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Filmless Radiology
The Microscope
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EMERGING TECHNOLOGY

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DEPARTMENTS

FEATURES

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Watching YOUR Cost of Doing Business

Jack F. Conley, DDS

The 1998 American Dental Association House of Delegates (HOD) left this long-time observer of ADA programs and services with some decidedly positive impressions.

The House of Delegates decision-making process has always been democratic and thorough in its efforts to address the needs and wants of the majority of the approximately 107,000 active dues paying members. None the less, over the years there have been instances where California delegates have questioned whether the design and costs of ADA programs approved by the HOD have effectively met the needs and program preferences of California members. It isn't difficult to conclude that the needs of a California Dental Association member in Los Angeles are significantly different than those of a member of organized dentistry in rural Maine or in any of the many vastly different environs that comprise this country. We are learning that the needs and preferences of dentists from the many ethnic origins that populate California may make it difficult for CDA or a component society to make decisions about programs and services for members that are acceptable to the majority of their respective membership bases as we move ever closer to the end of the twentieth century.

Thus, it is easy to recognize that a national organization formed to represent and serve the interests of a unified profession that is becoming increasingly divergent in its demographic composition, will face increasing difficulty in meeting its goals unless it is able to successfully readjust its traditional mode of operation. In recent years, California delegates have been concerned about some ADA HOD proposals that have added to an increasing tripartite membership dues total. These programs were perceived to not have the same value here as they purportedly had in other districts of the American Dental Association.

The potential for a significant increase in ADA dues this year was particularly worrisome to CDA delegates as they convened in San Francisco for the 1998 HOD. As most colleagues who read this know, the 1997 ADA HOD had directed that the American Dental Association undertake extensive efforts this past year to educate the membership to the purpose, goals, content, and cost of a proposed ADA National Public Awareness Campaign. If the proposal was approved this year, a dues increase of $304 per year per member for three years was expected.

In addition, increases in dues to build up the financial reserves of the ADA, and to cover renovations to the Chicago headquarters building had been expected to add another $80 to the 1999 dues bill. Also, it has been customary at each recent ADA HOD meeting to add the cost of all approved programs at the current session to the dues base which was established the previous year and has been used to frame the projected budget for the coming year. It was therefore anticipated that proceedings at the 1998 HOD could add as much as $400 plus the costs of any other new program or task approved by the HOD. As a matter of record, the 1998 HOD approved new or continuing programs with a total cost anticipated to be slightly in excess of $1.8 million for 1999.

Given the knowledge that CDA and some component dental societies had proposals that could also increase

the tripartite dues package, California delegates were even more sensitive to economic issues than in the recent past. A recent ADA random membership survey on the impact of the $300 tab for the Public Awareness Campaign left little doubt that membership losses to CDA and its component societies could be significant if that campaign was approved. The stage was set for lively debate on the one hundred plus resolutions before the HOD, the most significant ones having been identified above.

Reference committee testimony prior to the first HOD business session conveyed a clear message that many members across the country believe that the profession must undertake continuous efforts to strengthen its public image in the effort to increase dental awareness and demand for care. Increasingly, member dentists believe that any public awareness activity should be a function of their membership dues, which led 1998-99 ADA President Timothy Rose to comment during his address to the HOD that the ADA dues should really be considered "...a cost of doing business." rather than membership dues.

Given the strong member preference for the public awareness campaign and the recommendations from the ADA Board of Trustees that favored the strengthening of association reserves and the renovation of the headquarters building, it is remarkable that the 1998 House of Delegates was able to minimize dues increases for 1999 and 2000, thus keeping "your costs of doing business" under reasonable control.

The HOD did not reject public awareness activity, preferring a more conservative, gradual approach to implementation of materials developed to date in five states in the coming year. It will also allow for some development of new materials and their associated cost. Most important, it will enable evaluation and further development of the program components in order that the programs can be kept vital and relevant in the states in which they will operate.

We believe it is important to the future health of the American Dental Association that programs are designed for implementation in states where they are needed and wanted, rather than on the massive global basis on which the public awareness program was originally designed. This method of implementation or adoption of new programs, should be of significant merit to the profession. Given the fact that it is difficult to design association-wide programs that will meet the special needs of every state or group within the ADA membership, core programs initiated by the ADA can be customized by the individual constituencies at their expense, to meet their particular needs.

The major cost of the program will be borne by those who will use it and modify it to their specific use. The basic costs of this program and all of the remaining programs, reports, or services approved or requested by the 1998 HOD amounted to a more modest ADA dues increase of $17 in 1999. Other examples of the cost consciousness of the 1998 HOD were actions reducing the level of association reserves from the 45% recommended by an independent study, to "a goal of 30%," and the denial of the funding request for the headquarters renovation.

Finally, the HOD took the unprecedented action of reducing the budget figure used for calculating ADA dues for the year 2000 to $343, demonstrating again during this session, its intent on keeping spending under control, keeping dues and services they fund attractive to the membership. The future of the profession, based upon these proceedings could not be projected to be more positive. The process of deliberation, while democratic, was not constrained by tradition, and was guided for the first time by the recognition that needs and preferences differed in the states and districts that make up the ADA. The decisions of the 1998 HOD were more equitable to all individual constituencies than they had been in the recent past.

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New Treatments Hold Perio Promise

By David G. Jones

Bacteria lurking below gumline and creating havoc for periodontal health soon may be consigned to the microbial scrap heap, because dentists have some new, more potent weapons to battle periodontitis.

Three recently adjunctive treatments recently approved by the Food and Drug Administration hold promise for interceding against the condition which affects about 20 million Americans.

Periostat, Atridox, and PerioChip are now part of the arsenal in the fight against gum- and bone-destroying bacteria and its after-effects. The therapies, considered an adjunct to scaling and root planing, appear on the market during a surge of interest in suspected links between periodontal disease and increased risk of heart attack and stroke.

"We're going to discover more relationships between oral and systemic disease," says Dr. Daniel M. Meyer, associate executive director of Science for ADA. "So this is one of many things to come down the pike to address that."

Two of the new treatments, PerioChip and Atridox, work by delivering anti-microbials to the patient's periodontal pocket. Periostat works by blocking the body's natural response to periodontal disease, resulting in oral tissue destruction.

Dentists can prescribe Periostat in pill form as the first drug approved to treat the body's response to gum disease, rather than directly fighting the bacteria that has already accumulated on teeth. The pill, developed by Collagenex Pharmaceuticals, Inc., of Newton, Pa., contains a low dose of the antibiotic doxycycline hyclate, which blocks the body's natural response to periodontitis. Periostat works by suppressing the bone-destroying enzyme collagenase, produced by the body in response to oral bacterial infection. Collagenase fights the infection, but also breaks down collagen, a protein found in healthy teeth and gums.

Atridox is a site-specific anti-microbial delivery system intended for use in the non-surgical treatment of chronic adult periodontitis. Developed by Atrix Laboratories, of Fort Collins, Colo., Atridox involves applying high doses of doxycycline directly into periodontal pockets. It then forms a gel that solidifies in the pocket's shape, releasing the antibiotic during a weeklong period as it is absorbed.

PerioChip, which like Atridox is biodegradable, is manufactured by Astra Pharmaceutical in Westborough, Mass. It is a firm gelatinous strip soaked with the antibiotic chlorhexidine and placed directly into periodontal pockets greater than 5mm deep. The strip dissolves in about a week while it administers the antibiotic.

Meyer stresses that dentists want more detailed studies of the drug's long-term effects, and patients must still properly brush and floss to help fight the bacteria that cause gum disease.

"But," he adds, "these new treatments have the promise of slowing down the disease."

Gerald J. Pieroni, DDS, president of the California Society of Periodontists, says the products would be appropriate for certain uses, but may have some limitations.

"For instance, these products are basically the second or third generation of anti-microbials delivered in pocket settings, or in the case of Periostat, in pill form," he says. "Studies that came out during the first six months of use of the previous generation of products was very favorable, but after the first year the majority of the cases returned to or near their original preoperative condition."

Pieroni also says fair assessment of the new products can be made only after a track record is established during a year or two of their use.

Steven G. Detsch, DDS, a periodontist and chairman of CDA's Council on Research and Developments, says that while the antibiotic effects of the newly approved treatments is well-documented, there is a downside.

"Over time, because of the increasing use of antibiotics, some pathogens have become resistant to tetracycline and its derivatives," he says. "The anti-collagenase effect (in Periostat) will always be present, but you stand the chance of developing 'superbugs.' This is like any other tool – in the right hands it is great. With the wrong bug in the wrong place, though, it can cause problems."

Detsch says dentists don't normally do microbial testing, so general practitioners may not be able to do a culture insensitivity test every time they use the doxycycline on patients.

But he adds that "there will be cases where its use would be indicated where other forms of standard therapy were not effective."

Pieroni says dentists contemplating use of the new products should provide full disclosure of additional therapeutic needs to the patient and to weigh expected results against the limitations.

"We would just want anyone considering their use to realize they may not be a panacea," he says.

In Search of Cyber-Snickers

Dentists always need the facts, but sometimes they just want to have fun.

And just as many web sites offer important information about dentistry, some also offer a bit of humor. The following sites address the lighter side of the profession:

- The "Virtual" Dental Center at www-sci.lib.uci.edu/HSG/Dental.html has

oodles of links to a variety of dental sites with an odd assortment of unrelated links thrown in. One can find just about anything there, from dental literature search engines to the current time in Singapore.

- For a good listing of dental resources and news groups for dentists, check out indy.radiology.uiowa.edu/Beyond/Dentistry/boards.html.
- Dental Cyberweb at www.vv.com/dental-web offers original articles, case studies and newsletters for dental professionals as well as virtual education opportunities and links to other dentistry-related sites. While there, be sure to visit tales from the dental crypt.
- Good (to some) jokes can be found at Entertainment at gbsystems.com/ingles.htm. That site also features scientific articles, classified ads and information about dental associations. Much of the information is in Spanish.

Other sites that offer general information for dentists and also have a substantial number of links include www.dental-resources.com, a service of Proctor & Gamble, and www.dentalsite.com/dentists/.

