AAID believes such instruction falls short of what dentists must know before adding implants to their practices.

"Dentists need to be well-versed in implant dentistry before using mini-implants," said Kim Gowey, DDS, a past AAID president. "Without extensive implant knowledge, they will not know proper surgical techniques and all the basics about bone healing critical for implant success. If you want to practice implant dentistry, there are no shortcuts for gaining the necessary knowledge and training."

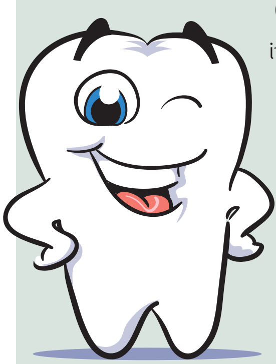
At the recent AAID annual scientific meeting, Todd Shatkin, DDS, noted that mini-implants are half the diameter of traditional implants — almost the size of a toothpick — and the insertion procedure is less invasive as well as half the cost of traditional implants. "Mini-implants made from titanium alloys are strong enough to withstand normal chewing force and can be used confidently for immediate-load, long-term restorations," Shatkin said, adding he now uses mini-implants for stabilizing dentures, single-tooth implants and full-arch restorations.

"The FDA has approved some mini-implant systems for long-term use, and patients can have a denture stabilized in about an hour or get a single-tooth implant in 30 minutes," said Shatkin, who also reported his findings from his February 2007 article published in *Compendium Dental Journal* that showed his overall success rate with mini-implants was 95 percent. Shatkin commented implants now are widely accepted in the dental profession for denture stabilization and crown and bridge applications.

Toothfairy Grant Supports School's Efforts to Battle Caries in Children

Indiana University has received the Heraeus Toothfairy Grant in an effort to eliminate pediatric dental disease for disadvantaged youths.

The $15,000 grant by the National Children's Oral Health Foundation will support the dental school's efforts on caries prevention and restorative treatment for economically disadvantaged children.



Christopher Holden, Heraeus president said, "Heraeus feels very strongly that it has a responsibility to use its resources to impact the greater community — and to transform lives in a positive way. That's why we donate a portion of proceeds from the sale of our core products to the foundation and are proud to be an NCOHF corporate underwriter."

The school is a member of NCOHF's national Affiliate Network, which is dedicated to delivering comprehensive oral health services to millions of children and their families to help eliminate preventable pediatric dental disease, according to a press release.

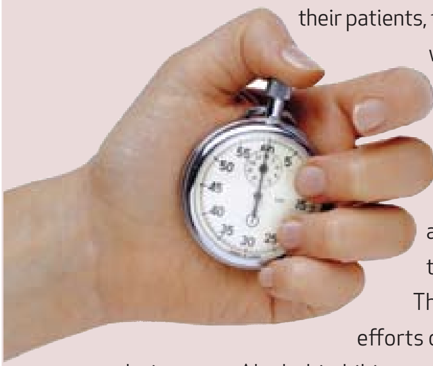
The Toothfairy Grants program provides major donors a way to directly support programs that help eliminate the No. 1 chronic childhood illness in the United States: pediatric dental disease.

Early Diagnosis of Oral Cancer Encouraged

With an estimated 500,000 new cases of mouth cancer being diagnosed each year throughout the globe, dentists, especially prosthodontists, are being encouraged to ensure their patients are diagnosed early.

In a recent article in the *Journal of Prosthodontics*, researchers, led by Michael A. Siegel, DDS, MS, FDS, RCSEd, described the diagnostic tools currently available to prosthodontists and the epidemiology of oral cancer to ensure their patients are diagnosed as early as possible.

"If prosthodontists and other dentists are more vigilant in performing oral cancer screening examinations on all of their patients, the quality of life and survivability from these cancers will be greatly improved, whereby morbidity and mortality will be greatly reduced," researchers said.



While all dentists are trained to detect these tumors in an early stage, only 28 percent of patients reported ever having had an oral cancer examination. Patients who have lost their teeth must be specifically counseled about returning for prescribed, regular recall examinations, according to a press release. They may wrongly think that as they do not have all or any of their teeth, they do not need to be regularly followed by a prosthodontist.

The need for prosthodontics was expected to decrease with the increased efforts of preventive measures; however, the need is actually on the rise as the population ages. Alcohol-imbibing and tobacco-using adults over the age of 40 run the highest risk of developing oral cancer. But since these cancers can develop in anyone at any age, yearly trips to the prosthodontist are becoming increasingly important, the authors said. Several companies recently have marketed simple tests to help the dentist in the early detection and diagnosis of oral lesions before they turn into cancer. The tests are relatively inexpensive and painless.

GENE THERAPY, CONTINUED FROM 149

is so important because the next wave of improving medical therapeutics goes beyond saving lives, and moves forward to improving the quality of life."

The study collaborated with Targeted Genetics, a Seattle-based biotech company, which released human trial results last summer demonstrating the same gene therapy approach used to stop periodontal disease was successful in addressing another nonlife-threatening, disabling, recurrent affliction: rheumatoid arthritis. In that study, Targeted Genetics tested 127 human subjects using the gene treatment, which showed a 30 percent improvement in the relief of pain and gain of function, among other positive results.

Those suffering from rheumatoid arthritis are four times more likely to also have periodontitis, which has been linked to systemic issues ranging from bacterial pneumonia, heart disease, and stroke. It is thought the spread of bacteria from the oral cavity invades other parts of the body.

Through this gene therapy, Giannobile's group discovered a way to assist specific cells using an inactivated virus to boost a naturally produced molecule soluble TNF receptor. In patients with periodontitis, this factor is underproduced, according to a press release. The molecule delivered by gene therapy behaves like a sponge, soaking up the excessive levels of a tumor necrosis factor, a molecule known to exacerbate inflammatory bone destruction in individuals suffering from joint deterioration, periodontitis, and rheumatoid arthritis. With this therapy, periodontal tissues were saved from destruction by more than 60-80 percent.

"If you deliver the gene into the target cells once, it keeps producing in the cells for a very long period of time or potentially for the life of the patient," said Giannobile. "This therapy is basically a single administration, but it could have potentially life-long treatment effects in patients who are at risk for severe disease activity."

The next step is additional safety testing on periodontal patients, Giannobile added. The findings were published online Dec. 11, 2008, prior to its publication in *Gene Therapy*. The National Institutes of Health funded the studies. Giannobile's coauthors include Haim Burstein, a research scientist at Targeted Genetics Corporation, and members of U-M research team Joni Cirelli, Chan Ho Park, Jim Sugai, and Katie MacKool.

Floss Your Way to a Healthier Mouth

It's really just a string, but it can deliver a punch to gum disease and caries-fueled germs.

A study in the *Journal of Periodontology*, "Treatment outcomes of dental flossing in twins: molecular analysis of the interproximal microflora," provides new information about the importance of a flossing, as well as to brushing daily the tongue and teeth.

"The purpose of this study was to assess the effects of dental flossing on the microbial composition of interproximal plaque samples in matched twins. The study was a two-treatment, examiner-masked, randomized, parallel-group, controlled study," noted authors, Patricia Corby, DDS, MS, assistant professor of Periodontology and Implant Dentistry, and Walter Bretz, DDS, MPH, DrPH, associate professor of Cariology and Comprehensive Care, New York University dental researchers.

Fifty-one well-matched twin pairs (each set of twins was a case and a control), were studied by Bretz and Corby, regarding treatment responses to dental flossing over a two-week period. Following that period, putative periodontal pathogens and cariogenic bacteria were overabundant in the group that did not floss as opposed to the group members who did.

The authors also noted that, "Twins who flossed had a significant decrease in gingival bleeding compared to twins who did not floss. Relative to baseline, bleeding scores were reduced by 38 percent over the two-week study period in the flossing group of twins."

In conclusion, the researchers said, "In a well-matched twin cohort, tooth, and tongue brushing, plus flossing, significantly decreased the abundance of microbial species associated with periodontal disease and dental caries after a two-week program."

Because twins have similar dietary habits, health practices, and live together, they are considered ideal subjects for research that compares periodontal diseases and dental caries development in people similar environments and age.

Practicing Emotional Intelligence

Letting your emotions get the upper hand can have devastating consequences on your business, as well as your private life. To be successful at home and at work, it is important to practice what is commonly known as "emotional intelligence."

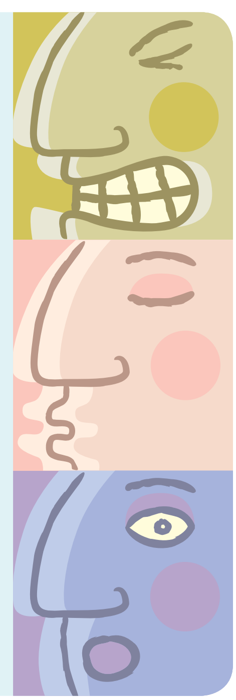
Author and public speaker William Frank Diedrich, writing in the August issue of the *Journal of the Michigan Dental Association*, noted that having a negative emotion or a bad reaction to a problem doesn't make you emotionally unintelligent. Emotional intelligence, he said, is about what you do with the emotion you are experiencing.

"It is your willingness to step back and observe what is happening," he wrote.

Emotion is the body's response to thought, Diedrich said. What this means is, no outside person or situation can actually make you feel anything. What you feel is a response to what your mind is telling you about a particular person or situation. Emotional intelligence is grasping this fact and turning it to your advantage.

"When I experience a worrisome or other fearful thought I get silent," Diedrich commented. "I stop thinking about people and situations, and I focus my thoughts on the physiological symptoms that I am experiencing."

By practicing emotional intelligence, one can move through times of distress much more quickly, and that will limit the impact that stress has on your personal life and one's practice, Diedrich said.



New Technique for Surgical Guides

A new surgical guide technique appears to have addressed age-old shortcomings.

Trevor Bavar, DDS, in a recent issue of the *Journal of Oral Implantology*, presented a new technique that uses a single guide with reduction sleeves. This method accommodates different-sized drilling, records implant positioning and angles on the guide and creating an index, generates custom copings and abutments, and emplaces an acrylic temporary but esthetic bridge, according to a press release. All this in one visit.

Additionally, in using the custom measurements from the index and bite registration, the final prosthetic can be created and the completed bridge can be installed in just three noninvasive follow-up visits. Using this index and guide system, surgical specialists and restorative dentists can work separately or as a team to address esthetic, prosthetic, and implant needs simultaneously.

In the past, surgical guides have been used to help dentists record implant locations and angulations for dentures and bridges. The arrival of computer-assisted tomography allowed dentists to map the patient's available bone, placement of prosthetic teeth and bite impression, and produce a surgical guide before the patient underwent any procedure.

To read the entire study, go to: allenpress.com/pdf/ORIM34.610.15631548-1336-34.6.pdf

Honors

Charles G. Eller, DDS

Charles G. Eller, DDS, La Mesa, Calif., was inducted as the international president of the Pierre Fauchard Academy. Eller, who also is a fellow in the International College of Dentists and the American College of Dentists, has been active in community affairs, served on several scientific councils for the California Dental Society, and served as longtime president and publisher of the International Academy of Gnathology. He was honored for his career achievements.

UPCOMING MEETINGS

2009	
April 20-22	National Oral Health Conference, Portland, Ore., nationaloralhealthconference.com.
May 14-17	*CDA Presents The Art and Science of Dentistry*, Anaheim, 800-CDA-SMILE (232-7645), cda.org.
Sept. 11-13	*CDA Presents The Art and Science of Dentistry*, San Francisco, 800-CDA-SMILE (232-7645), cda.org.
Sept. 30-Oct.-4	American Dental Association 150th Annual Session, Honolulu, Hawaii, ada.org.
Nov. 8-14	United States Dental Tennis Association fall meeting, Scottsdale, Ariz., dentaltennis.org.
2010	
April 26-28	National Oral Health Conference, St. Louis, Mo., nationaloralhealthconference.com.
May 13-16	*CDA Presents the Art and Science of Dentistry*, Anaheim, 800-CDA-SMILE (232-7645), cda.org.
Sept. 24-26	*CDA Presents the Art and Science of Dentistry*, San Francisco, 800-CDA-SMILE (232-7645), cda.org.

To have an event included on this list of nonprofit association continuing education meetings, please send the information to Upcoming Meetings, CDA Journal, 1201 K St., 16th Floor, Sacramento, CA 95814 or fax the information to 916-554-5962.

CDA JOURNAL, VOL 37, Nº3

History and Current Use of Clinical Photography in Orthodontics

DONNA L. GALANTE, DMD

ABSTRACT The history of dentistry and photography began in 1840 when the first dental school was opened, and the world's first photographic gallery was opened and operated by a dentist turned photographer. Since that time, photography and dentistry have been partners as photography has become an integral part of a patient's record and treatment plan. The specialty of orthodontics has led the way in this model of recording patient data.

AUTHOR

Donna L. Galante, DMD, a diplomate of the American Board of Orthodontics, is in private practice in Rocklin, Calif.

Photography provides the orthodontist with the ability to record patient data in a unique and standardized way. For more than 150 years, photography has given us images that record people, places, and events. Photography is part of the human experience. Every day, the average person in the United States is exposed to more than 1,000 photographic images.[1] It is estimated that, as of 2002, there were 900 billion photographs archived worldwide, with 75 to 100 billion new photographs added every year.[2]

These photographs record events, document scientific discoveries, and give a view of the world, even if one never leaves the home. As technology advances at a rapid rate, more and more people will rely on it more and more for the acquisition of knowledge.[3]

The year 1839 was a birth year for both photography and dentistry. That year, the first practical process of photography was presented to the world and the first dental journal was printed. A few years later, both professions would change our way of life in the United States and eventually worldwide. Stimulated by the first dental journal, the world's first dental school, Baltimore College of Dental Surgery, and the first dental society were organized. At the same time, the world's first photographic gallery opened, operated by a dentist-turned-photographer.[4]

Alexander Wolcott (1804-1844) is known as America's trail-blazing photographer, but few know that he was also a dentist in New York City. Wolcott played a key role in the history of photography in the United States. He obtained the patent for his invention of a camera on May 8, 1840. He also developed a system for photographic studio lighting in February 1840, and one month later, made history by opening the first commercial photographic studio.[4]

Wolcott met an untimely death at age 40; however, his love of photography quickly spread through the burgeoning dental profession. Dentists worldwide became intrigued with photography and bought cameras to record their world. American dentists were among the first health practitioners to use clinical photographs of patients to record results of treatment.[4]

In 1848, Drs. R. Thompson and W.E. Ide of Columbus, Ohio, removed a patient's left superior maxillary bone along with a large tumor of the jaw, and repaired the defect with an oral prosthesis made of gutta percha. They photographed the patient before and after surgery, wrote an article and submitted it along with photos to the *American Journal of Dental Science* in 1850. This marked the first time that before-and-after photographs of a dental procedure were published and a new frontier in diagnosis and treatment planning in dentistry began.[4]

Orthodontics, the first specialty in dentistry, has been the frontrunner in utilizing photographs for diagnosis, treatment planning, and patient documentation. Dr. Edward Angle, one of several men credited as being the "father of orthodontics," was the first known orthodontist to photograph his patients as part of his diagnostic work-up.