(Mention of a web site does not imply endorsement by the Journal of the California Dental Association. All of the web addresses listed were active and accurate at the time of publication. However, because of technical considerations and other factors, links may change.)

Young Drinkers May be in Your Chair

The use of alcohol is so pervasive in society that attention to its use by young people has not drawn attention comparable to that given to smoking, except possibly when a college student dies during a fraternity hazing, writes H. Barry Waldman, DDS, in the May-June issue of the Journal of Dentistry for Children.

Trying to "fit in" was the reason most often given by elementary schoolchildren to explain their use of drugs and binge drinking (five or more drinks in a row at least once in the past two weeks). According to Waldman, in 1996, by eighth grade, one of four children had used alcohol in the past month. Fifteen percent had binged.

Among family factors that lead to alcohol use by children, Waldman cites both poor family management practices – including failure to set clear expectations for behavior, lax monitoring of children and excessively severe and inconsistent discipline – and low bonding to family. Drinking by parents also has been linked to an earlier age of alcohol drinking by children.

How does all this relate to pediatric dentistry? Waldman reports that 5.9 million 12- to 17-year-olds indicate they are heavy alcohol drinkers. Many children in dental operatories may use alcohol, Waldman notes, and may have been drunk the previous night and may still have a hangover.

Pediatric dentists must extend patients' medical and family history review formats by taking into consideration the changing environment within which their young patients live. Alcohol now must be included in history reviews, he notes.

"We cannot assume that the 9- and 10-year-olds (and their parents 'in the best of families') are not heavy or binge alcohol drinkers," Waldman says.

Dental Personalities: It's No Contest

Researchers at the Creighton University School of Dentistry, in Omaha, Neb., have determined there is little difference between personality types of general dentists and dental specialists, according to a study published in the Journal of the American Dental Association.

The researchers analyzed surveys completed by 472 dentists who graduated from the Creighton University School of Dentistry between 1964 and 1984. Researchers used the Myers-Briggs Type Indicator, a psychological measure designed to determine personality preferences, learning behavior and management styles to assist with career choices. Previous research using the MBTI on medical specialists found several correlations between personality types and choice of medical specialty career.

The researchers found that 23.4 percent of general dentists and 20.9 percent of specialists are most likely to fall into the ISTJ category – people who are introverts, sensing types, thinkers and judgers.

ISTJs also can be described as people who prefer to work alone and need quiet to concentrate; prefer established procedures and standard methods for resolutions, use logical analysis, are task-oriented and prefer to develop, schedule and implement plans.

The Creighton researchers also found that almost 14 percent of general dentists and 14.3 percent of specialists fit into the ESTJ category – extroverts, sensing types, thinkers and judgers.

The third most common category among general dentists and specialists is ISFJ, or introverts, sensing types, feelers and judgers. Researchers concluded that once an individual has selected dentistry as a career, personality characteristics are not a significant variable regarding the type of dentistry performed.

Say What?

Listening is a key element in communication and people skills, and most people listen to respond, not to understand.

According to an article in the October issue of the Journal of Dental Technology, a good listener hears not only the words, but also the pace and the tone of the conversation. Poor listening skills can

lead to misunderstandings, hurt feelings, arguments and problems in one's practice.

How good a listener are you? The following test might offer a clue. Answer each of the following questions by putting U for usually, S for sometimes, or SE for seldom ever.

- When you talk with another person, do you . . .

1. Look directly at the individual?
2. Watch the individual while listening?
3. Decide from the individual's appearance and delivery whether he has something important to say?
4. Listen primarily for ideas and underlying feeling?
5. Determine your own biases, if any, and try to allow for them?
6. Keep your mind on what the other person is saying?
7. Interrupt immediately if you hear a statement you feel is wrong or that you don't like?
8. Ensure that you've considered the other person's point of view before answering?
9. Try to have the last word?
10. Make a conscious effort to evaluate the logic and credibility of what you hear?
11. Ask questions after you have heard the other's point of view to show that you understand what they have said?

Your Scores:

On questions 1, 2, 4, 5, 6, 8, 10 and 11 give yourself:

- 10 points for each answer of Usually
- 5 points for each answer of Sometimes
- 0 points for each answer of Seldom Ever
- On questions 3, 7, and 9 give yourself: 10 points for each answer of Seldom Ever
- 5 points for each answer of Sometimes
- 0 points for each answer of Usually

- If your score is:
- 110 – You are a good listener.
- 109-85 – This is acceptable, but you could improve.
- 84 or less – You definitely need to work on your listening skills.

Becoming a good listener has many benefits – personal, social and professional. Much miscommunication can simply be the result of not listening to others. And if you expect others to listen to you, you must become a good listener yourself. If you are not a good listener, the people talking with you feel that you are disinterested. Then, when you wish to inform them or give directions, they may refuse to listen. You know how it feels when you talk to your employees and they look as if they are not paying attention. So to communicate better, you have to become a responsible listener.

This article appeared in its entirety in the October 1998 issue of the Journal of Dental Technology, the official publication of the National Association of Dental Laboratories.

Healthy Smiles For Everyone

Keeping a healthy smile poses special obstacles for children and adults with physical or mental handicaps that inhibit adequate brushing and flossing.

For many people, tasks that most people can accomplish easily – such as brushing and flossing – require complete concentration or special assistance. But according to a report by the Chicago Dental Society, adults and children who have a physical or mental handicap have a greater risk of developing dental problems such as tooth decay and gum disease.

Some factors are dietary. For example, an inability to chew adequately may mean that some people need to consume food that is pureed. The carbohydrates in these foods can stick to teeth and promote cavities. Other disabled people must eat frequent, small meals which increase exposure of teeth to cavity-causing acids. Other disabled people take medications that include large amounts of sugar to make them taste better. The sugars promote tooth decay.

Combine those problems with the fact that many disabled children are unable to brush or floss their own teeth. Individuals who have spinal cord injuries, muscular dystrophy, multiple sclerosis or cerebral palsy have limited dexterity. Older people who have suffered a stroke or have arthritis have difficulty brushing. People with mental retardation or Alzheimer's disease do not remember to brush regularly.

In many cases, health professionals, home care providers, or family members can help provide the appropriate dental hygiene tasks. The following suggestions may help people to brush and floss without assistance:

- Attach the toothbrush handle to the person's arm with a wide elastic band.
- Enlarge the toothbrush handle by enclosing it with a sponge, bicycle handle grip, or by sticking the handle of the brush through a pliable rubber ball. Lengthen the toothbrush handle with a piece of wood or plastic such as a ruler or wooden tongue depressor.
- Bend and mold the toothbrush handle by running hot water over the handle – not head – of the brush.

Many disabled people should consider switching to electric toothbrushes because they are easier to operate and are thorough. Disabled people also can use floss holders and even electronic flossers that are reaching the market.

An Oasis of Development

Significant strides in the fields of dentistry and dental surgery have been made by Arab doctors and surgeons, notes an article in Arab Dental News, by Dr.

Mohamed Bitar, a dentist who practices in Beirut.

The lead story of the publication reminds readers of the contributions Arabs have made in the dental professions, which are documented in Western texts that focus on the history of the profession.

Perhaps the greatest contributions were made by Abu-al-Qasim Khalaf ibn-Abbas al Zahrawi, known as Albucasis, who lived in the 10th century and is recognized as one of the first important oral surgeons. Albucasis understood that calculus on teeth is a major cause of periodontal disease and he created explicit instructions for scaling using instruments he had designed.

Albucasis advised that one should be very slow in deciding to remove a tooth, "as this is a very noble organ, the want of which cannot in any way be perfectly supplied." He cautioned that patients who have toothaches should carefully determine which tooth was at fault, since often a patient is deceived by pain and asks to have removed what proves to be a sound tooth.

Albucasis also noted that when teeth are missing they should be replaced with artificial ones made of ox bone and splinted to sound teeth.

Other significant contributions were made by the following pioneers who lived in the same time frame:

- Abu-Bakr Myhammad ibn-Zakariya al-Razi (841-926), know as Rhazes, wrote many books, but his greatest achievement was "Kitab al-Mansuri," a survey of Arabic dentistry from the 7th through 10th centuries. The survey is probably the first book since ancient times to discuss dental anatomy in detail. Rhazes identifies not only the individual teeth but the mode of action of the mandible, or lower jaw.
- Ali ibn'l-Abbas al-Majusi (died in 994) published an excellently organized work known as the "Royal Book," which covered the entire spectrum of Arabic medicine and included one chapter on diseases of the teeth.
- Abu' Ali al-Hysayn ibn-Sina (980-1037), known as Avicenna, was a prodigious writer and creator of "Al-Qanun" (the canon), one of the best-known medical texts of all time. Concerning dental treatment, he stressed the importance of keeping teeth clean and recommended a number of toothpastes including salt, and burnt and powdered snail shells. Avicenna examined in detail the causes of toothache and prescribed fumigation of toothworm. One of the most significant sections of the canon deals with the treatment of fractures of the jaw: The correct setting of the jaw can be accomplished by putting a supportive dressing around the jaw, head and neck and a light splint along the teeth. If necessary, gold wire might be used to reinforce the stability of the bandage.

Clearing Hurdles

After competing in the hurdles since his high school days, Dr. Fred Johnston, an orthodontist and CDA member who practices in Fremont and Pleasanton, finally accomplished his running goals.

On July 31, at the Masters National Track and Field Championships, held at the University of Maine campus, the 52-year-old Johnston won the gold medal in the 100-meter high hurdles. The next day, he took second place in the 400-meter hurdles. On Aug. 13, he won the gold medal in the 400-meter hurdles at the Nike World Masters Track and Field Championships held in Eugene, Oregon. He is now training for the Masters World Track and Field Championships, to be held in Gateshead, England in July 1999.

Johnston, a father of two teenage children, trains three times a week thoughout the year.

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21st Century Dentistry

Mark J. Friedman, DDS

Rapid advances in new technologies are having a profound impact on the practice of dentistry. Computers and fax machines are commonplace in offices throughout the country, but other more sophisticated devices are being introduced to improve on traditional dental methods and procedures. Advances are emerging rapidly making it difficult for the dentist to know which ones will ultimately benefit patient care and which are of little clinical value. This is because new devices and procedures have no track record when they are first introduced. Therefore, the informed practitioner must make careful assessments of the benefits, risks, and costs associated with these advancements. The contributing authors will present a selection of 21st century advancements. They relate to important digital records and vision enhancement.

More than ever before, pen and paper are being replaced with digital bits of information. From chart notes to radiographs and photographs, digital capture and storage has become easier, more practical and more economical. Not only does information in this form provide for instant access, but it can also be readily transmitted around the corner or around the world with a simple phone call. The paper-free dental office is no longer science fiction and new advancements are beginning to make the transition more appealing than ever. Two of the authors will address how digital records will influence the practice of dentistry and how the transition to such systems can be made virtually seamless in a real-world environment.

Another area that is rapidly expanding in the dental profession is the quest for vision enhancement. Many dental professionals are adopting magnification loupes. The desire to enhance the control over magnification and lighting during dental procedures has ushered a variety of surgical microscopes into mainstream dentistry. Although these instruments were initially advocated for improving the precision of endodontic therapy procedures, they are rapidly finding their way into restorative dentistry as well. The use of surgical microscopes for routine oral diagnosis and restorative procedures provides the operator with an instrument to improve the level of precision beyond currently acceptable standards and guidelines. The authors will present some of the challenges and new concepts that will ease the transition for practitioners who desire to use a microscope in restorative dentistry procedures.

Technological advancements will continue to provide dentists with new devices and systems that claim to be better than traditional means. Using the appropriate technology to make the delivery of dental care easier, more efficient and more precise is a noble objective. Ultimately, however, it is the practitioner's understanding, skill and commitment to quality, not the technology that makes the difference.

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Microscope-Assisted Precision (MAP) Dentistry – A Challenge for New Knowledge

Mark J. Friedman, DDS, and Howard M. Landesman, DDS, MEd

ABSTRACT The purpose of this paper is to acquaint the dentist with the learning needs associated with the use of microscope-assisted precision dentistry (MAP) and identify certain concepts that will assist in the education process. Although the learning curve is considered to be lengthy and often difficult, the authors believe that the clinical benefits of MAP dentistry are well worth the necessary effort to achieve a level of competency with this methodology.

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In a recent publication, the authors of this paper introduced the term "microscope assisted precision (MAP) dentistry" to distinguish an advanced level of operator exactness with the aid of a microscope.[1] The surgical microscope not only provides a variety of magnification options, but also the control of coaxial illumination for a shadow-free visual field. In addition, it allows the dentist and auxiliary to work in precise concert with one another because they share the same visual access to the procedure being performed.

Interestingly, at a local school of dentistry two surgical microscopes are being used by a very limited number of faculty as a teaching methodology utilizing video networking to demonstrate the fine detail of operative dentistry. This allows an instructor to perform a procedure in real time (or videotape), while the student gains a perspective of the procedure from the faculty's point of view. However, the use of the microscope is not taught as a part of the regular curriculum at this time. A "handful of senior students" were given minimal instruction in the use of a surgical microscope. They were asked to use it as an adjunct to making a cavity preparation (MO inlay) on a plastic tooth in a simulator manikin head. The outcomes of this exercise suggest that as part of their formative training, students could be taught to use the surgical microscope in a minimal amount of time and achieve a reasonable level of proficiency at improving their level of precision (Fig. 1).

In general dentistry, there are numerous opportunities to take advantage of better vision for both diagnostic and restorative intervention. Well-documented human subject studies are essential in order to validate the efficacy of the surgical microscope for use in general practice. Nonetheless, it appears that when a general dentist has received basic training, and subsequently has a period of time to adjust to the technical differences inherent with the microscope, it enhances his/her ability to discern more detail and perform with greater precision. In a recent paper on microdentistry, Mora states "... that

to reach a comfort level with maximum productivity can be time consuming and frustrating."[2] The authors believe that the clinical benefits of of MAP dentistry are well worth the necessary effort to achieve a level of competency with this methodology.

Figure 1. A small group of senior dental students experience making a cavity preparation on the dental simulator using a surgical microscope.

Figure 2. Typical microscope mounting from the ceiling affords ease in maneuverability without restricting the working environment when not being used.

History

Today, the specialties of otolaryngology, ophthalmology, neurosurgery and other medical subspecialties use surgical microscopy as an everyday procedure in order to achieve improved vision and illumination. This approach of handling diminutive hard and soft tissues with precision has generated new requirements for micro-instrumentation.[3-9] As a natural extension from medical microsurgery, MAP dentistry has gained acceptance in the areas of endodontics and, to a lesser extent, periodontology.[10-21]

Although there are a few individuals who have been early adapters, the use of surgical microscopy in performing conventional restorative procedures in operative dentistry and fixed/removable prosthodontics is a relatively unexplored area for investigation. In a book published by Martignoni and Schonenberger in 1990, the authors describe the clinical use of an operating microscope in restorative dentistry.[22] Chou and Pameijer, in 1985, described how a laboratory technician can more accurately trim stone dies more accurately with the aid of microscopy.[23] Leknius and Geissberger[24] demonstrated that students make approximately one-half the number of clinical and laboratory errors with the introduction of 2X magnification loupes in the fabrication of a fixed prosthesis. They further suggested that "magnifiers" should become an integral part of the instrumentation used by students of dentistry.

The Philosophy of MAP Dentistry

Traditional dental techniques have historically placed a major diagnostic emphasis on the tactile input received from the tip of a sharp explorer traversed over the surface of a tooth, or junction of a restoration on or within the tooth. This tactile evaluation process is often the sole criteria by which a restoration is deemed clinically adequate or defective. The subjective information obtained from this type of inspection is also the only criteria for developmental caries detection in the absence of definitive radiographic evidence. In some instances, this assessment method is the major parameter for smooth surface caries detection as well. The diversity of such clinical data collection can vary significantly depending upon the condition of the explorer tip, the angle of contact with the tooth, the force applied and the specific location(s) of the explorer during the inspection process. Most important of all is the interpretation of this tactile data by the clinician.[25]

The brain's interpretation of the tactile information received from an explorer can be compared to a blind person using their hands on the face of another individual to "see" what they look like. The brain develops certain mental "pictures" based upon sensory input from the digits. In restorative dentistry, we naturally use a combination of visual and tactile information to make our assessments. Quite often, the final decisions are based more on the tactile information than on the visual information.[26] This is because the areas of assessment are frequently not accessible to direct vision (e.g. subgingival margins) or our unaided visual acuity cannot adequately resolve the necessary detail to make an accurate assessment. A common example of this decision process is the diagnosis of occlusal caries on a restoration-free tooth. If the radiograph is ambiguous and the explorer does not demonstrate a definite "stick", the tooth is usually designated as a "watch-monitor-recheck" category even if dark "suspicious" stains are highly suggestive of incipient caries development. It is reasonable to speculate that with better visual inspection methods of the occlusal surface of teeth, the ambiguity often associated with an explorer inspection may be greatly reduced.

Learning to use the Surgical Microscope

There are five distinct challenges that must be overcome by the dental team when incorporating a microscope into the treatment operatory. The first consideration is how the instrument should be set up into the specific working environment.

To be practical in restorative dentistry, the microscope needs to have adequate maneuverability around the head of the patient without restricting access to the oral cavity for the dentist or the auxiliary. This requires a well-balanced arm that supports the weight of the microscope head. As more accessories are added to the

Figure 3. Simple rock switch on the microscope handle is wired to the chair base motor allowing focusing to be performed without moving the microscope.

Figure 4. Using the rubber eyecups, the operator makes minor position corrections by tilting or moving the head slightly, which saves time and does not require hand contact. Eyeglass corrections can be dialed in as needed.

Figure 5. To minimize microscope movements and gain complete access to the oral cavity, the 12 o'clock position is ideal for restorative dentistry. Deviation from that position forces the auxiliary (using a binocular) to move as well.

Figure 6. A freshman dental student automatically assumes ideal posture and arm support when using the microscope for the first time. Notice the support of the upper arm and shoulder with the wrist support stool.

Figure 7. The same student in **figure 6** assumes a less than ideal posture in order to gain a "comfortable" distance from the mannequin. Notice the position of the neck and lack of support for the shoulder, arm and wrist.

Figure 8. It is critical that the operator does not rotate a wrist support chair without first moving away fro the patient's head. Otherwise, an accidental contact from the wrist support with the patient's face can occur.

head (observer tube, inclinable binoculars, camera, etc.) the counter-balance support becomes more critical for the head to maintain fluid yet steady movements. The instrument can be mounted on a floor stand, on a wall or from a ceiling mount (Fig. 2). The floor stand allows for transport of the instrument from one area to another. However, the vast majority of practitioners prefer a ceiling or wall mount. The natural hysteresis (oscillating movement) of the microscope head is distracting to the observer. To reduce this effect, every attempt should be made to insure that the microscope is firmly affixed to a rigid surface. It should be installed in a position that will minimize excessive extension of the support arm during normal working conditions.

Another element that becomes apparent when using a microscope is the importance of patient-to-microscope positioning and repositioning that takes place during treatment. Experience has demonstrated that although microscopes manufactured for dentistry are easily repositioned in an infinite manner, whenever possible it is much more efficient to move the patient's head or the dental chair rather than the microscope head. A small rocker switch can be attached to the microscope handle to activate the dental chair base motor (Fig. 3). A light touch of the switch will raise or lower the chair base which acts as a coarse focus adjustment. The authors have found this an invaluable modification by greatly reducing the need to reposition the microscope vertically during a procedure.

A specialized foot control can also be configured for this operation. By reducing the need to change the microscope's vertical positioning, the operator and assistant can maintain ideal posture throughout a procedure. Furthermore, a well-balanced microscope can easily be moved left or right with slight tilt of the head by maintaining pressure on rubber eyecups. If the operator wears corrective glasses, they can be removed because the oculars have a built-in compensation adjustment (Fig. 4). Such repositioning with slight head movements results in greater efficiency.