The Edward Angle Orthodontic Papers, dated 1893 to 1940, include letters, photographs of patients and Angle himself, X-rays, manuscripts with photographs, and minutes from meetings and programs. These are the earliest known photographs used in orthodontics for diagnostic and teaching purposes.[5]

Today, in orthodontics, it is standard practice to take facial and intraoral photographs of patients as part of their initial diagnostic records and at the conclusion of orthodontic treatment. Graber and Swain, in their classic textbook for the orthodontic profession, devoted an entire chapter to the importance of diagnosis and documentation.[6]

The capture of dental clinical photographic images requires standardization, planning, a systematic approach, and attention to detail. The accurate recording of a patient's malocclusion is so important in orthodontics that the American Board of Orthodontics, as part of their rigorous testing for board certification, has outlined a very detailed format for clinical photographic images.[7]

Extraoral photographs should have the same magnification so they are consistent. The top of the patient's head and all of the jawline should be included in the frame, and all views should be taken in portrait format. The patient must have all jewelry and eyeglasses removed. Hair should be placed behind the ears and, if very long, may need to be pulled back. All three planes of space are on the Frankfurt horizontal. Patients' lips should be in a relaxed, natural position, and their eyes should be open and looking straight ahead.

There are three standard extraoral views. The first is an anterior view with a full smile; the second is an anterior view with lips at rest; and the third is a profile with the patient facing to the right and lips at rest. Ideally, the background should be white or a very dark color. Either way, there should be no shadows on any of the extraoral views.[8]

Intraoral photographs should be taken on a scale of 1:2 and used for the anterior view in full occlusion, the right and left buccal views, and the upper and lower occlusal views. Photographs should be free of saliva and bubbles. Good quality cheek retractors and mirrors are essential for consistent photographs. The anterior and both buccal views are typically taken with a direct approach. The occlusal plane should be horizontal and in the middle of the frame for all these views.

On the buccal views, the focus should be on the first premolar tooth with the aim to show all the teeth from the central incisors to the second molars. Both occlusal views should be taken with the mirror angled at 45 degrees to the occlusal plane in order to obtain an image that is perpendicular to the occlusal plane. Both occlusal views should include the second molars or even the third molars, if present.[8]

Today, the specialty of orthodontics continues to lead the way in clinical photography. More recently, the dental profession at large has started to use clinical photography as part of diagnostic and treatment planning processes. Photography has come a long way since Wolcott's initial photographic images in the mid-1800s. Its value in documenting cases, presenting information, and educating dentists has increased to the point that it has become integral to diagnosis and treatment planning decisions. ■■■■

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CDA JOURNAL, VOL 37, Nº3

Clinical Digital Photography Today: Integral to Efficient Dental Communications

ROBERT SHOREY, DDS, AND KENNETH E. MOORE, DDS

ABSTRACT Digital clinical photography today allows clinicians to take advantage of the power of visual communication. The advent of digital imaging is a leap forward for clinical photography because of the elimination of the considerable delay between image capture and review noted with previous film-based photography. In a short span of seven years, digital photography has overcome its shortfalls and can rival film photography for quality images.

AUTHORS

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Vision is a powerful tool in human communication. Studies show that the visual pathway for learning using images is more memorable and has greater speed and precision than written or auditory learning alone.[1-4]

Over the course of history, humans have harnessed the power of images through graphic sketches, drawings, paintings, and photography. Medical and dental professionals adopted the use of photographic images for clinical documentation as far back as the beginning of photography.[5,6]

The first dental journals gained mainstream popularity at the same time as photography emerged to augment the written word. For a long time, film photography has been considered a useful documentation and communication tool respected by professionals and laypersons alike. However, drawbacks to the use of film have been the lag time between the capture and viewing of images, cost, film processing, and storage issues. The general principles of photography are the same for film-based cameras and digital cameras.[7]

What makes the advent of digital imaging a new leap forward for clinical photography is the elimination of the considerable delay between image capture and review. The ability to see digital images immediately and appraise their composition, focus, and exposure cannot be equaled by film cameras that require time-consuming film development and expense before the results can be evaluated. Digital photography allows greater freedom for trial and error adjustments, eliminates

FIGURE 1. Two entry-level Canon SLR clinical camera bodies. The Canon XSi (12 megapixel) on the left and XTi (10 megapixel) on the right. Both cameras are light and have a small profile. Canon ring flash and 60 mm macro lens attached to complete the system as a close-up clinical camera.

FIGURE 2. Aligning the X-ray head to make a precision exposure is necessary to avoid distortion of the image.

FIGURE 3. Revealing the anatomy and aligning the camera for a proper anterior image.

the additional expense of retakes, and facilitates the creation of duplicate images.

Intraoral video cameras were a step forward in the 1980s and 1990s, and they still play a role in the dental practice. They provide real-time results that can be shared with patients; they are relatively simple to operate; and they can provide a source for archival digital images. However, video cam systems have several shortfalls. Most video cam systems have relatively low resolution and distorted image presentation.[8] Patients have a difficult time understanding the images because they are close-ups and significant landmarks are missing. Consequently, patients often cannot comprehend the image orientation without explanation.[9]

In addition, most video cam systems are considerably more expensive than quality entry-level clinical single-lens reflex, SLR, camera systems (**FIGURE 1**). While the upfront cost for a digital clinical camera setup may be greater than a similarly configured film camera, the expense can be offset by the ultimate savings from unnecessary film processing, duplication, and storage.[10]

It is the authors' opinion that now, more than ever, the efficiency and affordability of digital imaging make clinical photography a viable clinical tool that can be used routinely by the average dentist and support staff. Time has become a precious commodity for dentists and patients alike. With digital photography, dentists can share clinical images with patients at the same time as their initial examination.

Recently, a consumer publication dedicated to the science of photography presented an historic overview of the top 20 film cameras of all time. The magazine ranked the 1888 Kodak film camera the No. 1 camera, stipulating that, "What makes this humble-looking box camera so pivotal and consequential is not its ingenious construction or technical brilliance, both of which are noteworthy, but the idea it embodies — creating a camera capable of producing satisfying photographs in the hands of an ordinary person having no particular technical skill."[11]

This commentary about a film camera that is more than 120 years old parallels what can be said about advances in the most recent generation of digital SLR cameras. When the first consumer digital SLR cameras were introduced, like the Nikon D1 developed in 1998, questions were raised about whether satisfactory results could be achieved equal to film and whether the average person or dentist could easily master digital technology.[12,13] The D1 was a 3 megapixel camera with questionable color accuracy, relatively low resolution compared to film, technical complexity, and a high price tag.

Now, 10 years later, these initial significant flaws have been overcome. Digital is considerably more affordable, can produce useful clinical images on par with consumer film cameras, and can be operated by the average individual without advanced technical expertise. While film photography still offers the ability to produce images with a higher resolution than digital, this is of questionable benefit since most clinical images are not viewed or printed in such high resolution.

Mastering this technology has many rewards. Dentists can communicate better with patients before, during, and after treatment concerning the current state of their oral health; concisely chronicle any irreversible procedure; and share information with other members of the dental-medical team (dental lab and specialists).[14] Doctors and staff can more easily master this technology because they receive instant feedback concerning the results of their image capture and can make adjustments immediately.

Because dentists are committed to quality and excellence, clinical digital photography can prove a useful tool providing opportunities for self-assessment of treatment outcomes. Photographic images can reveal insights into areas of needed improvement. It has been noted that one of the best defenses against malpractice suits is informed consent and good clinical documentation. Digital photography is a powerful and efficient documentation tool.[15-17]

Several medical specialties like dermatology, plastic surgery, and ophthalmology have embraced digital photography as an important diagnostic tool.[18,19] Dental specialties, such as orthodontics, have adopted clinical photography as a regular part of their suggested diagnostic protocol. It has been suggested that diagnostic clinical images include five standard intraoral photographs: right, center, and left views with teeth in maximum intercuspation, as well as maxillary and mandibular occlusal views.[16,20]

The intraoral photographic images provide a clear, well-illuminated view of hard and soft tissues, teeth alignment, bite relations, and the condition of existing restorations. In its publication, *A Guide to Accreditation Photography*, the American Academy of Cosmetic Dentistry suggested 12 views for case documentation. Most clinical photographic series include extraoral portrait images along with intraoral images. It is generally believed that greater skill is needed to capture standardized, consistent intraoral clinical images than extraoral portrait images.[21] However, proper composition, subject posture, magnification, and lighting are all important factors in useful clinical documentation including clinical portrait photography.[22-24]

Standardization requires planning, a systematic approach, observance of protocols, and attention to detail. The regimentation and skill sets required for taking quality clinical photographs are very similar to those necessary for taking good dental radiographs (**FIGURES 2 AND 3**). After capturing a clinical photographic series, the images can be loaded into a computer and viewed without any additional software beyond the computer's operating systems like Windows XP, Windows Vista, or MacOSX.

Occlusal views allow patients to tour their mouth and see both hard and soft tissue and the relationship of adjacent teeth, condition of restorations and structures. Lateral side views can show bite relations and malocclusions. Front views can expose issues relative to wear, symmetry, tissue inflammation, and the relative beauty of the smile, as well as more subtle issues such as midline discrepancies and occlusal cants, which may be less apparent when only plaster study models are available.[21] Patients can usually relate to the discussion of photographs of their own mouth more than dental radiographs and study models.

In 2001, the October issue of the *Journal of the California Dental Association* was dedicated to the newly emerging technology of digital clinical photography. Seven years later, this technology is ripe to be a regular part of the standard of care for the entire dental profession. Current trends in this emerging area are toward lowering camera costs and improving features. Limiting factors of digital photography recognized in 2001 have mostly been eliminated; the remaining obstacles may simply be recognition of the benefits and acceptance of this technology by clinicians and their staff as a useful part of their daily practice. ■■■■

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Clinical Digital Photography: Implementation of Clinical Photography for Everyday Practice

ROBERT SHOREY, DDS, AND KENNETH MOORE, DDS

ABSTRACT Clinical photography requires a regimented system of image acquisition similar to the regimentation needed for dental radiographs. Clinical digital photographic equipment is rapidly advancing. To achieve the best image quality and resolution, digital single-lens reflex systems are necessary. DSLR clinical systems are made of three components: camera body, macro lens, and flash attachment. Other ancillary equipment is necessary to achieve appropriate clinical image reveals and composition. Recommendations are given to assist in the implementation of clinical photography in the dental practice.

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Most of the same principles apply to taking effective clinical intraoral photographs as they do in producing excellent dental radiographs. Both systems provide indelible visual diagnostic information and both reveal comparative parameters of oral health at a fixed point in time. In dental school, most dentists receive training that helps them recognize the need for dental X-ray image standardization.

It is well accepted that good placement and proper exposure are necessary to achieve diagnostically relevant and comparable radiographs. Therefore, it should be obvious to those striving to capture relevant clinical photographs that a similar set of rules for standardization would apply. For intraoral clinical imaging, it is desired to capture images that are proportionally accurate, well-illuminated, and clearly focused from the front to the back of the image composition. Dentists also want consistent subject composition in X-rays and to be able to compare image subjects at different points in time.

Recommendations for quality anatomic imaging have been established by several authorities such as the Westminster Scales, the Institute of Medical Illustrators, the BioCommunications Association, the Pankey Institute, and the American Academy of Cosmetic Dentistry.[1-4] A com-

FIGURE 1. Canon G9 compact camera with close-up lens and light diffuser to improve lighting for intraoral photography.

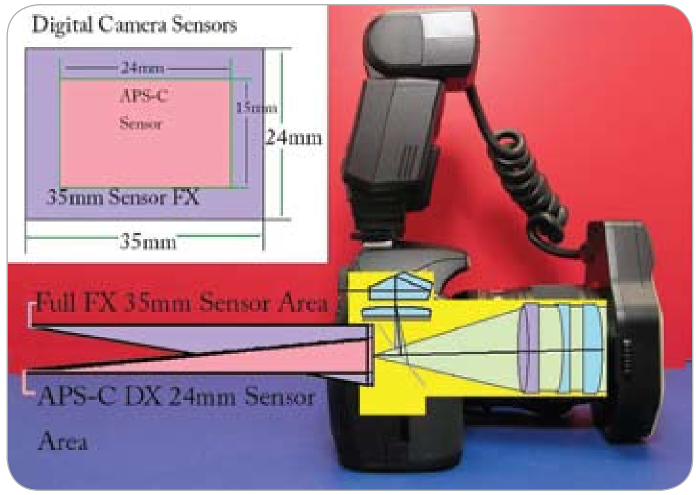

FIGURE 2. This illustration shows the variation of sensor size used in digital SLR cameras. The image capture area is smaller than a 35-mm film camera unless the digital camera is designated to have a full-frame (FX) digital sensor.

mon theme of the guidelines established by these authorities is the standardization of image composition and magnification, good subject illumination and exposure, and image clarity. To achieve all of the suggested photographic parameters recommended by these organizations, it is essential to have the correct equipment.

Dental Digital Systems

Currently, two mainstream digital dental camera systems are prevalent. The first is basically a "point and shoot" camera system, like the Canon G-series. (The G9/G10 designs are the most current versions.) These systems have a modified lens and a flash diffuser to optimize close-up photography and subject illumination (**FIGURE 1**). These camera systems are popular because they are compact, light, and simple to use. However, there are major photographic quality compromises to using these systems: a very narrow depth of field due to the fixed lens limited f-stop setting, and considerable distortion during close-up imaging.

Digital SLRs for Clinical Photo Image Accuracy

Because of these limitations, any shots involving significant anterior-posterior depths, such as lateral views, will result in the most anterior and most posterior teeth being slightly out of focus and objects closest to the camera lens will appear larger. Therefore, these systems do not achieve several of the recommended clinical photographic parameters. If one is planning to adopt and implement digital photography, a single-lens reflex, SLR, camera with appropriate lens and flash attachments is the camera of choice.[5-7] Other digital cameras can capture oral images, but like the limitations discussed previously with Canon G-series systems, they will be lacking in one of three image parameters (proportional accuracy, good subject illumination, or total clarity of subject focus).

Currently Available Digital SLR Systems

Digital technologies are rapidly advancing. In 1998, only a few digital SLR cameras were available. Today, there are many reasonably priced digital SLR models appropriate for capturing high-quality clinical images. For instance, two entry-level Canon and Nikon digital SLR camera bodies (Canon XSi and Nikon D60) provide satisfying results for clinical photography. It is now accepted that Canon, Nikon, and other top name-brand SLR cameras such as Sony, Olympus, and Pentax, equipped with a 6 megapixel or greater sensor and outfitted with proper accessory components, will provide acceptable clinical image quality. Most authorities agree that at least 3 megapixels is appropriate for clinical photography.[8-11] In 2009, this may be considered a retrospective comment since most DSLR system choices range beyond the 3 megapixel minimum from 6 to 21 megapixels. Three main components are needed to assemble an SLR clinical camera system: a 6 megapixel or greater digital SLR camera body, a quality macro lens, and a ring or lens barrel-mounted point flash/twin-flash systems. The latter two components are not new to photographic technology and are not distinct to just digital SLRs.