Most general practitioners recognize that an operating position that approximates 12 o'clock is the most convenient when working on the scope. This not only places the operator at the most ideal position, but it also allows the auxiliary to work from the most efficient and comfortable position as well. Most dental units are designed for the assistant to be positioned approximately 90 degrees from the head of the chair. Working from the head of the chair exclusively means that for the operator to visualize the complete oral cavity, he/she must

take advantage of the mouth mirror and position the patient in a relatively supine position (Fig.5). One immediate benefit that will be realized from this configuration is that the operator works in a completely relaxed and posture-correct position, regardless of which quadrant of the oral cavity is being treated. Some manufacturers have introduced operator stools with wrist supports to enhance ergonomics and contribute to ideal posture while working with the microscope. These wrist supports reduce fatigue and make it more comfortable for the operator, but they also decrease intention tremor by reducing the distance from the fulcrum to the fingertips. This extra support acts to steady hand movements when working on the microscope and it likely reduces muscle fatigue in the shoulder, back and neck since these muscle groups will not be enlisted to help support the weight of the arm and forearm (Figs. 6-7). Care needs to be exercised when using these operator stools since the wrist extension can inadvertently contact the patient's head or face as the operator rotates the stool. It is important to always move the stool backward before rotating it to avoid accidental contact with the patient (Fig. 8).

Operating with the microscope offers new challenges to the dental team relative to instrument transfer because the assistant does not approach the oral cavity in the exact same manner to which she/he is accustom. With the proper objective lens (typically 200 - 250 mm), there is more than adequate access to the oral cavity for routine instrument transfer. However, with the observer attachment, the assistant will likely be working from a slightly increased distance from the oral cavity (Fig. 9). The most striking adaptation that becomes apparent is that normal peripheral vision is eliminated. For this reason, the operator must rely heavily upon the skills of the assistant to pass instruments and materials more accurately and efficiently than ever before. The actual instrument transfer will never be visible even at the extreme edges of the visual field. The assistant needs to be aware of this visual constraint and reduce the diameter of the transfer area to the region of the objective lens. If the dentist removes a finger rest to reach for an instrument, it is more difficult to regain it when looking into the oculars of the microscope. Even minor wrist movements will take an instrument out of the visual arena. It is extremely beneficial if the assistant uses the observer attachment so that she/he can see the magnified field as well. Without having access to the same magnified perspective as the operator, an understanding of the detail transpiring within the working arena is lost. One of the unique elements of using the surgical microscope for restorative dentistry procedures is the ability to allow both the operator and the assistant to see precisely the same visual image with the same illumination at the same exact time. Working with a dual binocular system gives the sense that the operator and the assistant have an "invisible Ethernet" connection. Since they see the same image at the same time from the exact same perspective, the assistant can anticipate actions more precisely. For example, if the mirror surface has debris obscuring the dentist's view of the operative field, the assistant's image is unclear as well and she/he will be inclined to clean the mirror before being asked to do so. This synergism proves to be positive for both the operator and the assistant. However, it should be kept in mind that the patient's well being cannot be assessed while observing the operative field through the microscope. Therefore, either the assistant and/or the dentist must, from time to time, check to insure that the patient is comfortable and not exhibiting any signs of distress.

An interesting side effect of working on the microscope is a sense of increased attentiveness due to the reduced visual field. Without peripheral images that can be distracting and interrupt concentration, the operator can focus his/her complete attention on the task at hand. For example, in a noisy restaurant one has to expend extra effort to block out background noise when trying to carry on a conversation with a specific individual. A quiet corner table allows for that conversation to continue more easily without the distraction of the added noise from the other patrons. Viewing through the microscope eliminates all peripheral visual distractions. A sense of increased concentration from automatically blocking out competing peripheral visual activity or "visual noise" in and around the treatment area is realized after only a few minutes on the microscope.1 This is an intriguing element of MAP dentistry that bears further scientific investigation.

A third element that the dental team must adapt to is how the magnified field influences everything used in a procedure. Traditional instruments appear bulky, awkward and often obscure vision significantly. This is most evident with the dental turbines. Their head sizes make it difficult to see around them. Often, by extending the bur shanks, the turbine head can be positioned to the periphery of the constricted visual field, allowing the operator to see the contact of the bur/diamond with the tooth at all times. Similar to the experiences in other fields of specialty, restorative dentistry will likely see new instruments and delivery systems specifically designed for MAP. Smaller instruments and modified materials will be needed to take full

Figure 9. When using an auxiliary binocular, the assistant will be working from a slightly greater distance from the oral cavity than usual. It may be appropriate to redesign an auxiliary chair specifically for MAP dentistry.

Figure 10. When using an auxiliary binocular, the assistant will be working from a slightly greater distance from the oral cavity than usual. It may be appropriate to redesign an auxiliary chair specifically for MAP dentistry.

advantage of this treatment modality. Even if an extra-small access cavity is achieved with the aid of a microscope and "micro" burs, there are no restorative material delivery systems capable of taking advantage of such small diameter openings (Figs. 10-11).

One immediate challenge to the operator is developing a strategy for instrument placement that does not limit visualization of the operative field. This is particularly important when using the mouth mirror. With the unaided eye and even with low power (2Xû4X range) magnification loupes, the visual radius is wide. The natural tendency is to position the mouth mirror in close proximity to the tooth or the object being visualized. Intuitively, the operator will move his/her head appropriately to gain an ideal optical axis from which to see clearly. It is also possible to look above or to the side of the dental turbine or dental instrument and the broad peripheral field presents an infinite number of repositioning possibilities relative to head position. In sharp contrast, the relatively fixed position of the microscope restricts such movements. It is axiomatic that as the level of magnification is increased (6X-12X range), the visual radius and depth of field are reduced, while at the same time all items within the field are magnified. Therefore, the mirror head, air turbine or dental instruments can easily obscure the view of the tooth surface. In addition, as these elements are brought into closer proximity due to a reduced visual circumference, they can obstruct one another making movements more difficult. For this reason, the operator must intentionally take a different approach to positioning the mirror in relationship to the tooth, turbine and instruments.

Figure 11. Unfortunately, no manufacturers yet provide restorative materials specifically for MAP dentistry. The smallest composite delivery system orifice covers Mr. Lincoln's nose, mouth and chin simultaneously.

Figure 12. Based on the rule of proximity, the turbine head will obscure the mirror image as it enters the field because the mirror is placed in proximity to the object of focus (the distal pit).

Figure 13. The mirror is positioned away from the root surface allowing full view of the object of focus without interfering in the placement and movement of the turbine and bur.

Figure 14. An oral retractor can be used for MAP dentistry procedures in lieu of a rubber dman, but it will reduce operative efficiency.

Learning to maintain the correct distance and position of the mirror surface relative to the other instruments and the primary object of focus is the single most difficult component of the learning curve for MAP dentistry. The most ideal position of the mirror is when it takes full advantage of the entire viewing circumference at a specific magnification. As the position of the critical elements come into closer proximity to one another, they begin to overlap making it difficult to see each one of them separately. The further the mirror is positioned from the object of focus the less interference will be created from the turbine head or any other instruments in the working area. Often, the position of the mirror may need to be at the perimeter or even outside of the oral cavity for optimum visual and working access. However, due to the magnification effect, it may appear as if the mirror is in close proximity to the object of focus (tooth, soft tissue, etc.). The authors have

termed this concept the rule of proximity that states, "as the level of magnification is increased, the distance from the mirror to the object of focus must also be increased." (Figs.12-13)

The fourth factor that the restorative team will recognize is that the use of effective isolation techniques greatly enhances success with microscope dentistry. The reliability of the rubber dam for isolation and visualization of the operative field is more critical when working from the head of the patient. It not only reflects the lips and cheeks for better access to the oral cavity, but it reduces the need for the patient to sit up and rinse. If the patient's movements are reduced, repositioning of the microscope is minimized. By contrast, if the operator and assistant are focused on maintaining retraction and isolation of the field, then their attention is continually drawn away from the magnified field. Not only is this tedious and time-consuming, but it will create frustration from having to reposition the microscope excessively, especially on longer procedures. Preparing prepunched rubber dam packs and having the entire set-up ready in advance makes application easy to achieve in a matter of minutes. Furthermore, the dentist who "rediscovers" the advantages of rubber dam will immediately enjoy the reduction of the blood and saliva fog in addition to the greatly improved visibility that this simple step provides. The greater efficiency of high velocity evacuation when using rubber dam also reduces splattering on the microscope and in particular the surface of the objective lens or lens cover. Discontinuing treatment to wipe the objective lens is another avoidable step that interrupts concentration and wastes valuable chair time.

In circumstances or with patients where a rubber dam is impractical, efficiency of microscope use is greatly reduced. Compromises to rubber dam use are the many oral retractors available. They provide some displacement of the lips and cheeks, but can be removed and replaced easily (Fig 14).

The final challenge that MAP dentistry represents is to the operator's psychomotor skills. This element of the learning curve is difficult to describe. When a dentist first starts to use a surgical microscope, he/she will immediately recognize that there is a need to refine stereotactic and fine motor skills. The vast majority of what dentists do on a daily basis is guided by a combination of both tactile and visual information. With the aid of magnification, vision is enhanced to a level that far exceeds the norms set forth by tactile assessment standards. The shift from a reliance on tactile information to visual information is virtually automatic when working with an operating microscope. Most restorative procedures still require that the operator gain perspective from a non-magnified view as well. Examples would be the assessment of a smile-line or an identification of preparation undercuts for a multiple-unit fixed partial denture. The transition from a tactile to a visual-weighted approach to general dentistry is as exciting as it is challenging. It may expand our knowledge and abilities to provide an unprecedented level of precision in the care of our patients.

Summary

The introduction of a surgical microscope into the dental operatory brings with it many challenges not usually associated with traditional 20th century dentistry. MAP dentistry represents a new technology emphasizing visual information rather than tactile input. Although the learning curve can be lengthy and difficult, the authors believe that the clinical benefits of MAP dentistry for the patient, the operator and the profession are well worth the efforts required. Controlled studies need to be performed with students and practitioners to obtain relevant data on the use of microscopy in general dentistry.

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The Integration of Filmless Radiology in a Resorative General Practice

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ABSTRACT A new faster, safer era has evolved for radiology in the dental office. This paper is a review of the latest technology that enables dentists to integrate filmless radiology into their practices.

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Digital radiology was introduced to the dental profession several years ago. Important features include reduced radiation exposure to patients, speed of image capture and elimination of the darkroom. The dental office can now provide a safer diagnostic procedure while maintaining or improving image quality. The digital image is available almost instantly for the dentist to view and can then be stored electronically on a computer hard drive. The images can be sent electronically between dental offices and around the world via the Internet. Photo-quality hard copies can be produced whenever desired on a choice of widely available inexpensive printers.

There are three types of systems used in dental digital radiology. Each offers advantages and limitations that will be discussed in this article. Two of the systems create digital images that dramatically reduce radiation and eliminate film. One type of digital system uses a mouth sensor and a cord connected to a computer to display a digital x-ray image on the monitor.1 The second type of digital system is cordless, using a storage phosphor transfer image plate, which after laser scanning integrates digitally into a computer and displays the image on a monitor.2 The third type is a hybrid system that involves digitizing existing x-rays by the use of a hardware scanner and scanning software, which converts existing films into a digital image for display.3

All three systems require a computer with Microsoft Windows 95 or 98 software and a monitor. Copies of the digital images can be enhanced with the software tools common to each of the digital image systems. The digital x-ray images can be stored electronically.

Photographic quality copies of digital radiology from any of the above discussed systems can be produced on high dot-

per-inch ink jet printers using photo quality coated ink jet paper. Each office develops their own criteria for printing and dispensing appropriate digital images. These image copies are currently accepted by most insurance companies as documentation of treatment similar to conventional x-ray film. Issues of possible fraud or manipulation of records are matters that will be more well-defined legally as the number of dentists adopting digital radiology as their standard of care increases.

Important Considerations

A number of questions are worthy for each dental practitioner to review and answer when considering a major decision such as introducing digital radiology into the office. For example:

- Is your office computerized with a Widows 95 or 98 software management system?
- How soon do you envision implementing this important improvement?
- At what future time will you consider placing computer workstations in your treatment room?
- What are the ball-park cost estimates for hardware, software, and wiring of your computer upgrades, dental office management systems and digital radiology, and how much will it cost to train your staff how to use them effectively?
- How do you plan to store and retrieve this important digital clinical information?
- If choosing a total digital radiology replacement system, what will you do with your present darkroom and equipment?
- Where will you place the new hardware with consideration for ease of access for key personnel including the dentist, hygienist, and chairside assistants?
- Have you considered developing a backup plan for a computer network crash or loss of electricity?

Figure 1. Most of the current available digital radiology systems use a hard sensor at the end of a cable, which connects to a computer.

Figure 2. When the sensors and connecting cord unite with image software, quality images appeaear instantly on the computer monitor.

Figure 3. Special holders and advanced training are required for the use of CCD sensors.

Figure 4. Breakthroughs in laser-scanning technology have permitted the creation of a practical cost-effective system for dentistry.

Corded Digital Radiology

Most of the current available digital radiology systems use a hard sensor at the end of a cable, which connects to a computer. (Fig. 1) This sensor contains a Charge-Coupled Device (CCD) similar to those used in video camcorders. The CCD chip is covered with miniature radiation-sensitive receptors that allow radiation to be turned down 60 to 80 percent compared to settings used for D-speed film. When the sensors and connecting cord unite with image software, quality images or pictures appear instantly on the computer monitor screen similar to developed conventional x-rays (Fig.2).

New users will find the need to spend a short time learning to read and diagnose digital images compared to conventional films.

Applications Of CCD Radiology

The CCD corded systems are popular among some dental practitioners for use in verifying endodontic procedures and implant placement procedures. Additional applications are also found in oral surgery to view pre-surgery areas and post surgery results. Another useful application is to more quickly obtain reduced radiation x-rays on emergency patients. CCD digital x-rays can be printed and included with the paper insurance claim. In the near future, digital x-rays will probably be sent electronically with an electronic insurance claim.

Advantages Of CCD Radiology

High-quality images similar to film is obtained within seconds of the reduced radiation exposure. The hard sensor is easy to cover with a disposable barrier. The hard sensor can be utilized thousands of times before the need for replacement. A choice of software and sensor design is available from several competitive

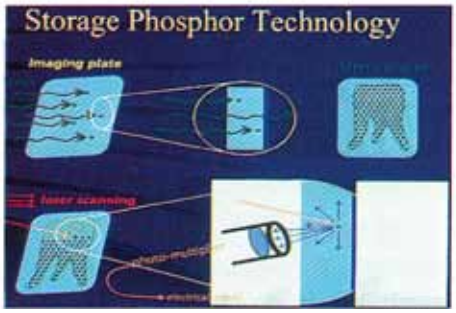


Figure 5. The digital image is produced using software that reads the laser signals.

Figure 6. The scanner can hold a choice of two different sytles of image-holding carousels.

Figure 7. The carousel is loaded with the storage phosphor screen in a low-light condition but does not need a dark room.

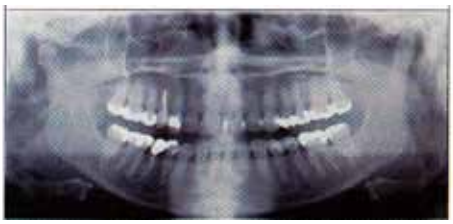
vendors. Darkroom chemicals are not used in CCD technology eliminating this expense and hazard. This technology is the leader where speed of image production is desired.

In the author's practice, CCD digital radiology is an important part of daily clinical practice for rapid completion of endodontic and implant procedures. Staff and patients alike welcome this instant information as well as the positive improvement of reduced radiation.

Disadvantages Of CCD Radiology

The apparent ease of use of CCD digital technology is sometimes detracted by the sizes of the various hard sensors in relation to some human mouths. A hard sensor will not fit some locations in the oral cavity. This may require an alternate digital backup system or possibly retaining conventional film. Also, multiple hard sensors are needed, which is expensive. Special holders and advanced training are required for the use of CCD sensors In obtaining a full mouth series of images, the cord or hardwire is sometimes in the way. In daily utilization, there is the danger of damage to the expensive sensors. Each office must make its own plan for the investment in digital radiology.

In the author's experience, CCD technology is cumbersome to use daily for high-volume radiology, such as the new patient examination (32-40 exposures) and recare x-ray examinations (24-36 exposures), because of the bulky stiff sensors, cords, and special holders.



Figures 8 & 9. The scanned image on the computer screen has a quality equivalent to film.

Figure 10. An easy way to erase storage phosphor screens is to store them on an X-ray view box witht he light on.

Figure 11 . An easy way to erase storage phosphor screens is to store them on an X-ray view box witht he light on.

Cordless Digital Radiology (Storage Phosphor)

The newer cordless digital radiology systems use a storage phosphor technology that has been available in medical x-rays for many years. Breakthroughs in laser scanning technology have permitted the creation of a practical cost effective system for dentistry (Fig. 4).

The storage phosphor imaging plate holds an image when exposed to a reduced radiation x-ray beam during the radiographic process. When the imaging plate is exposed to light of appropriate red wavelength, the image is released as blue light. When the imaging plate is optically scanned with a laser of appropriate red wavelength, the emitted blue light is simultaneously read via a photomultiplier tube. The resulting signal is electronically processed via software to produce the digital image (Fig. 5).

The Laser Scanning Container

The key equipment piece of the new storage phosphor system is the laser scanning container.4 The scanner can hold

a choice of two different styles of image-holding carousels (Fig. 6). The intraoral carousel holds up to 29 imaging plates of all conventional film sizes. Its design is to hold more than a typical full mouth series. The panoramic carousel will hold popular size panoramic imaging plates and additionally some intraoral image plates. A cephalometric carousel will be available in the future.

The carousel is loaded with the storage phosphor screen in a low light condition but does not need a dark room . To scan the images, the loaded carousel is placed into the laser scanner. One to three minutes later the scanned image is on the computer screen.

The image quality is equivalent to film (Fig. 8 & Fig. 9).

Scanning does not remove all of the image information from the imaging plates. Therefore, the first step in using the storage phosphor system is to erase the imaging plates. This is performed by exposing them to intense light for a minimum of two minutes. Fluorescent light sources are twice as efficient as incandescent sources at erasing imaging plates. An easy way to erase storage phosphor screens is to store them on an x-ray view box, with the light on (Fig. 10).

Additional exposure to light beyond two minutes does not hurt the imaging plates. However, if erasure is not complete, a ghost image from a previous exposure may appear.

Applications of Storage Phosphor Radiology

The cordless digital radiology system will be popular with general practitioners for the new patient x-ray examination. The system will be useful on returning patients for updating their x-ray examinations at their recare visits.5

Each office can continue to use existing x-ray equipment and simply turn the radiation down 60 to 80 percent compared to D-speed film. The individual storage phosphor image plate is placed inside a disposable barrier. Since it is the same size as film, it then can be placed on any film positioning device. The panoramic image plate is placed in the standard cassette and used as usual with the current intensifying screens that lower the radiation dose. The storage phosphor digital x-rays can be printed and sent with the paper insurance claim.

In the near future, the digital images will be sent electronically with the electronic insurance claim.

Advantages Of Storage Phosphor Radiology

The storage phosphor system delivers high quality images equivalent to film. The system is so flexible it is difficult to over- or under-expose an image. There are no chemicals, thus the problems associated with underdeveloped films are eliminated. There is no longer a need to dispose of lead and toxic processor chemicals. The storage phosphor transfer systems present a total replacement solution to eliminate all film, chemistry, the processor and the dark room.