Image Sensor Size, Lens Magnification, and DSLR Crop Factor

One of the salient differences between most digital SLR cameras and 35-mm film cameras is the size of the image capture target (**FIGURE 2**). Knowing this fact is necessary to the understanding of why the magnification level markings for many models of DSLR's are inaccurate. Digital cameras generally have a smaller image target. A 35-mm camera has an image capture area measuring 35 mm x 24 mm while most digital SLR cameras have a smaller target of approximately 24 mm x 15 mm (known as an APS-C size sensor). For clinical intraoral photography, the smaller focal target size may actually be an advantage as it increases the magnification ratio of the commonly used macro lenses. It is important to be aware of this fact because the standardized

FIGURE 3. Two Canon macro lenses: 100-mm and 60-mm. The 60-mm lens fits only specific Canon camera bodies. The 60-mm has similar capabilities but allows for a smaller camera profile. Sources: CanonUSA and DigitalCameraInfo.com http://www.usa.canon.com/consumer/controller?act=ModelInfoAct&fcategoryid=155&modelid=11156, http://www.digitalcamerainfo.com/content/New-60mm-EF-S-Released-.htm. Accessed Jan. 19, 2009.

FIGURE 4. Two Nikon micro (macro) lenses: 60-mm and 105-mm from left to right. The smaller profile of the 60-mm lens provides a smaller more light weight clinical camera profile.

FIGURE 5. Ring flash system on the left, dual-barrel-mounted point flash system on right. The system on the left is heavier and requires more experience.

FIGURE 6. Color-coded mirrors using microfiber towels for identification and sterilization.

FIGURE 7. Metal and plastic lip retractors to create anatomic reveals.

magnification ratio markings on SLR camera lenses are usually calibrated for a 35-mm target. Placed on a digital camera with an APS-C size sensor, the calibrated markings will not provide an accurate magnification indicator. This magnification discrepancy is called the camera's crop factor. The crop factor must be multiplied by the lens magnification markings to determine the proper standardized magnification ratios suggested in clinical photography.[12]

Macro Lenses

Dental photography is considered macro photography (close-up photography). A macro lens can capture images from a 1:1 magnification (life-size) to infinity. For clinical photography, a 60- to 100-mm macro lens is necessary with a depth of field aperture of 22 to 32 in order to achieve a clear subject focus.[13] (**FIGURE 3 CANON MACRO LENSES; FIGURE 4 NIKON MACRO LENSES.**) Lenses affect image quality (color, image sharpness), magnification, working distance, depth of field, and image distortion.[13] A 60-mm macro lens has some advantages over the 100-mm lens. A 60-mm lens on an APS-C camera allows closer proximity to the subject when taking both intraoral and extraoral images. This lens will usually be in focus for a 1:2 magnification at about 8 to 9 inches from the subject while the 100-mm lens will need to be about 15 inches from the subject to achieve the same magnification and focus.

The 60-mm lens also provides a smaller footprint, making it easier to handle in small hands. However, 60-mm lenses have two distinct disadvantages: they do not function as well with barrel dual-mounted outboard flash units because of the subject proximity to flash, and are therefore better suited for a ring flash unit. They also provide more distortion if used with a full 35-mm frame camera sensor.

It should be noted that the Canon 60-mm EF-S macro can only be mounted on specific Canon APS-C camera bodies. When choosing a lens, consider this piece of equipment's cost and quality more carefully than the camera body. The lens retains its value over time more than the camera body; it is the piece of equipment most likely to be transferred to a newer camera body as new models come to market.

Flash Attachments

Intraoral photography relies on flash photography to provide sufficient subject illumination (**FIGURE 5**). The mouth is a dark cavern and the camera lens must be closed down to an f-stop (aperture) of 22 to 32 to provide proper depth of field focus. This necessitates using a good flash system. A ring flash may be considered the most all-around intraoral flash system and will provide illumination to the darkest reaches of the mouth.

Some clinicians prefer a single- or twin-barrel-mounted point flash system because it can provide details of surface texture and color that are otherwise eliminated when using ring flash systems. The ring flash system is less complicated and can achieve average acceptable images without consideration of light trajectory, flash proximity, and shadows.

Retractors and Mirrors

In addition to a good clinical camera, lens, and flash system, a clinician will need a set of lip retractors and surface-coated photographic mirrors to expose and create the necessary anatomic reveals (**FIGURES 6 AND 7**). A typical setup could include plastic or metal lip retractors and two specially shaped mirrors (buccal and occlusal mirrors). The mirrors are usually surface-coated chromium, rhodium, or titanium mirrors necessary to provide maximum reflectance and avoid image reflection distortions. Because of the delicate surface coating, special care is necessary to maintain the photographic mirrors in a scratch-free condition. Cleaning and storage using automotive microfiber towels will prolong the use of these mirrors.

Implementation of Clinical Photography in General Dental Practice

The principles that helped most dentists learn the didactic fundamentals of dentistry can be applied to the implementation of clinical photography in the dental office. It is important to learn about the specific equipment armamentaria, practice on static study models, and practice with coworkers to master camera fundamentals and image composition. Train staff and share your knowledge with them to build a capable photographic team. Today's digital cameras have become much easier to operate than previous models. The storage and enhancement of digital images have become a mainstay of widely used computer operating systems like MacOSX, Windows XP, and Windows Vista.

The following are the authors' top 10 recommendations for those choosing to introduce clinical photography into their daily practice.

1. *Make clinical photography a regular part of your new patient examination*. Like dental radiographs, taking a regular series of clinical photographs will provide insights into a patient's current oral health status. In the authors' experience, including clinical photos in the new patient examination routine adds about 15 minutes to the diagnostic intake. Because digital photography provides almost instantaneous results, the images can be shared with the patient. Such visual aids usually lead to discussions that support co-diagnosis with the patient.[14-16]

2. *Master the camera before photographing patients, especially new ones.* Use study models to practice image focus and composition. After mastering photography of the static models, practice with staff members before moving on to patients.

3. *Use a computer system or laptop to display images in the operatory or consultation room.* Don't rely on your camera's LCD screen to share and discuss your clinical images with patients. When convenient, print out a copy of relevant images with discussion findings noted using an indelible felt pin and provide the new patient with a copy of the image and notations.

4. *Set up the camera using two modes that allow distinct settings for intraoral photos and portrait photos.* The camera dial can be easily switched between settings when transitioning from portrait to intraoral images. However, one alternative would be to dedicate two cameras for clinical photography: one preset for intraoral images and the other configured and designated for portrait images. For intraoral images, a Canon camera can be set to manual with an aperture of 32 and shutter speed of 1/125.

For portrait images, set the camera to portrait or automatic. For a Nikon camera, use an aperture priority setting of 32 for intraoral images and set the camera to automatic for portrait. Do not use automatic focus when shooting any clinical images. Set the camera to a specific magnification for the specific task and move the camera in and out to achieve proper focus.[17] The flash settings can be set to through the lens metering (TTL) or manual. When using the manual flash setting, the images will have to be closely monitored for potentially necessary exposure adjustments. Review the camera documentation for exposure compensation controls necessary to adjust image exposures.

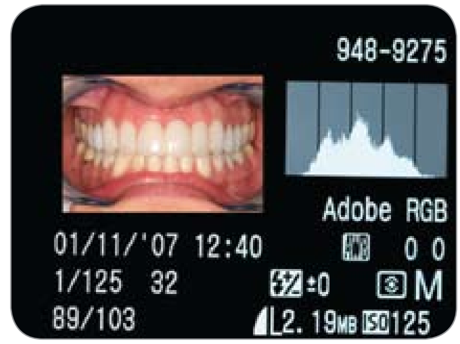

FIGURE 8. All digital cameras have an image review capability, along with information about the camera settings. The histogram showing in the right corner provides information about the light and dark pixels contained in the image. For dental images keeping the histogram nearly centered will usually provide a reasonably exposed image.

5. *To minimize overexposure problems, do not illuminate the subject with the operatory light while capturing images.* If light in the room is insufficient to illuminate the subject while focusing, use the built-in lamp available in most flash systems. Learn to use the digital camera histogram to review the photos (**FIGURE 8**). This provides a ballpark method for assessing image exposure. The histograph can be viewed through the camera LCD. When the subject is an intraoral image, keeping the graph centered usually results in a more evenly exposed image.

6. *Establish a regular routine, e.g., take portrait images first then intraoral images.* Choose a series that can be routinely achieved and provide useful results. Although some authorities suggest an extensive series of images, a simple series can be mastered by staff and will be easier to implement at first. A retracted anterior, right and left lateral, and upper and lower full arch will provide significant clinical information.

This simple series can usually be mastered by dentists and staff members.

7. The dentist should master the technology to adequately supervise image capture and troubleshoot equipment problems. For efficiency, ultimately, photography should be delegated to office staff. An explanation of the benefits of mastering this technology, such as the ability to educate patients about their needs and encourage more needed treatment acceptance, may inspire staff members to add it to their daily responsibilities.

8. Treat the camera as an important dental instrument; do not use the camera recreationally. This will minimize the amount of dust that can get into the camera and keeps the camera maintained on the appropriate clinical camera settings.

9. Don't use paper towels or tissues on your equipment. Automotive microfiber towels clean without scratching delicate photographic mirrors or camera lens glass. Use old microfiber towels cut into smaller sizes to wrap mirrors for heat sterilization. This avoids scratches from rubbing on dental instruments and prolongs the life of the mirrors. Do not use cold sterilization solutions on camera parts or mirrors and do not put mirrors in an ultrasonic cleaner. Wash mirrors in soap and water, rinse thoroughly, wrap in a towel, bag, and heat sterilize.

The microfiber towels come in colors and can be used to color code the mirrors, signifying the shape of photographic mirror contained in the sterilization pouch.

10. Celebrate your victories with patients and staff. Having photographs of your team's well-executed treatment brings back the memories and the emotions of a job well done.

Conclusion

Clinical photography can provide indelible diagnostic information that is easily recognized and understood by both professionals and laypersons. The use of digital photography enables images to be evaluated and shared with patients shortly after the photos are taken. Digital images can also be easily stored and duplicated. In order to get the full diagnostic value out of digital photography, a systematic method and regimentation of clinical images must be adopted.

Embarking on any new adventure involves taking the first step. Likewise, adopting digital clinical photography as a regular part of the dental practice starts by taking the first step. This article hopefully has provided some guidance and reasons for dentists to include this technology in their practices. As the journey continues, further insights will be necessary to understand and master the logistics, correct anatomic reveals, and take advantage of advanced options needed to really bring the team's clinical photographic skills to their highest levels.

Resources are available through dental organizations like the American Academy of Cosmetic Dentistry, the Institute of Medical Illustrators and dental continuing education programs. Reputable Web sites such as http://www.dpreview.com and http://www.steves-digicams.com/hardware_reviews.html also can provide information about choosing specific camera equipment. ■■■■

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Assessing and Achieving Accuracy in Digital Dental Photography

STEPHEN R. SNOW, DDS

ABSTRACT Accurate digital photography is becoming part of the standard of care for diagnosis and documentation in dental treatment. Proper exposure and color rendering are critical elements in the capture of useful images with excellent representational quality. Reliable photographic techniques must be consistently applied as a repeatable protocol to create an accurate record of pretreatment conditions and post-treatment results. Every software process that alters an image will degrade the pixel content and should be minimized or avoided.

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Concepts for this article were originally presented at the American Academy of Esthetic Dentistry Annual Conference in Kona, Hawaii, August 2005.

Excellence in cosmetic dental treatment procedures involves commitment and control. Proper diagnosis, prudent treatment planning, and careful application of proven principles in dental procedures are all required to achieve predictable results and meet patient expectations. Evaluation of photographic images is an indispensable part of the decision-making process.[1] Dental photography for medicolegal documentation, enhanced communication, clinical self-assessment, procedural illustration, and practice promotion provides an essential adjunct to treatment in the progressive dental practice.[2,3]

The American Academy of Cosmetic Dentistry has published *Photographic Documentation* and *Evaluation in Cosmetic Dentistry: a Guide to Accreditation Photography* to demonstrate the desired results of proper photographic documentation.[4] It contains recommendations for perfecting both magnification and alignment in dental photography. While this guide defines concepts and conventions for the composition of excellent dental images, consistent magnification and alignment by themselves are not enough. If the quality of an image is poor, the difference between initial clinical findings and final results may not be distinguishable. Additional criteria photographic images must meet to be useful and diagnostic.[4] Excellent photographic images must also have accurate exposure, accurate color, and accurate tonal range.[5] This article will explore the principles of these criteria and their interrelation as they pertain to intraoral photography with a digital single-lens reflex, DSLR, camera in dental imaging applications.

FIGURE 1. An overexposed image shows loss of highlight detail due to similarity of adjacent light tone pixels.

FIGURE 2. An underexposed image (of the same dentition shown in Figure 1) shows a loss of shadow detail due to similarity of adjacent dark tone pixels.

FIGURE 3. An ideal exposure (of the same dentition shown in Figures 1 and 2) displays discernable detail apparent throughout the image due to visible differences between adjacent pixels in the entire tonal range.

Accurate Exposure

In human vision, light enters the eye through a lens and is focused on the retina. The rods and cones within the retina are stimulated to convert and transmit the light energy to the brain for processing. The brain continually assembles the data into an image for interpretation and subsequent response. In digital photography, light enters the camera through a lens and is focused on a sensor. The electrodes within the sensor are stimulated to convert and transmit light energy data to an internal processor. The processor assembles the data collected by the sensor into an array of colored dots that collectively make up the final image. Each dot of color represents one picture element called a pixel.[2]

Precise photographic replication of the appearance of teeth requires accurate exposure.[6] Cameras are designed to mimic the abilities of the human eye in viewing light or dark objects in a variety of lighting conditions. The sensor and processor inside a digital camera, however, are not nearly as flexible as the human retina and brain in collecting, sensing, and interpreting light. The dynamic range — the difference between the darkest tone and the lightest tone that can be discerned simultaneously — is much more restricted in a camera. The amount of light entering the lens of the camera must be carefully controlled to ensure it does not exceed the limits of this range.

If too much light enters a camera, the image can be overexposed (**FIGURE 1**). In this case, adjacent pixels of light tones will be identical and highlight details will be indistinguishable. If too little light enters a camera, on the other hand, the image can be underexposed (**FIGURE 2**). In this case, adjacent pixels of dark tones will be identical and shadow details will be indistinguishable. An ideal exposure has discernable detail throughout the image (**FIGURE 3**). Adjacent pixels of all tones are all different throughout the image. Exposure accuracy should always be the highest priority of any photographer capturing any subject.[2,6]

Intraoral dental photography usually requires the use of a flash as a supplemental light source to overcome the dynamic range limitations of a camera in dental applications.[2,3] The flash casts light into areas of the mouth that would otherwise be hidden in shadows. When the clinician presses the shutter release on the camera, several events occur in rapid succession that coordinate the internal mechanisms of the camera with the flash burst to capture an image. A circular array of thin baffles moves inward from the outer sleeve of the lens toward its center to reduce the size of the iris through light will enter the camera. The size of the hole through which light passes is called the aperture of the lens.

Subsequently, a curtain covering the light-sensing computer chip (digital sensor) in the camera slides off to one side and out of the way to reveal the sensor, allowing light to strike its electrodes and initiate the image exposure. The curtain, or shutter, and the length of time it is open is known as the shutter speed. Finally, the flash strobe fires to intensify the light falling on the scene for the image exposure. At the conclusion of the exposure, the flash burst terminates, the shutter closes, and the aperture blades retract back to the sides of the lens.