The storage phosphor system image plates have the characteristics of film without film's attendant limitations. Differences in resolution due to current laser scanning limits can be overcome by the image software tools. The imaging plates are as thin as a piece of film and more flexible. The imaging plates come in all the same sizes as film: 0, 1, 2, 3, and 4, both panoramic sizes, and cephalometric plates. The imaging plates simply take the place of film, allowing the use of current x-ray equipment in its place. The reusable imaging plates are not damaged by x-rays, scanning or the erasing process. They can be reused thousands of times. The only thing that limits the life of an imaging plate is damage which might occur during use that causes creases or scratches, and that type of damage requires replacement.

In the author's experience, the busy dental practice may need approximately 75-100 storage phosphor screens for daily utilization. This number must be prepared, erased and stored daily in readily available light-proof containers. The initial investment in this large number of screens is quickly offset by the fact that they can be reused thousands of times. A part-time employee can be trained and assigned this task. The laser scanner and image file server is located centrally to the dental hygiene treatment areas and/or new patient examination rooms. Developing flow systems for implementation, coupled with adequate training and planning for a convenient location, can eliminate staff resistance to this new technology.

Disadvantages Of Storage Phosphor Radiology

To obtain storage phosphor images on the monitor takes one to three minutes of laser scanning time depending on number and/or size. The image plates must be hand packaged in disposable barriers for the quantity required in daily use. In the dental office, space and location for the laser scanner container must be well planned for easy access. The initial investment in digital radiology is a disadvantage that must be overcome with individual office planning and priority decision making.

Hybrid System

Newly improved scanning software allows the dental office to digitize existing film radiographs as well as patient paper files. It requires a high-quality scanner

with a transparency module integrated and connected to a computer and monitor.

Applications of Hybrid Systems

The dental office can digitize existing x-ray and paper files to incorporate them and form complete electronic or computer files for each patient. This digital information can be printed and sent with paper insurance claims. In the near future, the digitized images will probably be sent electronically and included with the electronic insurance claim. The software has expansion modules for computers that are network-connected to the scanning computer. An additional option to the network workstation viewing is to add the capability to capture video camera images directly into the scanning software.

Advantages of the Hybrid System

The use of scanning software can be a beginning step to becoming a digital dental office. The ability to convert existing records into a digital format is of great value. The hybrid system allows the dental office to develop digital radiology reproductions. It allows use of single computer and monitor to collect and store digital information. It trains the office staff in various new computer applications.

The author finds the ability to utilize scanning software and hardware an advantageous way to digitize and integrate valuable existing clinical records: A part-time employee can scan in five to 10 patient records daily, so in a matter of months an advanced computerized office can benefit from extensive on-line digital files. It is important to install and adhere to a comprehensive backup method to store and preserve digital files. High-speed backup tapes are available today to utilize on computer file servers to provide this protection. Software and/or hardware providers are a good source of information for backup systems.

Disadvantages of Hybrid Systems

Converting existing film x-ray files is a time-consuming process. Labor expenses to accomplish this process need to be calculated. Not all dental offices may wish to accomplish this process. A digital radiology system choice will still be a requirement in order to become a filmless dental office. The quality of the reproduction is dependent upon the quality of the scanning hardware and software. An investment in hardware and software is required.

Setup Options

All three systems are available in two setup options: A stand alone system or networked systems.

The stand-alone option is useful for smaller offices. The computer, monitor and support equipment can be placed in a central area or directly in the operatory. Diagnosis takes place at the monitor.

Microsoft Windows 95, 98 or NT networks will be useful for larger offices.6,7 The dedicated image file server and support equipment are placed in a central location. A computer and monitor are placed in each treatment room for diagnosis and any other locations desired for record keeping. A local area network is installed in the office configured to be client/server or peer-to-peer. A dedicated image file server is recommended in addition to the network file server. This allows the images to be accessed from the workstations located throughout the dental office.

Staff Training

In the CCD system, an important consideration is the significant learning curve for doctor and staff to use the cord and sensor components. New exposure techniques and special holders are often required to make the CCD systems work in the dental office. Several hours of added training are necessary for offices to implement CCD technology. A benefit of CCD-derived images is the availability for viewing in a matter of seconds.

Offices report 30-60 minutes of learning time per staff person to implement the storage phosphor digital system. The staff continues to use the same techniques in which they are currently trained. The same film holders existing in the office can continue to be utilized. Simplicity of use and ease of integration is a benefit of cordless technology.

In the hybrid system, use of hardware and scanning software can be learned in one to two hours. The actual digitized images are available for display in approximately one minute. Staff and patients will benefit from the ability to integrate office record systems.

Summary

The two systems of filmless digital radiography fulfill the promise of reduced radiation for the digital dental office. Both systems can utilize existing x-ray equipment and produce high quality digital images on a computer screen equal to conventional films. The hybrid system retains your present film-processing unit and allows converting existing x-rays into a digital format for display and storage. All three systems require a computer with Microsoft Windows 95 or 98 software as well as their own image storage software and support equipment.

Future improvements in the CCD digital systems may bring more flexible cords and thinner sensors. The cordless storage phosphor screens may come prepackaged and be less susceptible to low light. The hybrid system will offer faster scanning of existing x-rays and paper files with improved reproduction quality and greater detail.

By early in the 21st century, which is almost here, it will be possible to have all dental records formatted and stored on a computer and quickly accessible at any location desired in the dental office. The new millennium can bring the realization of a seamless transition to a paperless, filmless dental office.

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Digital Tools for Clinical Dentistry — An Internet Tutorial

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ABSTRACT Computer technology has expanded the scope of digital tools that play a significant role in the practice of dentistry. In the search for current information and references about these devices, the Internet has become an essential resource. This paper will deal with some of the available digital adjuncts and their useful application in the clinical practice of dentistry, and will point the reader to web sites that are pertinent and informative.

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For many years dentistry has evolved through a series of changes that have been progressive but not dramatic. Exceptions to this have included the advent of the high-speed dental handpiece, dental implants, and the necessity for barrier protection. The advent of the age of computing did little to alter this evolution, even though many dentists began to use computers for bookkeeping and office management. However, it appears that computer-based devices are now beginning to play a more significant role in the practice of dentistry, and this role will be expanded. As computerization of the dental practice spreads from the front office into the operatories, components are more easily added and, once the first implementation is accomplished, each addition becomes easier. Integrating all the components into a networked system is often a challenge, but is essential for a fully automated dental office.

The increased computing speed and storage capacity of modern computers exceeds dentistry's demands. The storage requirements of images – either radiographs or camera images – mandate significant storage capacity. The easy availability of large hard drives (nine and 18 gigabytes), external and internal alternative media (such as Jaz or Zip drives), and writeable and rewriteable CD ROMs have all facilitated image storage. The size of image files mandates large storage capacity devices as well as rapid processing speeds.

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With so many different products being offered to the profession, it is difficult to sort through all the conflicting advertising claims. Textbooks and periodicals cannot be published rapidly enough to accurately review current technology. The World Wide Web has become an essential reference for the electronics shopper. Before buying any product, the interested purchaser has the opportunity to use the rich facilities of the Internet to both review the various products and gather valuable scientific information about the technology. This paper will deal with some of the available digital adjuncts and their useful application in the clinical practice of dentistry, and will point the reader to web sites that are pertinent and informative. Primary consideration will be given to five devices: digital radiography, intraoral cameras, CAD/CAM, computer color matching and periodontal devices.

Digital Radiography Systems

Since its advent in the United States several years ago with the introduction of the Trophy® system, digital radiography has yet to fulfill the predictions originally made for it. Although it is difficult to accurately gather data, it is said that approximately 5 percent of the dentists in the United States use digital radiography. That percentage is higher in Europe. Approximately 6,000 digital x-ray systems have been sold in Europe in 1996, where the market is growing at a 35 percent annual rate.[1]

Digital radiography, also called computed radiography, is available in many forms, from the simple digitization of film using scanners or videography to the most complex and expensive computer-assisted tomography (CAT scan). The most common dental application of computed radiography involves the use of a sensor instead of typical x-ray film. This sensor is usually a charge-coupled device (CCD). Bell Laboratories invented CCDs in 1970.[2] Since that time, the CCD has revolutionized video recorders, cameras and other devices. Without delving deeply into the physics of this system, suffice it to say that the CCD is a type of silicon semiconductor that stores and transfers electrons. A phosphor screen photoelectrically generates electrons that are captured in wells and sequentially transferred and read out electronically. These microscopic elements of photosensitive material are comparable in size to those on radiographic film. Nearly all electronic cameras also use CCD technology (**Figure 1**) and there is a broad range of sizes and qualities of CCD sensors. Pertinent technical information for those wishing to gain a better understanding of CCD technology can be found on the Internet at:

- www.suni.com/pages/lasrfoc.htm, and
- www.suni.com/pages/laserf.htm.[3,4]

The CCD digital radiography sensor is typically composed of four elements: a sealed casing, a phosphor screen, a fiberoptic conductor, and the CCD itself. The fiberoptic conductor originally was tapered to allow a larger sensing area to be conducted to a smaller CCD. Current systems have larger CCDs that prevent the need for tapering. The phosphor screen converts x-ray energy to light energy, photons, that are conducted by the fiberoptic unit to the sensor. The quantity of the photon energy is directly related to the amount of x-ray energy, and the number of electrons deposited in the well of the CCD is likewise directly related to the source energy. Each electron well represents a point of information, just as do the silver crystals of traditional film. The semiconductor wells, however, are precisely ordered while the silver crystals of film are irregular and random. The number of electrons deposited is proportional to the strength of the stimulus. The semiconductor wells are then sequentially emptied in bucket brigade fashion, and reconstructed into a signal that equates to the relative penetration of the target by the x-ray beam. This signal provides information for the positioning and relative gray levels of the pixels on a display screen (monitor). Because the image is composed of varying gray levels represented by the number of electrons in a given well, it is important not to overexpose a CCD sensor. Unlike film where increased radiation may result in a better image, an overfilled CCD results in a much poorer image. It is better to slightly underexpose the image, and then compensate by manipulating the brightness and contrast using the software tools.

Diagnostic Accuracy

The primary criterion that digital radiography must meet is diagnostic accuracy. Dental x-ray film is still the standard against which a computed radiography must be measured. Several factors contribute to the diagnostic accuracy of a digital radiograph. These include dynamic range, resolution, and signal-to-noise ratio. Dynamic range relates to the relative blackness of blacks, whiteness of whites, and definition of the gray tones in between.

High dynamic range is desirable. Spatial resolution relates to the size of the smallest observable details. It is often measured using a line pair phantom[5] or by phantom devices using calibrated radiolucent or radiopaque elements (**Figure 2**). A greater number of line pairs per millimeter is better, although the human eye is limited in the number of line pairs it can discern without

Figure 1. The CCD of an intaroral camera is located behind the lens.

Figure 2. Lesions were sijmulated in these four exracted teeth. Round burs from No. 1/2 to No. 4 were used. The burs were embedded to varying depths and some surfaces were left unaltered.

magnification. Dental film is generally thought of as having more than 15 line pairs per millimeter. Current CCD based sensors systems are advertised as having from eight to 12 line pairs per millimeter, although much greater resolution (22 line pairs) is possible and will be shortly forthcoming from at least one developer. The signal-to-noise ratio is a measurement of the relative fidelity and clarity of the image signal against the interference from background noise. Obviously, the less noise and the stronger the signal, the better the image will be.

Film is not only the standard of comparison for diagnostic quality, but also for image size. Initially, sensors were small and bulky. Now, the active area of several sensors compares favorably to intraoral radiographic films. The active area of the sensor is less than the physical size of the sensor, since it must be encased in a hard, hermetically sealed housing.

CCD Design

The thickness of the sensor has been a matter of concern to many, since CCD sensors are all thicker than film. Sensors have become progressively thinner, with current models being between 5 and 9 millimeters and averaging approximately 6 millimeters. Much thinner sensors, 3.2 millimeters, are likely to appear on the market in the near future. The incorporation of the fiberoptic conductor between the phosphor screen and the sensor protects the CCD from direct irradiation, but sensors without a fiberoptic component can be made thinner. Such sensors have been marketed in the past, and a CCD sensor without a fiberoptic screen and using another method of sensor protection will be available soon. Again, image quality is the primary element of comparison, and advertising claims for one system or another should be supported or discounted based primarily on this criterion.

Phosphor Plates, Film, and CCDs

Phosphor plate systems, also termed PhotoStimulable Phosphor plate, or PSP, are an alternative to CCD sensors. These systems use a phosphor plate – a film-like package – that is stimulated by the radiation and then removed from the mouth and "read" by a scanning unit. Sensors come in numerous sizes including those for occlusal and panoramic views. This system is described in detail elsewhere in this issue (see The Integration of Filmless Radiology in a Restorative General Practice, by Arlen Lackey.) The phosphor plate "film" has an additional advantage of being flexible, whereas a flexible CCD system is, today, impossible. A primary advantage of the CCD sensors is the rapidness of processing. Current CCD systems often advertise "instant developing' whereas the actual time from image acquisition to image display may range from four to 10 seconds, and sometimes more. Nonetheless, this is far faster than either film or the phosphor plate systems. Furthermore, the image for the CCD systems is displayed while the sensor is still in position, and if correction is needed, the sensor only need be moved from the known position to the desired position. This is a great advantage, especially when the radiograph is being used for endodontics or for implant evaluation or, perhaps, locating a root tip during surgery. Since both film and phosphor plates require extraoral processing, this advantage is lost. A great advantage of the phosphor plate systems is the absence of a connecting cable. CCD systems without the cord and using radio frequency or infrared transmission technology will probably appear, but none are now available.

An advantage of both CCD and phosphor technologies over film is the reduction of the radiation burden. Although manufacturers advertise up to 90 percent reduction, this is not without diminished diagnostic quality. For some uses, such reductions are achievable and realistic.

Imaging Software

The software for a digital radiographic system is a major consideration. All image signals require initial processing to optimize image quality. Additional basic functions include image enhancement features such as incremental contrast and brightness adjustment, coloration, image rotation, image pan and zoom, grey level (gamma) correction, and image annotation. Image measurement is also helpful, but distortions may be misleading, and measurements should be considered relative, even when some form of calibration is used.

The coloration feature is often

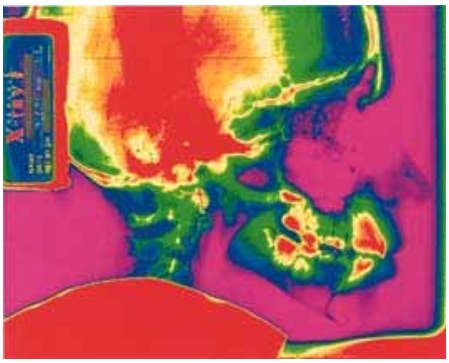

Figure 3. A cephalometric radiograph that has been colorized by a digital radiography software program. The soft tissue outline is clearly visible.

Figure 4. The die is contact-digitized to acquire a three-dimensional image.

marketed as being a unique and useful feature. Actually, coloration discards a considerable amount of information by assigning a color to a range of gray levels. Coloration can be helpful, however, when attempting to define the features of a given gray level, such as the soft tissue outline of a cephalometric film, which might otherwise be difficult to discern (**Figure 3**). Reverse imaging (transposition of the blacks and whites) can sometimes be helpful in image evaluation.

Many companies offer free demonstration software that can be downloaded from their web site for trial. The reader is encouraged to explore the web site addresses provided and take advantage of "home shopping" for computer radiography. Some of the web site addresses for demonstration software are:

- www.apteryxware.com
- www.televere.com/product.htm (online request for demonstration software)
- www.trophy.com (download)
- www.schicktech.com (download)

Imaging software should be seamlessly integrated with office management and patient record software. The imaging software should enable the user to import images, not only from the CCD source, but also from scanned sources. Twain, an industry-wide accepted protocol for scanners that is included with Microsoft Windows 95, makes importing images a simple matter. Unfortunately, not all digital systems consider Twain-compliance necessary and some companies that were contacted in preparation of this article seemed ignorant about its usefulness.

Most medical imaging systems also support a standard protocol recommended by the American College of Radiology called DICOM (Digital Imaging and Communications in Medicine). Those who have been primary supporters and developers of digital radiography in dentistry have been active advocates of the standard. More information about Twain and DICOM can be found at:

- www.whatis.com/twain.htm
- www.twain.org/about.htm
- ddsdx.uthscsa.edu/dicom/dicom.html

Security

One of the questions that often arises is, "How can I be assured that the image I see is an original, unaltered image?" This is a good question, since digital images can be easily altered, and the unknowing observer may be deceived. Insurance companies need to know that the conditions presented on the radiograph do, indeed, exist in the patient. This issue has been addressed in a number of ways. The most recent approach is by Eastman Kodak, who developed what has been called "Kodak DNA". The original image is given a file name extension that indicates that it is an original image. All pixels in the original image are mapped and recorded. Only the original image is given the delineating suffix, and all modifications are recorded differently. This development is relatively recent, and the success of the system is currently unclear. However, several leading software manufacturers are offering the system. Another method is known as a "secure tagged block". Original images are saved with an "stb" file type delineation (i.e. "filename.stb") and no alterations are permitted to the original image. Other systems are sure to evolve, and their success will be dependent upon the acceptance by third parties that authorize and remunerate dental care based on radiographic evidence.

Web site addresses of interest include:

- www.kodak.com/US/en/health/dental/softwareMenu.html
- www.apteryxware.com
- www.televere.com/product.htm

CMOS Technology

Another emerging type of sensor uses a different silicon semiconductor technology. Complementary metal oxide semiconductor (CMOS) devices are beginning to appear in dental digital radiology. CCD sensors are n channel silicon devices and can be considered a subset of CMOS technology.6 CMOS technology uses both the p and n channel transistors on the same chip - therefore the name "complementary". CCDs are said to offer the greatest sensitivity and fidelity. Advantages that are claimed for the CMOS technology include the need for a less energy to record an image and the highest level of integration that can reduce system cost. A negative aspect can be greater signal-to-noise ratio. However, an amplifying element can be incorporated to overcome this shortcoming.

It is probable that future digital radiology devices will use a combination of

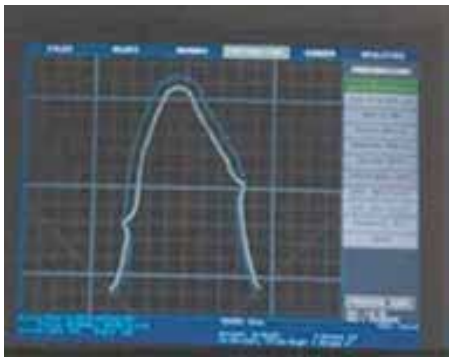

Figure 5. The coping is designed on the digital image.

CCD and CMOS technology to obtain the greatest advantages of the two technologies. It is beyond the scope of this paper to expand on the physics of these devices. Suffice it to say that the technology is relatively young but is emerging rapidly. Additional information can be found at www.suni.com/pages/laserf.htm.

Computed Radiography in Dentistry and the Internet

Almost as rapidly as information can be published, innovations and alterations make it obsolete. Readers are encouraged to use the power of the Internet to seek information on the many digital radiography systems available. The following list of web site addresses should prove helpful

CCD or CMOS sensors:

- Cygnus (Panasonic) http://www.zila.com/cygnus/cygnusray.htm
- Dent-X (Raegam) http://www.dent-x.com/SensaView.html
- Dexis meros.com/au/html/dexis.htm
- Dimax, panoramic http://www.planmeca.com
- Dixi http://www.planmeca.com/
- Ni-DX (Dentsply-New Image) http://www.dentsplynewimage.com/NI-DX.html
- Schick http://www.schihcktech.com
- Sidexis (Sirona) http://www.sirona.de/e/index2.html or http://www.sident.co.uk/sidexis.html

Digital intraoral, panoramic, and cephalometric radiography

- Trophy http://www.trophy.com

Stimulated Phosphor Technology:

- Soredex http://www.soredexusa.com/default.htm
- Dentoptix http://www.gendexxray.com/denoptix.htm

Other Benefits

In addition to the reduction in the radiation burden to the patient, digital radiography offers some other tangible benefits. Since the use of chemicals is obviated, there is no concern about the disposal of processing waste. This has become an issue, especially in metropolitan areas. Furthermore, although the cost of a digital radiography system is higher initially, there are fewer ongoing costs, such as the purchase of film, processing chemistry, or processors. The increasing acceptance of digital patient records mandates the incorporation of radiographs, and digital acquisition is preferable to scanning. Radiographs are not lost, and they are filed in an orderly and easily retrievable manner. This is a vast improvement over the typical random search through a myriad of envelopes and a sequence of complete mouth or bitewing mounts with which most clinicians are familiar.