These mechanical and electronic steps must be carefully synchronized to create a proper photographic image. The aperture must partially narrow before the shutter is opened and the shutter curtain must be open before the flash strobe fires. The shutter speed is necessarily much longer than the flash burst. Manufacturers of contemporary DSLR cameras typically synchronize a flash photograph capture with a shutter speed of 1/60-1/125 of a second. Although that time frame may seem very fast, the order of magnitude of the flash burst speed is typically about 10 times faster.

There are four factors that control the exposure in flash-assisted dental photography: the aperture opening (f-stop), the length of the flash burst, the distance from the camera to the subject, and the sensitivity of the media (ISO).[6] Shutter speed does not affect the exposure in flash-assisted dental photography because it is coordinated with the flash burst. It is the length of the flash burst and not the length of time the shutter is open that determines the true speed

FIGURE 4. A macro lens can ensure consistent diagnostic magnification and repeatable exposure distance for dental intraoral photography if the clinician selects the manual focus mode (MF) and then selects a desired magnification ratio in the indicator window.

FIGURE 5. The exposure selector wheel of the Canon 30D DSLR is set to manual (M) mode (see green arrow). All other settings represent different TTL (through the lens) exposure strategies that automatically set some (or all) of the camera's exposure controls.

FIGURE 6. An incident light meter can be utilized to measure the intensity of light falling on its sensor. The digital display identifies the proper aperture setting for a perfect exposure with the available light at that working distance, in this case, f32. (See green arrow).

(i.e., time) of these intraoral exposures.[7]

The photographer must determine how those four factors will be selected and set. Exposure control always requires light metering — a measurement of the amount of available light — and subsequent camera setting for proper exposure. The photographer can elect to allow the camera to measure light and determine exposure settings automatically or to perform that measurement and determination manually.[2,6]

Since a higher ISO often creates unwanted speckled artifacts known as "noise," the sensor sensitivity is typically set by hand to a low value and left untouched for all subsequent dental exposures. A constant ISO value of 200 is often ideal for intraoral purposes. Additionally, diagnostic dental photography requires that the working distance from the camera to the subject should be a repeatable constant to ensure that any dimensional differences noted between pretreatment and post-treatment images can be attributed only to clinical procedures rather than to inconsistent photographic technique.[6] To achieve a constant working distance, the lens must be set to manual focus mode, and the clinician must manually select a specific and consistent magnification ratio for each desired view[2,6] (**FIGURE 4**). The remaining variable factors that can affect the amount of light in dental photography therefore are the aperture and the length flash burst.[2,6]

To control these last two variables, current camera systems often incorporate TTL metering — a light monitoring system that measures the amount of light entering through the lens to automatically time the flash burst, set the aperture opening of the lens, or both.[2] Unfortunately, the amount of light entering the camera is partially dependent on the reflective optical properties of the subject that is being photographed.[2,6] To automatically calibrate a camera exposure, TTL programming assumes that a significant proportion of the content of each image corresponds to subjects that reflect medium brightness levels of light.[2,6]

This system works well if sources of midtone luminance such as a medium blue sky or green grass fill a substantial portion of the scene. When photographing a scene that contains a high percentage of light extremes, however, the use of automated exposure systems can be problematic. TTL controls may respond incorrectly and attempt to modify the exposure so that light or dark areas of the photograph appear to be a medium tone instead.[6]

If a camera analyzes the brightness values of a scene containing a high percentage of white or light areas (e.g., teeth), the TTL light measurement will incorrectly determine there is too much light in comparison to expected midtone values. In this case, the automated exposure would be inappropriately lowered, and the resultant image might appear artificially dim. If the camera evaluates a composition containing a dominance of dark areas (e.g., the shadows of the pharynx or buccal corridors), TTL light analysis will inadvertently sense there is too little light in comparison to expected medium light values. In this circumstance, the automated exposure would be inappropriately brightened, and the resultant image might appear artificially light.[6]

If a camera analyzes the brightness values of a contrasted scene containing a high percentage of both light and dark areas (e.g., an intraoral scene), the TTL light measurement can vary widely depending on the percentage of light or dark tones included. Even slight alterations in alignment and composition can cause noticeable exposure inconsistency. In this case, the automated exposure could be inappropriately lowered for one image and then inappropriately raised for another of the same subject. The resulting disparity in dim and the bright images can seem haphazard, inefficient, and frustrating for the clinician.

Manual exposure strategies provide the most accurate approach because they are not influenced by the varying amount of light that reflects off light or dark subjects[2] (**FIGURE 5**). Instead, an incident light meter is used to determine the amount of light falling on the subject[2] (**FIGURE 6**). The clinician selects a desired magnification distance and utilizes the light meter to determine the proper exposure for that specific distance. When the camera aperture is set manually, the exposure will always be correct for that distance, regardless of the reflective properties of the subject. All subsequent photography at that same working distance can be accomplished with a point-and-shoot style that requires no additional calculation for proper exposure.[6]

FIGURE 7. Nikon R1C1 strobe system (with a SU-800 radio controller and two SB-R200 slaves) is one of several available strobe systems that have been shown to produce a color temperature approximating 5500 degrees Kelvin when tested at a magnification ratio of 1:2.5.

FIGURE 8. The Canon 30D is one of several DSLR cameras that has an external button allowing convenient access for manually selecting the camera's white balance (in this case set to flash, see green arrows).

Color Accuracy

The colors that are ultimately visualized in a photograph are determined by a combination of the optical properties of the subject, the spectral content of the light illumination, the color processing algorithms in the digital camera, and the workflow of the computer hardware and software used to process the image.[8] To recreate an accurate representation of the appearance of the optical properties of the subject, the latter three factors must be carefully controlled.

To provide a light source with neutral spectral content, the clinician should select a strobe designed specifically for macro photography. Most contemporary macro flash systems simulate neutral daylight content with a color temperature that approximates 5500 degrees Kelvin (D55)[8] (**FIGURE 7**). Other light sources might possess different color temperature characteristics and could impart an inaccurate color cast or tinted appearance to the entire image.

When a photograph is taken, the DSLR camera converts the light energy striking to sensor into digital data that can be stored as a digital file. The white balance feature of the camera influences the computations that are made by the camera during this conversion. The white balance setting must match the color temperature of the light illuminating the photographed scene to properly compensate for its spectral content and eliminate any potential color cast. The photographer can elect to allow the camera to measure light entering the camera to determine the white balance setting automatically or to perform that setting manually.

Contemporary camera systems provide a TTL option for automatically controlling white balance. An internal light monitoring system measures the spectral content of the light entering through the lens to adjust the white balance color processing. Auto white balance algorithms are programmed with the assumption the scene contains a combination of colors that is, on average, neutral. These automated strategies work well when the scene has a balanced variety of red, green, and blue colors, or a predominance of neutral whites, grays, and blacks. Any imbalance in the captured color data would then indicate an unwanted color cast caused by the color temperature of the illuminating light source. The camera's auto white balance processing would alter the data appropriately to achieve a neutral balance and thus improve the color accuracy of the final image.

As with exposure determination, however, the use of an automatic white balance option in photographing an intraoral scene is problematic. Unfortunately, there is no neutral white, gray, or black to reference for calibration. There is no green grass or blue sky to balance reddish hues of gingiva and yellow-tinted hues of teeth. Auto white balance processing will erroneously add cyan to the image to neutralize the high proportion of red from the gingival tones while adding a tinge of blue to offset the yellow tones of the teeth. The resultant image will predictably seem to have an inappropriate bluish-gray cast.

To control the color processing algorithms of a camera for the most accurate color results, the photographer must set the white balance feature manually to match the light source and to coordinate with its specific color temperature.[3,5] The camera would then be compensating for the quality of light falling on the subject rather than the limited portion of the visible of the spectrum reflecting off the subject. Although a custom white balance profile can be produced to provide the best camera response, the flash white balance setting is a good starting point for clinicians who are taking initial steps toward improving color accuracy in their photographs.

The camera processes the captured color data of the digital image with the assumption that the spectral content of the light illuminating the subject closely approximates D55.[5,8] Major camera manufacturers often use a lightning bolt icon to symbolize flash features and to indicate when they have been selected (**FIGURE 8**).

FIGURE 9. Pretreatment evaluation image taken with manual exposure settings dictated by an incident handheld light meter.

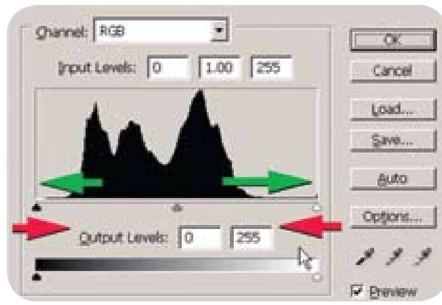

FIGURE 10. The histogram of the tonal content of the image shown in Figure 9. The slider controls of this software tool can be moved (see red arrows) to expand the tonal content and alter the appearance of the image (see green arrows).

FIGURE 11. The same pretreatment evaluation image seen in Figure 9 but with an expanded tonal content. The image displays significantly increased contrast but also altered color content.

Software Workflow

Computer hardware and software must be utilized to view digital images after they are captured. Whether or not a clinician learns to perform these procedures or elects to outsource or delegate the completion of the tasks to others, some form of digital processing must occur to convert the initial image data into a monitor screen display or a print. The selection of equipment, use of software, and application of image processing all affect the quality and accuracy of the final photographic result. Knowledge regarding the nuances of image processing is necessary to obtain proper results.[3]

The workflow is the series of steps, either automated or manual, that is applied to digital images as they are processed for viewing. One critical workflow component is that of database management. Sorting, selecting, naming, and storing images are essential procedures that allow efficient retrieval of images for later viewing.[3]

Beyond organizational tasks, computer software provides the photographer with ability to alter the size, format, or content of the images. The possibility of modifying a medicolegal record of diagnosis and treatment raises an ethical question. If an isolated selection of only part of the pixels within an image is altered by itself, the appearance of that portion will change relative to the remainder of the picture. This capability enables the operator to create images that simulate proposed treatment results and help patients visualize the possible esthetic benefits of dental care. Unfortunately, it also creates a potential for the operator to falsify the appearance of the image, hiding unwanted elements that are present or creating the illusion of other elements that are missing.

Clearly, the practice of furtive or fraudulent image alteration has no place in dental practice and the issue warrants extensive discussion in another forum. The focus of the remainder of this article will be on the wisdom of attempting to correct images in the ethical intent of accuracy rather than that of deceit.

Global image changes are software manipulations that are performed over all the pixels in the entire image.[3] Image rotation is one example. If a clinician mistakenly holds the camera in a tilted aspect relative to the patient's dentition during capture and inadvertently creates a canted dental image, rotation can be applied correct the error and provide improved representational accuracy.

Unfortunately, an angled portion of each corner of the image must be trimmed away and eliminated to maintain the original shape and aspect ratio. Even though the impact of improved alignment may seem to provide an enhancement, the software alteration has reduced the data contained in the image, altered its apparent magnification, and therefore reduced its diagnostic accuracy.

Similar software strategies can be applied to alter the luminosity of an image by globally modifying the brightness levels of its pixels. Evaluation of the efficacy and advisability of this workflow procedure requires the analysis of a histogram. A histogram is a bar graph that represents the tonal content of an image (**FIGURES 9 AND 10**). The x-axis designates the brightness levels of the tonal range, with pure black at the far left and pure white at the far right. Dark tones in the left third of the histogram are called the shadows of the image. Light tones indicated by the right third of the graph are called the highlights. The medium tones represented in the middle third of the histogram specify the midtones. Each column of the bar graph represents a unique and discernable color brightness from its adjacent neighbors. The more tonal levels present in an image, the greater the quality of detail it can contain. The y-axis of the graph corresponds to the percentage of pixels within the image at each tonal level. A higher peak of the graphed data represents a greater proportion of pixels with that specific luminosity present within the image.

When software is used to change the tonal content of a photograph, a corresponding change will be seen in the histogram as well. By moving the sliders under the histogram, the software repositions the white point and black

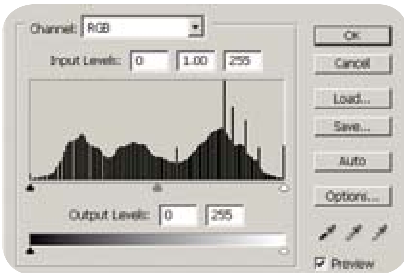

FIGURE 12. The histogram of the altered image in Figure 11. The widened graph of data (in comparison to Figure 10) reflects an expansion of tonal range. Although promoted as an image correction, there are now gaps in the data, loss of detail discernment, and image degradation.

FIGURE 13. The same overexposed image as in Figure 1 seen as originally published following inadvertent alteration and modification during publication. Note the orange cast in the appearance of the gingiva.

FIGURE 14. The same underexposed image as in Figure 2 seen as originally published following inadvertent alteration and modification during publication. Note the purple cast in the appearance of the gingiva.

FIGURE 15. The same ideally exposed image as in Figure 3 seen as originally published without alteration and modification during publication. Note the neutral and expected appearance of the gingiva.

point, proportionally redistributes the tonal values for all the pixels in between, and mathematically reassigns their red, green, and blue values to match.

Often this technique is utilized to enhance tonal contrast by making dark tones appear darker and by making light tones appear lighter (**FIGURES 10 AND 11**). Histogram-assisted brightness level manipulation has also been proposed as a method to compensate for initial exposure inaccuracies. This workflow application implies that exposure errors inherent in automatic TTL exposure don't matter because they can be corrected.

Myths of Image Alteration

Brightness level changes are simply mathematical alterations of the red, green, and blue numerical formulae that correspond to each pixel. Lower values correspond to darker shadows while higher values represent brighter highlights. Squeezing the white and black points toward the center of a histogram, however, also forces the pixel data to be distributed over fewer tonal levels. Often pixels that were previously defined by differing RGB formulae are now combined and lumped together as being the same. The consequence of identical pixel appearance is always a loss of image detail.

In addition to the irreversible reduction in image detail, the combined tonal levels are stretched out to cover the entire tonal range. Darker brightness levels must shift toward the black at the far left while lighter brightness levels must approach white at the far right. Histogram evaluation following tonal level manipulation reveals the exaggerated spikes of collapsed tonal level detail separated by gaps of missing data left behind as a sequella of that process. Gaps in the histogram data graph are manifested as a patchwork quilt-appearance detracts from the continuous gradient of tones that should be present in an excellent photographic representation of skin, gingiva, and teeth. Regardless of the effect of increased contrast or the illusion of exposure correction, any alteration of the brightness levels of an image will always degrade the detail of the image (**FIGURE 12**).

Since brightness level manipulations are produced by RGB formula changes for every pixel, any alteration in the tonal range will also alter the perceived color content in the final image. In another article by this author, three images were submitted to demonstrate the need for exposure accuracy[7] (**FIGURES 1-3**). Those images were intended to illustrate how overexposure can ruin detail discernment in the highlights while underexposure obscures detail discernment in the shadows.

During the publication process, the graphics department noted the disparity in the appearance of the three images and decided that the intentional difference was actually an unwanted mistake. The tonal content of the images was globally altered by the publisher so that the teeth in all three photographs would appear to look more uniform[7] (**FIGURES 13-15**). Although well-intentioned, this error dramatically illustrates how the alteration of tonal content simultaneously and undesirably alters color content. The images were all captured utilizing the same patient, but the appearance of the color content of the gingiva is significantly different.

Images can be adjusted with objective computer-analyzed protocol for improved color accuracy. With subjective histogram referencing techniques, however, color results can easily be skewed and inaccurate. Manual exposure techniques, manual white balance settings, and minimal software manipulation will yield the most predictable photographic results. For the best images, there is no substitute for accuracy and excellence in photographic technique.[7]

Conclusion

Digital photography can aid in diagnosis, treatment planning, delivery of care, and medicolegal documentation. Exposure accuracy is an essential factor for capturing and viewing correct representative images of clinical conditions. Manual exposure and manual white balance selection yield the most efficient, predictable, and consistent photographic results. Clinicians will achieve the best results through the implementation of good photographic techniques rather than subsequent image manipulation with computer software. ■■■■

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Three-Dimensional Surface Imaging of the Face

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ABSTRACT Accuracy, precision, quality, and simplicity are goals of diagnostic 3-D surface imaging of the face. The rewards include improved diagnosis, an ability to create a patient-specific model, simulate treatment, and improve treatment outcomes. This article discusses 3-D surface imaging of the face and selected clinical applications that add value to the image data.

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Two-dimensional photography has been the standard for facial imaging for decades but recently several methods have been developed for 3-D facial imaging. The current methodologies for creating 3-D facial images include close-range stereophotogrammetry, structured light, laser scans, CT scans, and MRI. Acquiring 2-D facial images is simple, does not require expensive equipment, and 2-D images are easy to format and print using a variety of software packages, such as Dolphin Imaging (Chatsworth, Calif.). All 2-D images have inherent limitations when the results are compared to the anatomic truth (anatomy as it exists in nature).

With a 2-D system it is difficult to control focal length, point of view, and lighting, and it is impossible to produce accurate images that could be used for anthropometric measurements. Precision is a measure of reproducibility and the inability 2-D systems to control focal length, point of view and lighting greatly reduces their precision. The inability to provide depth using a 2-D photographic system and the inability to calibrate for focal length produces an inaccurate representation of the anatomy.

All imaging technologies allow for the capture and display of anatomy. The capture and display variables of interest for this article are point of view, POV; field of view, FOV; focal length, and anatomic accuracy. These are important variables when discussing the differences in 2-D and 3-D imaging.

Point of View

Point of view refers to the visualization perspective. For example, a cephalometric projection usually refers to a lateral or posteroanterior POV. Using 2-D techniques, the visualization and capture

POVs are identical. Conversely, using 3-D techniques, the capture POV does not necessary match the display POV. For example, a 3-D CBCT capture may occur by circling a central ray around the head but the display angle can be user defined and is infinite. Therefore, there is an infinite number of viewing angles. In addition, a 3-D volume (CBCT), using software tools, can be reformatted or sliced along any plane, oblique plane, or curved plane to reveal the internal anatomy.

Field of View

Field of view refers to the dimensions and the anatomy captured by the imaging sensor. The variables related to the FOV include sensor size and spatial relationships between imaging source, anatomy, and sensor. It is often the goal of imaging to have the FOV match the region of interest (ROI) by collimating the X-ray beam and the sensor in order to minimize the radiation burden. To appropriately select the FOV requires imaging objectives that are designed to answer the clinical question being investigated. Matching the FOV with the ROI has the added advantages of controlling the radiation burden and improving the quality of the exam by reducing scatter radiation.

Focal Length

Focal length refers to the distance from the object being imaged to the recording sensor. The recording sensor includes film (X-ray or photographic) or digital sensor (CCD chip).

Anatomic Accuracy

Anatomic accuracy is an ideal imaging goal to accurately represent the anatomy as it exists in nature, i.e., the anatomic truth. The projection geometry associated with 2-D techniques does not produce accurate anatomic images. Three-D digital techniques have the opportunity to produce anatomically accurate images.

Imaging the craniofacial structures using 2-D film and digital acquisition techniques occurs with multiple POVs, multiple FOVs, multiple focal lengths, and variable resultant accuracy. This method deconstructs the anatomy into a collection of 2-D images. For the clinician to understand the anatomy using the 2-D deconstruction method requires a virtual reconstruction that attempts to reassemble disparate POVs, FOVs , focal lengths, and variables of differing accuracy. This is a difficult if not an impossible task.

> **THE IDEAL FACIAL** photographic system would be one that could accurately reproduce the 3-D geometry of the face, produce repeatable results, is low risk, is simple, fast, and produces photorealistic images.

The ideal facial photographic system would be one that could accurately reproduce the 3-D geometry of the face, produce repeatable results, is low risk, is simple, fast, and produces photorealistic images. Ideally, image data can be manipulated by software for future visualization and analysis.

A 3-D facial scanner creates a point cloud (mathematical or geometrical description as x, y, and z points) of the anatomic form (size and shape) and can photo-texture this point cloud with a photograph giving the 3-D image a photorealistic appearance. Three-D cameras are similar to 2-D cameras in that they have a cone-shaped field of view, and can only sense surface information that is in their direct line of sight. Three-D scanners acquire several images, each from a unique point of view, that are combined (registered or fused) into a common 3-D coordinate system.

Laser-Based Imaging

A 3-D laser scanner uses a laser light to sequentially probe the anatomy while a CCD camera records the laser probing. The distance and angle between the CCD camera and the laser are known and form a triangle. Using triangulation mathematics the facial elevations can be computed. The laser probe is recorded on the camera x, y field of view, and x, y coordinate locations are based on the distance from the camera to the probed surface. The face is sequentially scanned by a laser light source. Digital cameras monitor the illumination and triangulation geometry allows depth information to be calculated. Laser scanning of a face can take up to 30 seconds and this relatively long scan time creates the opportunity for patient motion with loss of coherency between measurement points.

Structured Light

A structured light camera is comprised of a pattern projector and a digital camera that are spatially offset. Structured light patterns (usually white light) such as grids, dots, or stripes, are projected onto the subject while the digital camera takes an image of the subject. The reconstruction software is initially calibrated with the spatial position of the camera and the specifics of the projected light pattern. The distortion of the light pattern is then analyzed by the software and the 3-D shape is inferred from the scale of the visible distortion. A single camera technique, because of line of sight limitations, cannot

FIGURE 1. This figure shows the active stereophotogrammetry 3dMDface system created by 3dMD (Atlanta, Ga.) and installed using a wall mount strategy at DDI in Roseville, Calif. The system has the option of being portable. The 3dMDface system uses four-machine vision 2 Mpixel sensors for capturing geometry and two-machine vision sensors for capturing texture. The options for the texture sensors are either 2 or 5 Mpixels each. The six sensors simultaneously capture the facial anatomy in 1.5 milliseconds. The capture volume can be up to 0.5 x 0.6 x 0.5 meters. The accuracy has been tested within 0.2 mm depending on the lens configuration.[5]

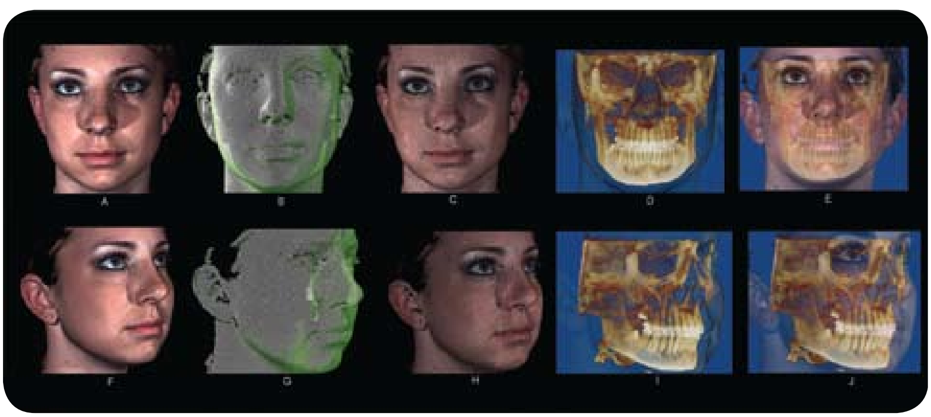

FIGURE 2. This figure shows a face image that was captured with 3dMDface using a range of 3-D visualization options. A and F show a photo-textured face from two points of view. B and G show the geometry of the face rendered as a polygon mesh. The stereophotogrammetry reconstruction algorithm creates a point cloud of approximately 100,000 surface locations. The polygon mesh was created from this point cloud using the points as vertices. C and H show the photo-textured polygon mesh using a volume render method of display. D and I show the polygon mesh of the face registered to the CBCT. The mesh and skeleton were registered using Dolphin 3-D software and displayed using a volume-rendering technique. E and J are a volume-rendering display created by Dolphin 3-D showing the 3dMD facial image registered to the CBCT generated by an Imaging Sciences (Hatfield, Penn.), iCAT machine.

acquire a full facial map of the patient with a single exposure. A full facial map requires multiple acquisitions and this reduces the accuracy and precision of the technique because the multiple images need to be stitched onto the same coordinate system and the time between exposures creates the opportunity for patient motion.[1,2]

Active Stereo Photogrammetry

Multiple calibrated cameras are spatially arranged with overlapping FOVs but different POVs that simultaneously capture the facial anatomy. This is an optical technique that does not require a structured pattern projection but uses a regular photographic flash to illuminate the face. Stereo photogrammetry uses image analysis algorithms to identify and match unique external surface features between the two photographs to generate a composite 3-D model by triangulating the points. The initial calibration procedure informs the analysis software of the precise 3-D location of each camera sensor.

The accuracy and efficiency of the analysis software can be improved by projecting a flat random pattern onto the subject to aid in the correspondence between the homologous image regions. The pattern on the surface provides the stereo localization algorithms with the base information required to build accurate geometry. The random pattern combined with the natural skin texture gives the image analysis software more detail to perform the triangulation.

Once the 3-D geometry model has been produced, the software maps the color texture information onto the model. Active stereo photogrammmetry has several advantages for clinical practice that include capture speed, a larger number of simultaneous viewpoints, and the ability to accurately compute the location of any derived point. Active stereo systems are capable of capturing the facial anatomy in less than 2 milliseconds and can compute approximately 100,000 facial coordinates[3-5] (**FIGURES 1 AND 2**).

Volumetric Imaging

Computed tomography, CT; cone beam CT, CBCT; and magnetic resonance images, MRI, are forms of volumetric imaging that produce 3-D information about the surface and subsurface anatomy. These volumetric techniques have been shown to be invaluable for diagnostic imaging but have some limitations when used for routine imaging of the surface anatomy of the face. All volumetric methods are expensive, may be associated with some risk to the patient, may not always be acquired with an optimal head position, may have distorted facial soft tissues secondary to stabilization devices, may have patient motion artifact, and may be limited to a small FOV of view, and therefore have incomplete information.

The fusion of 3-D surface imaging with volumetric imaging and associated modeling can provide the best of both technologies. This fusion occurs using multiobject software by registering or fusing the surface and volumes data onto the same coordinate system. Fusing the surface into the same 3-D coordinate space with volume data corrects volume artifacts created by patient motion and soft tissue compression, supplements missing volumetric data, and allows for correct display at a corrected head posture. The fused image data creates a patient-specific model that can be enhanced to add value to the original image data.

Modeling

Three-D imaging creates the opportunity for 3-D anatomic reconstruction and analysis. A 3-D image volume has a global reference or coordinate system (Cartesian coordinates) that is displayed as three orthogonal planes (axial, coronal, and sagittal). The coordinate system is often assigned to the anatomic volume by the acquisition device but can be modified later by the user with specialized software tools.

Multiple image sets can be combined into the same 3-D matrix. The process of combining these images into the same coordinate matrix is called fusion or registration. For example, a 3-D surface acquired using a visible light or laser scan can be fused onto a common coordinate matrix with a 3-D volume acquired using CBCT. Following the fusion of the two objects (surface and volume) they can be displayed, analyzed, and visualized together. The fusion of objects onto a common coordinate system can improve the accuracy and completeness of the anatomic representation. A process called anatomic segmentation can also add value to the image set. Segmentation creates an anatomic object that can be used for morphometric analysis, simulation, and biomechanical testing. For example, segmented objects may include individual teeth, mandible, maxilla, skin, and airway.

The objects are displayed and managed as rendered iso-surfaces. Each object may be assigned a local coordinate system. The global or original coordinate system monitors the position of each object using 6 degrees of freedom, DOF. The six DOF for each object are x, y, z, yaw, pitch, and roll. Fusion can also occur in 4-D. Fusion in 4-D occurs by spatially managing the object coordinate systems in a timed sequence of 3-D images. For example, the position of mandible, including the TMJs, relative to the maxilla and temporal bone, can be tracked and displayed by managing the local and global coordinate systems over time. This would allow for the creation of a virtual articulator (**FIGURE 3**).

Anatomic reconstructions can be used to create patient-specific models that can be analyzed. These models provide a visual representation of the patient and can also be used to measure size and shape of the selected attributes. The analysis data can be stored in a database for future reference. The database can later be analyzed to determine outcome values and develop prediction tables.

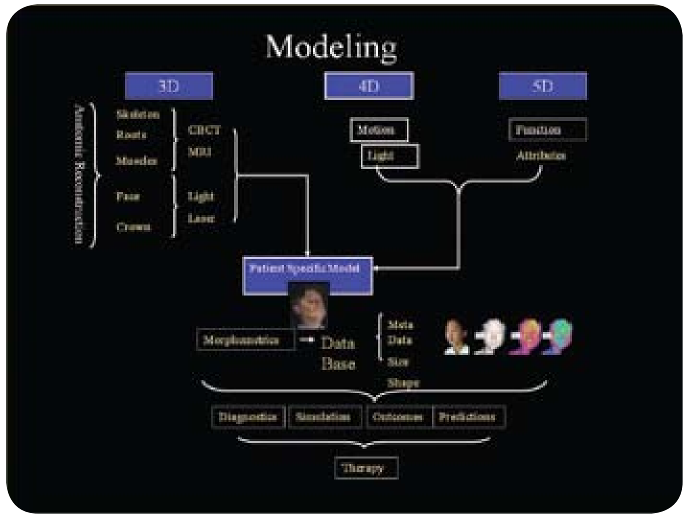

FIGURE 3. This figure illustrates the anatomic reconstruction of a 3-D patient-specific model using disparate imaging sources and fusing them on the same 3-D Cartesian coordinate system. The patient-specific model can evolve to a 4-D model by fusing a timed sequence of 3-D images onto the same 3-D coordinate system. Four-D systems can be used to evaluate change over time. Four-D modeling includes monitoring growth, development, jaw movement, facial expression, and treatment outcomes. Five-D modeling allows for the fusion of biomechanical attributes into the coordinate system and testing the biomechanical relationships between the structures. Information can be collected from the 3-D, 4-D and 5-D models, and stored in a database for retrieval and analysis. The data pool can be used for diagnostic, treatment simulation, outcomes analysis, outcome predictions and therapy.[6]

Multiobject models can be used for treatment simulations. Treatment simulations allow the operator to iterate treatment options or rehearse a treatment (**FIGURE 4**).

Anatomic reconstructions create the opportunity for a systems or integrated diagnostic approach. This approach allows for the analysis and consideration of anatomically related structures. A developmental disturbance of the TMJ (i.e., arthritis, fracture) may have a local effect on the ipsilateral joint and a regional effect on that side of the face. The joint pathology may limit or stop growth of the affected condyle. In addition, there may be a growth reduction in the vertical dimensions of the neck, ramus, and body of the mandible. The occlusal plane may be elevated on the affected side. The lateral development of the mandible may be reduced and the cranial base (fossa) may be depressed on that side. The limited growth of the mandible may alter the occlusion, maxillomandibular spatial relationships, facial profile, facial growth pattern, and the airway shape and size.

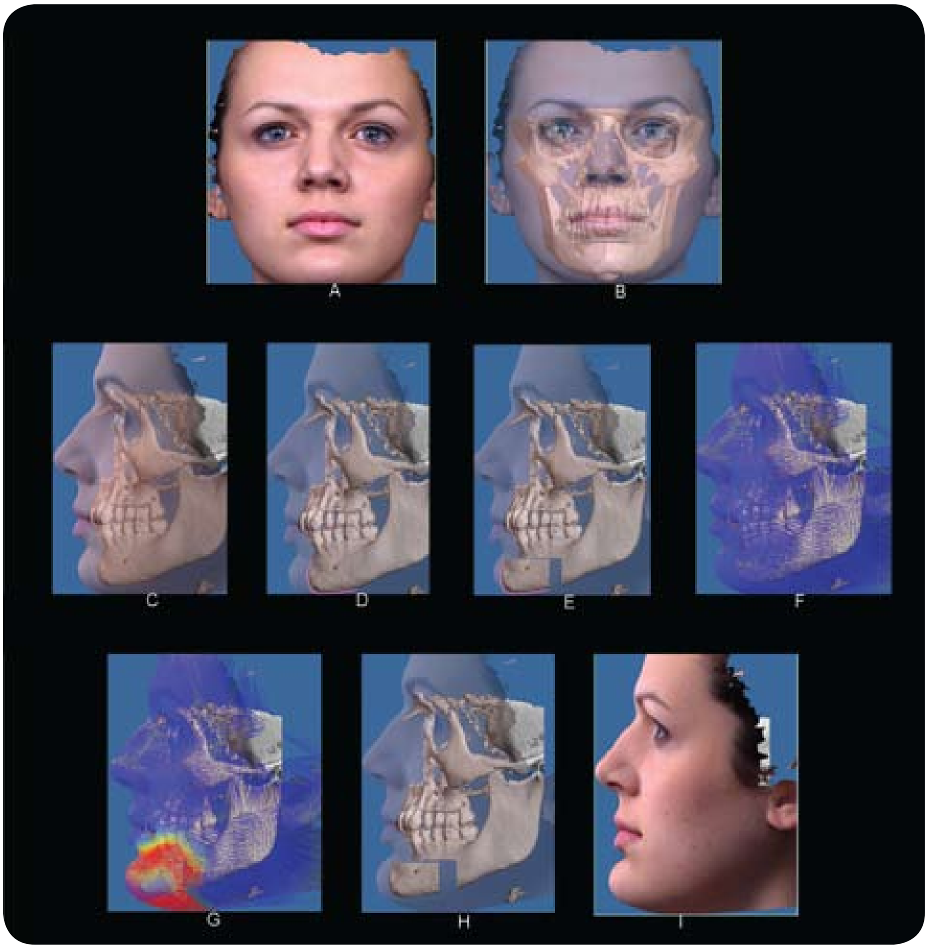

FIGURE 4. This figure illustrates functional (5-D) modeling on a patient-specific model. The software environment for generating the patient-specific model and the simulation was Vultus by 3dMD. The 3-D facial image was created by 3dMD's active stereophotogrammetry system (**FIGURE 1**). The skeletal data was produced by Imaging Sciences Int., iCAT. The skeleton was segmented in Vultus and fused with an imported facial image of the same patient to create a patient-specific model (A-B). Elastic properties through the use of a mass spring model (approximately 400,000 programmable springs and coils attached the skin to the skeleton) were applied to the model to help simulate the biomechanical relationships between the skeleton and overlying facial soft tissues (F-G). This simulation model was created by 3dMD. Using an osteotomy simulation tool, a region of the mandible was selected and outlined with a pink line (D-E). Note, the osteotomy is not anatomically correct and is only being shown as a simulation concept. The selected osteotomy segment was advanced (E). The advanced segment perturbed the springs and coils and they applied a force to the surface mesh (G). The surface mesh was deformed by the model to simulate the effect of the mandibular osteotomy (H-I). (Courtesy of Dr. William Harrell, Jr., Alexander City, Ala.)

Conclusions

The ultimate goal of imaging has been to accurately represent the anatomy, and this can be achieved for surface imaging of the face using 3-D methods, such as stereophotogrammetry systems. Software provides a multiobject environment where disparate 3-D image data can be combined into the same 3-D coordinate system and create a patient-specific model that is comprised of surface and subsurface structures. The accuracy and precision of 3-D facial images provides the opportunity for valuable clinical applications. These 3-D facial photography systems are currently being used for a variety of applications including monitoring patients through the process of growth, development and treatment, cleft lip and palate, orthodontics, orthognathic surgery, and craniofacial anomalies. ■■■■

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Technical Analysis of Clinical Digital Photographs

DANIEL R. LLOP, CDT

ABSTRACT Clinical digital photography adds an efficient, new dimension to the information provided to the dental technician. Through the use of digital photography, the clinician can create a series of images that communicate key prosthetic facial and dental landmarks for the dental technician to use in analyzing and creating the final prosthesis for the patient.

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For the past 100 years, one of the key objectives has been to recreate a virtual patient model through the use of articulated dental plaster models. In the 1920s, McCollum and Charles Stuart pioneered the use of dental articulators as a method to transfer anatomic determinants in order to create a modeling device for articulating the human bite, thus improving the prosthetic results created by laboratories.[1] The use of articulators today provide needed anatomic information but falls short on key areas related to facial soft tissue, symmetry, and key skeletal relations of the jaw to other facial landmarks.

Clinical film photography have been known to provide useful information not captured by an articulator, but are necessary to create a more comprehensive virtual model of the patient. The inefficiency of film development and duplication, along with its expense, has been a barrier to making photography a standard of the laboratory information gathered by the dentist.

Digital photography has removed that barrier. Now, capturing images and their duplication is much more efficient and easy to assemble for transfer to the laboratory technician, adding useful information that can be referenced for patient modeling perspectives.

Having a more comprehensive visual representation of a patient is a desirable objective because it facilitates the creation of prosthetic work that more concisely blends with the biology and esthetics of the living patient, as opposed to only information obtained from stone models and lab prescription. In conversing with dentists or specialists, the Achilles heel of their practice is the dental laboratory's

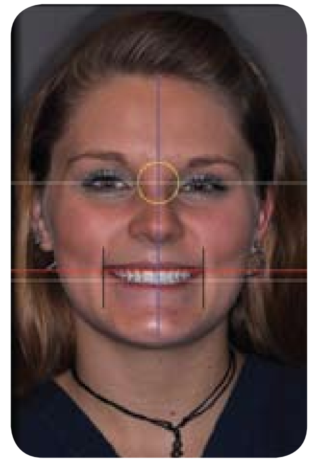


FIGURE 1. Average smile line is equivalent to the labial movement revealing 75 percent to 100 percent of the anterior teeth, as well as the interproximal gingival papilla. If the patient exposes the gingival margins during smiling, disappearing margins or metal margins on the buccal of the restoration might be disagreeable to the patient.

inability to consistently and accurately create a prosthesis or restoration that meets the patient's expectations. The information provided through photography can help the technician and dentist reach their mutual objectives more consistently by providing a common visual data, which aids the technician in visualizing how the stone model's anatomical and dentition landmarks correlate to the patient's facial anatomy during prosthetic fabrication.

Photography adds many of the skeletal and facial landmarks as they relate to the dentition's shape, shade, texture, and position, and has, up until now, been communicated with a facebow transfer, impressions, models, drawings, and written lab slips. Information regarding soft tissue and skeletal asymmetries, fullness of lips, along with the general landscape appearance of teeth was left to the lab technician's interpretation of the lab slip, which depends on his or her mental perception.

This article will utilize a series of 17 images that can easily be captured preceding patient treatment by utilizing a clinical digital camera, and will demonstrate the information that can be interpreted from these clinical photos. The dentist and lab team should identify the needed photographic information and the most beneficial series of images routinely needed by the laboratory. Another factor that should be anticipated is whether a lab will be viewing the images on a computer monitor or print medium as this will influence the reliability of factors such as color and the general appearance of the images. The topic of color calibration will not be covered in this article.

The author will demonstrate that having clinical photos of a patient will communicate a more complete virtual patient model, showing key prosthetic facial and dental landmarks for the dental technician to analyze in creating a beautiful smile, improving biologic compatibility, and enhancing functional results.

A situation that might be analogous to using an articulator alone for the construction of prosthetic dental restorations will first be examined. There are three analogous parties: the homeowner (patient), the architect (dentist), and the builder (laboratory). Now, imagine trying to build a house remotely for an empty lot with only written information about the location landscape, slope, neighborhood, or style of house.

> **HAVING A MORE** comprehensive perspective and a more accurate visual model of the construction site will usually result in more consistent quality results.

The builder followed exactly what was on the architect's plans. The house is delivered to the property on time, as promised, only to find it was a great disappointment. The floors were not level, the framework was not quite right, and the style was not in harmony with adjacent properties. Now, the builder is responsible for redesigning the house to perfection. Had the architect conveyed what he wanted using digital photographs showing ground and aerial views of the neighborhood, adjacent properties, lot size, elevations, and street views, the final outcome would have been much different.

Again, as it is illustrated, having a more comprehensive perspective and a more accurate visual model of the construction site will usually result in more consistent quality results.

This sequence of 17 digital photographs reflects how sophisticated dentistry has become. By utilizing digital photography, the dental professional and the dental laboratory can bring the pieces of the esthetic patient puzzle together to create an exceptional prosthetic outcome.

Technical Analysis

This patient was selected because of her full complement of teeth and the symmetry of her face. Although a somewhat ideal subject is illustrated in these images, one can apply this analytical approach of facial geometry to less ideal arch forms and any combination of missing or restored teeth. The review of useful clinical photographic information utilized by laboratories covers multiple areas of interest such as shade, tooth morphology, facial symmetry, bite relations, aging of teeth, and attrition.

For brevity and focus, this article will limit itself to the discussion of facial and dental analysis that a dental technician can find useful for evaluation during the fabrication of prosthetic restorations. Shade evaluation will not be addressed.

Smile Line

The first step in the evaluation of this photo group is to evaluate the exposure of the anteriors during smiling as shown in **FIGURE 1**. One can evaluate the patient

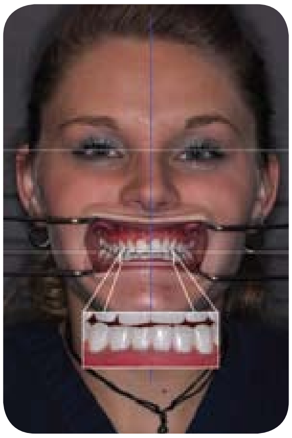


FIGURE 2. Clinical photography offers a wide array of views when cropping and expanding tools are used on the photo. The lower anteriors are viewed at close-up detail to examine line angles, texture, translucency, shape, and wear.

FIGURE 3. The buccal corridor refers to the dark or negative space visible during smile formation between the corners of the mouth and the buccal surfaces of the upper teeth (commissure). A prosthetic evaluation of the buccal corridor can play a role in the determination of including the first or second premolars in the treatment plan.

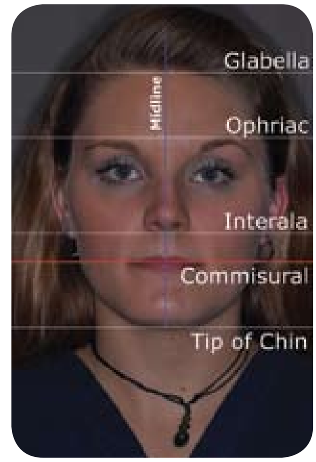


FIGURE 4. Measuring the face into three sections allows the technician to gain a general idea of facial horizontal harmony.

has an average smile line. Average smile line is equivalent to the labial movement revealing 75 percent to 100 percent of the anterior teeth, as well as the interproximal gingival papilla[2] (**FIGURES 1, 10, AND 11**).

The prosthetic observations determined from this patient information would allow the technician to understand the importance of establishing a correct gingival display and emergence profile as it relates to the patient's smile line. It must also be taken into consideration that it needs to be ideal, displayed or not. The material choice would also be a determining factor with a medium to high smile line, as well as margin prep design in order to hide metal show-through. For instance, if the patient has high smile line, consideration for the margin design could be a chamfer or shoulder margin, with material choice of 360-degree porcelain margin.

Smile Width

The smile width in **FIGURE 1** reveals the number of teeth exposed from anterior to posterior. In this patient, eight to 10 teeth are visible. Analysis of the smile width is a determining factor in the correct planning of both buccal preparation and the material choice for the restoration. If the patient exposes the gingival margins during smiling, disappearing margins or metal margins on the buccal of the restoration might be disagreeable to the patient.

Midline

The midline in **FIGURE 1** is drawn on the photograph from the center of the forehead through the tip of the nose and chin. When obvious asymmetries are present, it may be best to use the more reliable cuspid bow (filtrum) as a midline landmark. The interpapillary line is drawn through the center of the pupils and the intersection of where the two lines form a cross. The more centered and perpendicular the two lines, the more harmonious the facial geometry.

Incisal Horizontal Plane

In examining the IHP symmetry in **FIGURE 1**, the incisal plane (whether normal, flat, or reverse) can be observed in this view. Additionally, a prosthetic determination or evaluation can be made as to the length, incisal curvature, and horizontal symmetry of the anteriors. The material choice can be evaluated relative to the amount of wear that is revealed regardless of the etiology of the wear. If the etiology of the wear on the occlusal table is determined to be correctable through TMJ analysis, then more options for material choice could be made available.

Occlusal Plane

The occlusal plane in **FIGURE 2** is the horizontal evaluation of the maxillary occlusal surface as it relates to the ophriac or eyebrow line, the interpupillary line and commissural line. The occlusal plane is normally parallel or 10 percent divergent to "camper's plane."[3] To evaluate the occlusal plane geometric symmetry, the incisal edges of the central incisors, cuspids, and first molars are traced and evaluated for parallelism to the interpupillary line and commissural line.[4] The prosthetic intervention is aimed at realigning the occlusal, horizontal, and interpupillary plane to re-establishing a more harmonious smile.[5,6]

Commissural line (lips) is the horizontal line drawn from one corner of the mouth to the other. This line usually is parallel to the eyebrow line, (ophriac) IP line and the "O" plane.[7-10]

Buccal Corridor

The buccal corridor in **FIGURE 3** refers to the dark or negative space visible during smile formation between the corners of the mouth and the buccal surfaces of the upper teeth (commissure). Two aspects of smile esthetics are the buccal corridor width (the difference between the visible maxillary posterior dentition width and the inner lip commissure width); and the smile arch (the curvation of the maxillary teeth in relation to the curvature of the lower lips or tooth/lip arc difference).[11] The ideal arch form is broad and conforms to a "U" shape.

A narrow arch form causes the anterior teeth to appear too dominant,

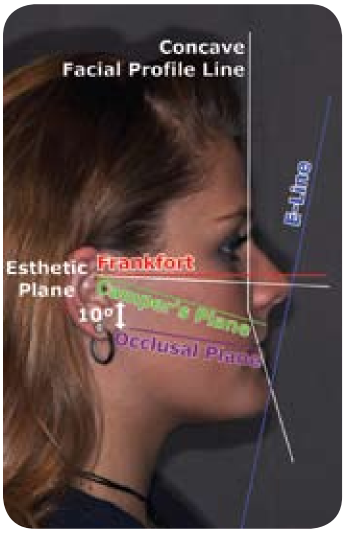


FIGURE 5. The facial profile line is evaluated by drawing a vertical line through the glabella, subnasal, and tip of the chin. This angle, when formed, designates either a convex, concave, or straight, normal facial profile. A normal facial profile is roughly 170 degrees. The Frankfort plane represents, by dentition, the horizontal plane, even if during clinical observation it is, in fact, parallel with the horizon only when the patient bends the head slightly forward.

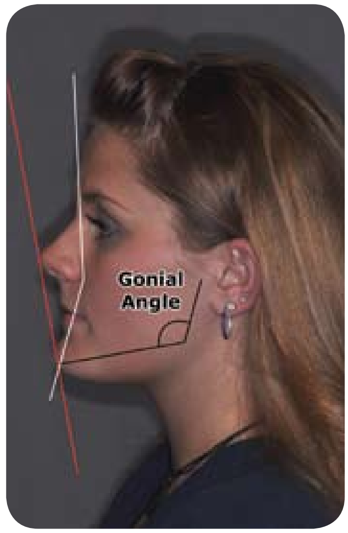


FIGURE 6A. This photo offers insight as to the skeletal classification of occlusion when restoring large edentulous areas as well as understanding wear patterns on the remaining teeth, thus resulting in tooth position for strength and restorative material choice.

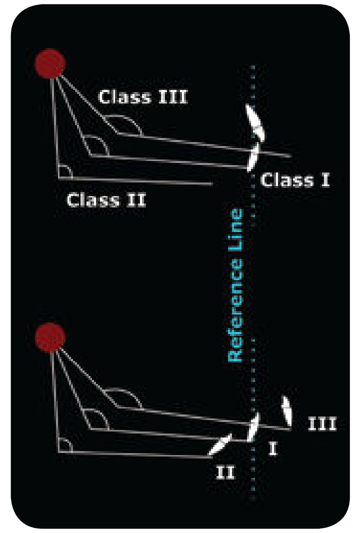


FIGURE 6B. In the Figure 6 profile photo, one can observe the patient has a larger gonial angle and the tendency will become more class III.

creating a negative space in the posterior. A prosthetic evaluation of the buccal corridor can play a role in the determination of including the first or second premolars in the treatment plan. Orthodontic treatment may be indicated if the buccal corridor is too narrow. In **FIGURE 3**, the lower lip smile line is evaluated to help establish the incisal smile line of the upper anterior teeth (**FIGURES 3 AND 4**).

Measuring the face into three sections allows the technician to gain a general idea of facial horizontal harmony. With the aforementioned facial landmarks, the face is divided into three vertical sections and measured for equality between sections from the hairline to the eyebrow to the interala to the chin, allowing evaluation of vertical and horizontal symmetry. If the horizontal lines are out of parallel with each other, the clinician might discuss with the patient the desired horizontal plane on which to build the occlusal plane.[12] Additionally, the use of a facebow will capture the current occlusal plane and will be validated by the digital photographs. The technician then has a visualization of the disharmony or relative harmony of the facial geometry versus the true occlusal plane.

Facial proportions in **FIGURE 4** are observed by dividing the face into three equal parts. If the lower one-third proportion is not equal to the middle third, the vertical dimension might be decreased or increased according to desired facial symmetry. The vertical position would be validated by reversible esthetic means, such as composite mock-ups, or a diagnostic wax-up that could be made into shelled-out acrylic temporaries to test new vertical dimensions.

E-Line — Facial Profile Line — Frankfort Line — Esthetic Plane — Camper's Plane

The E-line, not to be confused with the esthetic plane, helps the technician evaluate lip support and the classification of anterior occlusions such as overjet. The E-line is determined by the line that connects to the tip of the nose and to the tip of the chin. Normal upper lip profile to the E-line is about 4 mm posterior to the line, while the lower lip is about 2 mm posterior. According to Ricketts, the E-line measurement can be altered confidently by prosthetic treatment and care should be taken when restoring the anterior teeth.[13] At this point, the dental technician can verify the overjet, lip support, and labial inclination from the evaluation of the profile photographs in **FIGURES 5 AND 6** to be consistent with the dentist's diagnosis and treatment plan.

In **FIGURES 5 AND 6**, the facial profile line is evaluated by drawing a vertical line through the glabella, subnasal, and tip of the chin. This angle, when formed, designates either a convex, concave, or straight, normal facial profile. A normal facial profile is roughly 170 degrees.[14]

The Frankfort plane represents, by definition, the horizontal plane, even if clinical observation reveals it is, in fact, parallel with the horizon only when the patient tilts the head slightly forward.[15-17] Conversely, when the patient's head is held erect, with the eyes gazing toward the horizon, the Frankfort plane lifts upward at the front to form an angle of

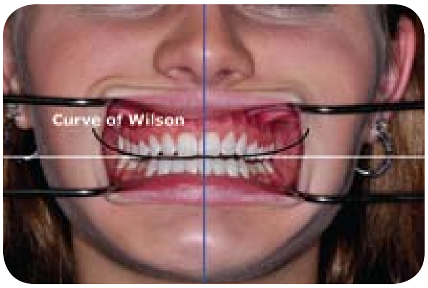


FIGURE 7. The lateral curve of Wilson and the curve of occlusion.

FIGURE 8. The curve of Spee and maximum intercuspation (MIP).

FIGURE 9. The curve of Spee.

FIGURES 10 AND 11. Emergence profile refers to the angle in which the tooth emerges from the gums. The technician must mimic the silhouette of the natural emergence of the tooth. The proper emergence profile will avoid swelling and inflammation.

FIGURE 12. The axial inclination of the anterior teeth should be a mirror image of the contralateral teeth, however, slight deviations in the same teeth may occur if kept harmonious.

about 8 degrees (although the angle could have considerable variation) with the arbitrary horizontal plane that is commonly referred to as the esthetic plane.[15-18]

The esthetic plane helps the technician articulate the upper cast on a fully adjustable articulator in the correct superior vertical incline.

The camper's plane, a line drawn from the inferior border of the ala to the tragus, can simulate the upper occlusal plane with a difference of 10 degrees between the camper's plane and occlusal plane at the distal aspect of the lines.[19] These prosthetic measurements relate to prosthetic considerations, whether a denture, partial or a full-mouth rehabilitation case, can be helpful in determining the articulation and occlusal plane angle, which in turn sets up the rest of the occlusal considerations such as curve of Spee and curve of Wilson.

Gonial Angle

In the **FIGURE 6A** profile photo, one can observe the patient has a significantly large gonial angle and the tendency will become more class III.[20] This gives the technician insight to the skeletal classification of occlusion when restoring large edentulous areas as well as understanding wear patterns on the remaining teeth, thus resulting in tooth position for strength and restorative material choice[21] (**FIGURE 6B**).

Curve of Wilson/Curve of Spee

In **FIGURES 7-9**, the views demonstrate the curve of Wilson, curve of Spee, maximum intercuspation, and curve of occlusion.

The lateral curve of Wilson of the occlusal table is formed by the lingual inclination of the posterior teeth because the lingual cusps are lower than the buccal cusps, they form a curve with their antimeres.[22]

The curve of Spee, as described by Von Spee, starts at the tips of the mandibular cuspids and follows the buccal cusps of the natural premolars and molars, and continues to the anterior border of the ramus.

The curve of occlusion is the occlusal surface that makes simultaneous contact with the major portion of the incisal and occlusal prominences of the existing teeth.

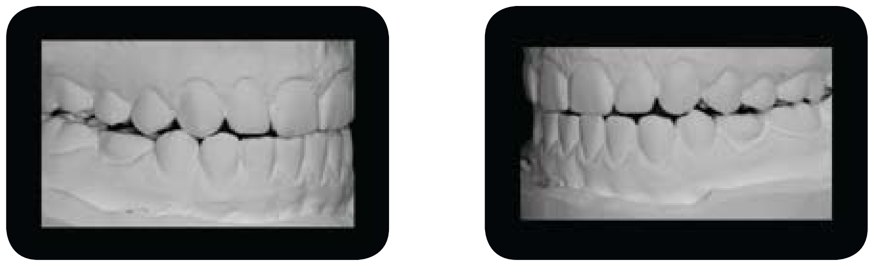
Maximum intercuspation, MIP, refers to the occlusal position of the mandible in which the cusps of the teeth of both arches fully interposition themselves with the cusps of the opposing teeth. All of the observations made from **FIGURES 7-9** play an important role in orthodontic and prosthetic rehabilitation, and from a technical point of view are used to determine esthetics, tooth morphology, and function.

Emergence Profile

Emergence profile refers to the angle in which the tooth emerges from the gums. The technician must mimic the silhouette of the natural emergence of the tooth. The proper emergence profile will avoid swelling and inflammation. This is particularly important when restoring implant restorations as shown in **FIGURES 7-11**, relating to the mind's eye of a harmonious emergence profile.

FIGURE 13. According to these measurements, the central should be 60 percent wider than the lateral, and, in turn, the lateral should be 60 percent greater than the cuspid that is in frontal view.

FIGURES 14A AND 15A. Eccentric movements are validated by these types of digital photographs, technically to assure the pass through wear facets are present on the teeth.



FIGURES 14B AND 15B. Regardless of the etiology of the wear patterns, the technician will take great care to replicate what has occurred in the patient's mouth.

Gingival Harmony/Axial Inclination/ Golden Proportions

The overall esthetic evaluation by the clinician and patient are determined by the harmonious covering of the neck of the teeth by the gingival tissue. Ideally, the gingival margins should be kept parallel to the horizontal reference point aforementioned in this article (the interpapillary and commissural line). They should be a scalloped design and drawn apically down into the zeniths of the prospective anterior teeth. The zenith point of a tooth is the tallest point spanning vertically.

The gingival margins of the maxillary central incisors and the canines should be symmetric and in a more apical position compared to those of the maxillary lateral incisors.[23]

When considering the tissue sculpture and emergence profile in an implant case, the dental technician can trace the proper gingival outline on the digital photograph and prepare the soft tissue replica by the sculpturing of the sulcus on a stone model with a red stripe football diamond bur. Consequently, the gingival zenith will be in harmony with the contralateral side for optimum esthetic desires.

The Axial Inclination

The axial inclination of the anterior teeth, compared to the midline, should have a slight incisal mesioinclination and a slight apical distoinclination.[24,25] The axial inclination of the anterior teeth should be a mirror image of the contralateral teeth, however slight deviations in the same teeth may occur if kept harmonious. Angles contribute strongly to the fabrication of the prosthetic crown as it relates to lines, angles, and gingival zenith (**FIGURE 12**).

The Golden Proportion

The Golden Proportion measurements are widely used to develop a pleasing restoration to the mind's eye. The Golden Proportion is used by artists, mathematicians, and architects; but it was not until 1973 that Lombardi introduced into dentistry the application of the Golden Proportion, which was further developed by Levin in 1978.[26,27] The Golden Proportion states that the ratio between the width of the lateral incisor and the central incisor should be 1:1.618, while the optimal ratio between the width of the lateral incisor and the cuspid is 1:0.618 (**FIGURE 13**). According to these measurements, the central should be 60 percent wider than the lateral, and, in turn, the lateral should be 60 percent greater than the cuspid that is in frontal view.[28] Individual tooth length to width ratios such as a 75-80 percent length of the tooth to the width of the tooth ratio has been shown to create the most esthetically pleasing guide by which sizes of teeth can be extrapolated.

Eccentric Movements

Eccentric movements are validated by these types of digital photographs technically to assure the pass through wear facets are present on the teeth. Anterior guidance can be evaluated on the casts as the technician replicates the patient's muscular eccentric movements (**FIGURES 14A AND 15A**).

By observing the wear and eccentric movements, the technician could better understand the etiology of the oral environment. From MIP to eccentric movements, the technical analysis will help create the replication of nature, while revealing the pinnacle of dentistry, when man-made material disappears into nature, emulating both function and invisible beauty (**FIGURES 14B AND 15B**).

Occlusal Patterns

The occlusal patterns and ridge groove direction, as well as occlusal layering and staining are present in these photos. Arch form as aforementioned can also be evaluated on **FIGURES 16 AND 17.** Circular anatomy, incisal embrasures, and proximal contacts are easily distinguished from this digital photograph.

FIGURES 16 AND 17. The occlusal patterns and ridge grove direction, as well as occlusal layering and staining, are present in these photos.

FIGURE 18. The photograph communicates the patient's exact crown shade.

FIGURE 19. If done incorrectly, light will refract off the matching shade, thus, giving false shade information.

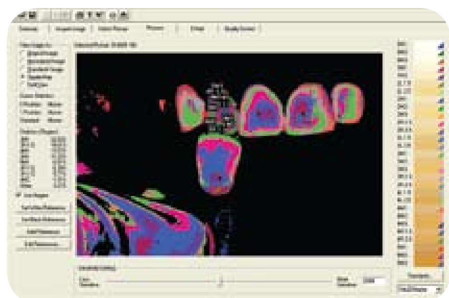


FIGURE 20. When the information is input into the computer, a patient-specific shade map will be created.

FIGURE 21. When crown shading is matched to perfection, the result will be perfect natural coloring that is difficult to set apart.

Without these visualizations, accurate fabrication could not be easily achieved.

Shading

With an absolute black and absolute white tab, 30-degree angled photos, and a matching shade tab, a dentist can easily communicate with the lab to have the patient's crown shaded perfectly (**FIGURE 18**). The matching shade tabs that closely represent the patient's shade should be photographed along with several 30-degree angled shots. These 30-degree shots must be angled to eliminate all light refractions in order to obtain the tooth's entire shade surface. If this is not done when inputting the shade information into the computer, there will be a void where the light was refracted, thus giving false shade or no shade at all (**FIGURE 19**).

The lab then inputs the information into the computer and prints out a unique shade map specific to only one patient (**FIGURE 20**). By using digital photographs for shading information, a common visual data could be used to verify the exact shade required for the final result, eliminating shading errors, which in turn results in excellent patient satisfaction (**FIGURE 21**).

Conclusion

Digital photography adds an efficient, new dimension to laboratory information. Photography brings the mounting of laboratory cases closer to the visualization of the actual patient. When a series of analytical views are taken and placed in sequence, the clinician is providing a set of outstanding visuals that allows the technician or artisan to validate their articulated model mountings and comprehend landmarks that before were absent from the process of prosthetic fabrication.

With more information leading to greater precision, a technician can showcase his or her technical skills and become totally immersed in the patient's desired restorative outcome. Photography can turn plaster models into a human being that a lab technician can connect to as a case is being fabricated. As visual information becomes more robust with future breakthroughs in technology, the ability to virtually simulate the living being will facilitate more functionally beautiful lifelike results. ■■■■

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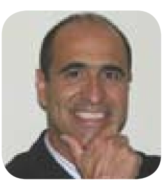
CDA JOURNAL, VOL 37, Nº3

Course Abstracts From the Upcoming *CDA Presents* in Anaheim

The following speakers will give presentations at the 2009 *CDA Presents The Art and Science of Dentistry* in Anaheim. For more information on the meeting, please visit cda.org/09.



Dr. Cardoza is a forensic dental consultant for San Diego and Imperial counties and the California Department of Justice. He is also the director of the California Dental Identification Team.

Ms. Willie is an administrator at the California Department of Justice.

Dr. Wood is a forensic dental consultant for several cities, counties, and the California Department of Justice.

Dr. Spencer is a forensic dental consultant to Alameda, Contra Costa, and San Mateo counties and the California Department of Justice.

The following lecture will be held at CDA Presents *on Friday, May 15, from 10 a.m. to 12:30 p.m. at the Anaheim Convention Center, Ballroom A. The lecture offers 2.5 C.E. units in Dental Board of California Category I.*

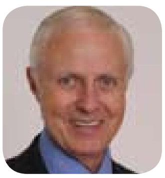
ANTHONY CARDOZA, DDS; DUANE SPENCER, DDS; JEANNINE WILLIE; JAMES WOOD, DDS

Forensic Dentistry — "CSI Anaheim" — Who Was This?

A hiker stumbles across skeletal remains in the desert. A woman walking her dog finds an unusual bone in its mouth. A house burns down when no one is home, but later firefighters discover a body. Who are these people? What happens when they can't be identified by conventional means? How can dentistry play a role in solving these mysteries?

This course will illustrate how dentistry can play a vital role in the identification of people when visual clues, fingerprints, and tattoos aren't sufficient. It will look at the routine and the truly bizarre cases. The challenges of cases where people cross state lines or appear from other countries will be discussed. Dental professionals will learn what they can do in their own practices to ensure that critical records are available to assist authorities when they are needed to make that ID.

This course will cover forensic dental identification by starting with the basics and using actual casework to illustrate the principles of forensic dentistry and working through more complex cases.



Dr. Christensen is the founder and director of Practical Clinical Courses, Provo, Utah, and dean of the Scottsdale Center for Dentistry.

The following lecture will be held at CDA Presents *on Thursday, May 14, from 9:30 a.m. to noon at the Anaheim Convention Center, Ballroom D. The lecture offers 2.5 C.E. units in Dental Board of California Category I.*

GORDON J. CHRISTENSEN, DDS, MSD, PHD

New Aspects of Dentistry — 2009

This presentation is designed to identify, discuss, and demonstrate several of the new and evolving concepts in the profession with emphasis on crowns, fixed prostheses, and the related techniques. The discussion will be directed toward the success of the new concepts relative to previously available products and concepts. Should dentists be incorporating them into their practices? Are they better than previously available materials, devices, and techniques? Topics include fixed prosthodontic advancements, all-ceramic crowns, the best cements, fiber-reinforced resin-base composite posts and cores, the most adequate build-up techniques, bonding build-up materials, and new concepts and differences in tooth preparations and impressions for metal, PFM, and all-ceramic crowns.

Upon completion, the participant will be able to identify, discuss, and demonstrate several new concepts in the profession. The participant will also have a thorough understanding of crowns, fixed prostheses, and related techniques, and be able to incorporate products and concepts into his or her practice.

Dr. Emmott has been a featured speaker at every ADA Technology Day.

Dr. Feuerstein is the technology editor of *Dental Economics* and an ADA Seminar Series speaker.

Dr. Flucke is the technology editor for *Dental Practice Report* magazine and chairman of the Missouri State Peer Review Committee.

Dr. Goldstein is known for his frequent clinical articles featured in *Dentistry Today* and for his expertise in dental digital photography.

Dr. Jablow is president of Dental Technology Solutions

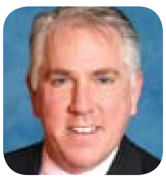
Dr. Miles is an adjunct professor at the Arizona School of Dentistry and Oral Health and the University of Texas.

The following workshop will be held at CDA Presents *on Friday, May 15, from 8 to 11 a.m. and continue from 1 to 4 p.m. at the Anaheim Convention Center, Room 304 A/B. The workshop offers 6.0 total C.E. units, 3.0 each for Dental Board of California Categories I and II.*

LAWRENCE F. EMMOTT, DDS; PAUL H. FEUERSTEIN, DMD; JOHN C. FLUCKE, DDS; MARTIN B. GOLDSTEIN, DMD; MARTIN J. JABLOW, DMD, FAGD; DALE A. MILES, BA, DDS, MS

Friday Technology Day: New Technology Advances in Dentistry

Technology has become an important part of dental practices during the past few years, but there are a number of confusing options. This technology roundtable puts dentistry's leading technology experts at the disposal of attendees. Six tables will be set up for this limited-attendance event, which will allow participants to sit with each of the six presenters throughout the day, listen to a short presentation on the expert's topic, and finish with a discussion at the table. Dental professionals are encouraged to bring their tough questions because there will be an expert in the room who will send them home with the answer. Topics include treatment room setup, paperless strategies, the latest high-tech products, conebeam CT diagnosis and treatment planning, digital photography, and Internet/Web processes that can be integrated into a dental practice.



Mr. Hargett is an internationally recognized presenter for the Ritz-Carlton Leadership Center.

The following lecture will be held at CDA Presents *on Friday, May 15, from 10 a.m. to noon at the Anaheim Convention Center, Room 204 A.*

JEFF HARGETT

Legendary Service at the Ritz Carlton

Creating legendary service begins with a strong, sturdy foundation that includes the mission, vision, and standards of the organization; the selection and teaching of talent; creating loyalty, not just satisfaction, among its customers; and empowering staff to create exceptional memories. This course gives an inside look at one of the world's most recognized hospitality brands.

Many organizations believe it takes large amounts of time and money along with grand gestures to create a legendary level of service. Legendary service can begin by simply opening one's eyes, ears, and hearts to the opportunities that make a difference. At the Ritz-Carlton, the ladies and gentlemen of the staff are empowered to bring together the Ritz-Carlton's standards of service and their own desire for excellence to create experiences known the world over as legendary.

Dr. Hawkins is the director for the CDE IV program at the Faculty of Medicine and Dentistry at the University of Alberta.

The following lecture will be held at CDA Presents *on Thursday, May 14, from 9:30 to noon and continue from 1:30 to 4 p.m. at the Anaheim Convention Center, Ballroom B. Each section of the lecture offers 2.5 C.E. units in Dental Board of California Category I.*

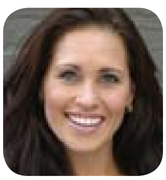
J. MEL HAWKINS, DDS

Local Anesthesia: 35 Years of Hits, Near Misses, and Misses

This presentation will discuss the reasons for lack of effective anesthesia with an emphasis on mandibular technique. The neuro-anatomy and histology of the pterygomandibular triangle will be reviewed to help attendees understand the complexities of the conventional inferior alveolar block and its associated lingual and buccal nerve blocks. This is essential in the development of a logical approach to needle placement. This concept can help to ensure the successful application of clinical pharmacology and anatomy.

Local anesthesi, will be examined. Safety, dosages, and toxicity of the different agents — including case reports and morbidity/mortality — are also presented, along with some of Dr. Hawkins' private practice experience.

After a thorough review of the pros and cons of the conventional inferior alveolar block, the Akinosi and Gow-Gates mandibular blocks will be discussed and then amalgamated in a "mixed," or hybrid, approach. Information on multitasking supplementation with infiltrative and advanced techniques will be combined with other "tips and tricks."



Dr. Odiatu is a practicing dentist and an instructor at the University of Toronto. Ms. Odiatu is a certified trainer and a Ms. Fitness Universe.

The following lecture will be held at CDA Presents *on Friday, May 15, from 9:30 a.m. to noon at the Anaheim Convention Center, Ballroom C.*

UCHE ODIATU, BA, DMD; KARY ODIATU, BPE, BED

Creating Balance: At Work, Rest, and Play

Everyone seems to be searching for life balance these days. But is it possible? A dental career is demanding: challenging patients, difficult team members, ordering supplies, staying on top of technology, and professional development credits. Also vying for a dentist's time are children, favorite shows on TV, e-mails, maybe the daily newspaper.

But who has time these days to relax with the TV or the newspaper when the Fed Ex driver is at the door, and the BlackBerry is vibrating in the gym bag? The human body is well-adapted to taking care of short-lived emergencies and occasional stresses. But if stress is ongoing or prolonged, the body and mind are adversely affected. What happens may or may not be surprising: poor digestion, hampered immune functioning, weight gain, accelerated aging, memory issues, emotional imbalance, chronic physical complaints, and fatigue.

In this new and insightful session, attendees will receive a toolbox of strategies to manage the pressures of working in the demanding health care field. There are key foods to eat, specific exercises to perform at work and in the gym, important ways to alter breathing, and of course cognitive restructuring or new ways to look at work, rest, and play.

Dr. Swift is professor and chair of the Department of Operative Dentistry at the University of North Carolina.

The following lecture will be held at CDA Presents *on Saturday, May 16, from 10 a.m. to 12:30 p.m. and from 2 to 4:30 p.m. at the Anaheim Convention Center, Ballroom D. The lecture offers 2.5 C.E. units in Dental Board of California Category I.*

EDWARD J. SWIFT, JR., DMD, MS

Untangling the Confusion of Today's Restorative Materials

The development of new materials for restorative and esthetic dentistry continues to proceed at a rapid pace. Unfortunately, development can proceed so rapidly that many clinicians are left confused by the wealth of new products that is available for various procedures. This course will present the latest information available on current dentin/enamel adhesives, composite resin restorative materials, and visible light-curing technology. Proper use of these materials is critical to the success of routine direct and indirect restorations and esthetic cases. The information provided will be based on scientific evidence, but the practical clinical application of all materials will be emphasized. The primary aim of the presentation is to eliminate confusion so that the practitioner can make informed choices when selecting materials for use in the practice.

Dr. West is an affiliate associate professor at the University of Washington.

The following lecture will be held at CDA Presents *on Friday, May 15, from 9 to 11:30 a.m. and continues from 2 to 4:30 p.m. at the Anaheim Hilton Hotel, Room California C. Each section of the lecture offers 2.5 C.E. units in Dental Board of California Category 1.*

JOHN D. WEST, DDS, MSD

21st Century Endodontics: "Are You Ready?"

This program will give practitioners the tools they need to predictably and consistently produce successful endodontic results. They will gain proficiency that will enable them to approach endodontic treatment with ease and confidence rather than concern or fear. This course will teach the three essential skills that will immediately affect endodontic results. After taking this course, attendees' results will be characterized by a newfound competence, confidence, and consistency. By teaching intentional outcomes and simple ways to measure results, this lecture will show dentists how to put the fun back into endodontics.

Nature has been trying to tell dentists for years how to perform masterful endodontics. Now it is time to listen. Endodontics is one discipline that can positively influence a practice's bottom line and be a solid part of making a practice recession-proof. Patients know when the dentist knows what he or she is doing. In this course, attendees will learn how to do endodontics the right way.

CDA JOURNAL, VOL 37, Nº3

Personal Trainers

I was lucky. I got my own personal trainer along with my marriage license.

Robert E. Horseman, DDS

ILLUSTRATION BY CHARLIE O. HAYWARD

Training is everything; the peach was once a bitter almond; cauliflower is nothing but cabbage with a college education.
—*Mark Twain*

In the overwrought world of celebrities or wannabe celebrities, no member of their entourage is more important than the personal trainer. Sure, the financial manager is essential to negotiate the $7 million real estate flips and to minimize the damage to the exchequer done by serial monogamy and common-law cohabitation katzenjammers, but it is up to the personal trainer to tackle the cottage cheese cellulite and deficient washboard abs.

It wasn't until the advent of low-rider pants previously worn only by plumbers that the abdominal musculature became of such transcendent importance. Now that talent is not a requisite, these are the physical attributes that make or break you after the plastic surgeons are finished.

PTs frequently have an Olympian status exceeding that of their clients, making house calls as dear as the monthly payments on the Bentley. Obviously, celebrities can't go to fitness centers and YMCAs and perspire with the hoi polloi. One might as well be clad in Wal-Mart sweats. Today it would not be unusual to observe a large number of persons in the form of personal trainers, nutritionists, secretaries, press reps, and brokers to arrive like a SWAT team at even a D-list celeb's front door along with the paparazzi to make certain no triviality is overlooked.

I was lucky. I got my own personal trainer along with my marriage license, although having lapsed into a catatonic silence shortly after the vows, I didn't realize it at the time. Looking back over the last 62 years, I have come to realize what every woman contemplating saying "I do" questions instinctively at the outset, "Is he trainable?"

Men are not so introspective. I saw my future wife at the beach. She was wearing

CONTINUES ON 225

DR. BOB, CONTINUED FROM 226

a one-piece black bathing suit. I remembered my father's advice, "Check out her mother — it's a preview." I did; was more than satisfied, and four months later we were man, wife and personal trainer.

I had enjoyed a three-year perpetual training exercise in the Marine Corps during WWII, so my wife concluded that, at the very least, I could make a bed, and might, with a little additional brush up, hang up my own clothes. Embracing the personal trainer motto — "So much to do, so little time" — she fell to with a will.

Prepare a hearty breakfast for a man and he's good at least until lunch. Teach him to make his own breakfast and you can sleep in until 10. Given free reign, no rational woman would consider the former after the honeymoon has worn off. In my wife's case, the arrival of three offspring, necessarily postponed her 10 a.m. arising plan for a decade, but training has many facets beyond the obvious toilet seat position. Thus, in time, I was able to pass proficiency tests in diaper changing, bottle preparation at 2 a.m., and to learn the consequences of forgetting birthdays and anniversaries.

I had received my driver's license on my 16th birthday 10 minutes after the DMV opened. For 11 years I negotiated parking places, avoided parked cars, pedestrians, and stray animals all without further training. I had no idea what hazards were out there until my wife, as required by her training obligations, patiently pointed them out to me. For the last 62 years, thanks to her better perspective from the passenger seat (both front and back), I have been able to negotiate parking places, avoid parked cars, pedestrians, and stray animals without mishap.

My personal trainer has been successful instructing me in the art of ironing my own shirts and shopping for groceries using the secretive scanning methods known only to other women. I can squeeze, shake, thump, smell, detect expiry dates, calories per serving, compare generic with brand and spend inordinate amounts of time looking for unheard of items in the feminine hygiene section without being questioned by the management.

That's not to say I have learned it all. Coupons, for example. I would rather be savaged by fire ants than break out a sheaf of coupons at the checkout counter. I still roam the aisles for hours myopically looking for something rather than ask a knowledgeable employee, even if I could find one. I am a work in progress.

After buying at my bride's insistence one of those weird Dyson vacuum cleaners that turned out to be so heavy she couldn't push it, let alone lift it, I learned the fine art of vacuuming. She read me the manual. I am now proficient in the use of 10 accessories and acknowledge the necessity of periodic maintenance. I have mastered the care and maintenance of the coffeemaker and can sometimes detect when things need dusting without detailed written instructions.

With divorce rates averaging better than 50 percent, it becomes painfully obvious that many males are running the risk of failing to become all they can be. Even the U.S. Army is offering to help. That's why many mothers are so happy to see their sons off and married. With the new trainer at the helm, she can, at last, snooze until 10.

Next month I am scheduled to learn why there is a right and wrong way to assign dirty laundry to the Maytag. Who knew? So much to learn, so little time. ■■■■