As sensor technology improves and professional response makes additional investments in research feasible and profitable, improvements in digital radiography will accelerate. As this occurs, the use of film will diminish. Whether or not film will ever be replaced is a matter of conjecture.

Computer Assisted Design, Computer Assisted Manufacture (CAD/CAM)

Dental CAD/CAM has been in development for over 24 years, but has yet to be broadly accepted. It is evolving, however, and may eventually be practical in ways quite different than originally conceived. The CEREC system by Sirona has been the most commercially successful. It has evolved through two iterations, CEREC I, and CEREC II. The first used a single 3 centimeter diamond disk, and had limited resolution (256 x 256 - 8 bit). The software was also somewhat limited and the accuracy was questioned. The current system, CEREC II, uses both the diamond disk and a 2 millimeter diameter diamond point. The resolution has been doubled to 512 x 512. The software is also much improved, offering more automatic features. It also added the opportunity to define the third dimension of cusp height and groove position. These features are, however, somewhat limited. The system was designed for the chairside fabrication of ceramic inlays and onlays. More recently software has been added to allow the fabrication of crowns. Obviously the internal accuracy of such restorations is limited by the cutting tools available. More information may be gleaned from the Sirona web site at: http://www.sirona.de/e/index2.html.

The Japanese have been very active in the research and development of CAD/CAM programs. The Japanese government has underwritten a substantial portion of such investigations, but private industry has also contributed greatly. The recent introduction of the CAPS (Computer Assisted Prosthodontic System) follows the more traditional concept of CAD/CAM and is an impressive unit that uses automated laser point scanning to digitize the die. The system was developed by Nikon and although it is not commercially available in the United States it was exhibited at a recent dental meeting. Other systems are advertised but not available in the US. An example is a system found on the Internet

Figure 6. The coping is returned to the laboratory.

Figure 7. The completed restoration on the right central incisor. (Courtesy Rotaert Dental Laboratory, Hamilton, Ontario BC.)

Figure 8. The Pikkio Spectrophotometer.

at: http://www.advance.co.jp/dental-cadim/index-e.html.

Noble BioCare, in conjunction with Sandvik, has developed a quite different use of CAD/CAM and redefines the role of the dental technician. The preferred tooth preparation for this all-ceramic system is a chamfer margin. Impressions are made as for a conventional restoration, and the dies sent to the dental laboratory. The dies are then traced by an automatic machine that produces a digital three-dimensional representation of the master die (**Figure 4**). The technician then defines the features of the die, marks the margin, and designs the coping (**Figure 5**).

These digital data are then sent electronically to the corporate laboratory in Sweden. There a die is recreated by the CAM process, but the dimensions of the new die are expanded three-dimensionally to compensate for the shrinkage of the porcelain that will be formed upon it. A process termed "isostatic pressing" is used to form aluminum oxide ceramic onto the die. This process is not possible in a dental laboratory because of the high sintering temperature of alumina. This material is then completely sintered, resulting in an unusually strong ceramic coping (**Figure 6**).

This material is, however, opaque, and the completed restoration is veneered to achieve the desired esthetic result. This, of course, requires the same technique and skill needed for any other esthetic ceramic restoration. Excellent functional and esthetic results are possible (**Figure 7**). More information on the Procera system may be found at: http://www.nobelbiocare.se/acomp/procera.htm.

Computed Color Matching:

Every dentist who places esthetic restorations has at one time or another been frustrated by the process of trying to match the color of natural teeth with ceramic or resin restorations. Conventional shade guides have severe limitations, both in design and in product execution. Even the latest iterations of shade selection systems do not cover the dental shade range. It would seem that in today's highly technical world we should be able to develop a computer-based shade selection device. After all, there are spectrophotometers at the local paint store and automobile paint shops use a spectrophotometer for your car repair. Why doesn't the dentist have one for shade selection? Unfortunately, the dental color measurement problem is very complex. It has been said7 that the dental shade selection problem is the most difficult of all color measurement situations. Teeth have every difficulty that can be encountered: they fluoresce, are inhomogeneous and translucent, and have small, irregular surfaces. In the past, several devices have attempted to solve the instrumental approach to dental color measurement. All failed. Today there are several devices that are presently, or soon will be, offered to the dental profession. "Pikkio", (**Figure 8**),

a development of a Swiss and Italian venture, briefly entered the marketplace and is currently being refined. It is a hand-held unit that can be downloaded to a computer. The device gives the user the closest Vita® shade guide, and the amount by which the tooth varies from it. Additional information may be found at: http://www.mht.it/.

Wolf Industries of Vancouver, BC (http://www.wolfindustries.com) will soon market a device that provides the nearest match to both the Vita® and Ivoclar® shade guide, and the amount by which the tooth differs from the guide (**Figure 9**). Shofu Dental Corporation is said to be ready to offer a device researched by the group at Iwate University in Japan. The exact software behind this device has not been released as of this writing. The appearance of multiple devices attempting to solve this problem is testimony that the scientific community recognizes the need for assistance in dental shade selection, and the willingness to underwrite the development of a solution. In addition to the devices cited, several others are known to be under development. Certainly, most restorative dentists would welcome reliable technical support in shade selection and color matching. However, the device would

be most helpful if it not only correctly analyzed the tooth color, but also the optical properties such as translucency and surface gloss. Restorative materials correlated to these readings should then be developed to optimize predictable results.

Figure 9. Wolf Industries DCS Spectrophotometer.

Intraoral Cameras

There is no doubt that the greatest success in digital dental adjuncts has been the acceptance of intraoral cameras. It is estimated that approximately 45 percent of the dentists in the US have intraoral cameras. The market growth has slowed, but to many practitioners, the intraoral camera is an essential part of the clinical armamentarium. When intraoral cameras were first introduced they cost $25,000. Today cameras can be found for under $2,000 and up to almost $10,000. Initially, all cameras were cart based. The idea was to move the cart with the camera and a printer (and, perhaps, a computer) from operatory to operatory, as it was needed. While the concept was simple, the implementation was not, and dentists soon found that the "mobile" cart was awkward, and was rarely moved. Today's intraoral cameras have become progressively smaller, easier to use, and more "user friendly" (**Figure 10**). Many intraoral cameras allow the placement of docking stations and only the camera is moved from room to room. Most dentists that have found the practicality of intraoral cameras have made the investment in multiple units to solve the problem of availability, and have networked the units to a single printer.

Although there is a substantial price variation, purchasers should evaluate their needs, and consider price versus performance. There are at least 20 vendors today, and the same product may be sold under different brand names. Networking the operatories permits using one camera in multiple rooms, or to file images on a server from any room. Some cameras have an on-board chip that precludes the need for a computer to print images on a centralized printer. If images are to be filed in the computer, a digitizing board is needed to capture images from an analog camera. Actually, all images are initially digital, as they are acquired from a CCD (**Figure 1**), and converted to analog format for display. Digital cameras preclude the need for a digitizing board.

There are numerous cameras with various features and preference for a given camera may be an individual matter. Many factors should be considered.8 The camera should be easily focused, produce a clean, sharp, true-color image, and be protected from cross-contamination. Cameras should be able to capture an image of a complete arch, and be capable of focusing down to a single tooth. It is helpful if the camera is activated upon being picked up. A number of cameras are now cordless. This is a convenient feature, but it may limit the brightness, since there is no fiberoptic connection to an AC light source. The most productive way to explore each system is to surf the Internet sites and review the merits of each product and then ask for local demonstrations of selected products. Table I provides the source, product name and web site address for a number of cameras. As with all products that require a substantial investment, it is recommended that prospective buyers request a list of previous customers who can be contacted to ascertain their appraisal of the product.

Figure 10. Intraoral cameras have progressively decreased in size from the original cart-based systems to the recently introduced hand held wireless portable model with self-contrainedd monitor focusing.

Typically, images are filed in the patient's record and should be easily accessible, just as radiographs are filed. Image management software is helpful in modifying images, and simple maneuvers such as cropping, rotating, changing brightness and color balance are found in most basic programs. Cosmetic imaging software which enables altering the image to help plan the treatment outcome can also be helpful. Such programs have a significant learning curve, and to make the process more productive, it is often delegated to a non-dentist employee.

An intraoral camera in the hygiene area is of great help. Patients can see their original condition and be shown where they are lax in their oral care. Areas of concern can be recorded and filed, either as photographs printed and appended to the chart, or filed digitally in the patient's virtual chart. The dentist can then review the images when the patient is being treated.

Images may also be transmitted to the dental laboratory with the casts and work request. This is particularly helpful when anterior esthetic restorations are

TABLE 1.
Intraoral Camera Resources

SOURCE	PRODUCT	WEB SITE ADDRESS
Air Techniques	VistaCam Omni	None
Computer Age Dentist	CADcam	http://www.computeragedentist.com/software/CADcam.html
Cygnus	Cygnascope 500, Oral Vision 1000	http://www.zila.com/cygnus/index.htm
DMDS	Telicam, Telicam Elite	http://www.dmdcorp.com/telicam.html
Dentsply (New Image)	AccuCam Concept III	http://www.dentsplynewimage.com/acucam_concept3.html
	AccuCam Polo	http://www.dentsplynewimage.com/acucam_polo.html
Dent-X	Sens-a-View	http://www.dent-x.com/SensaView.html
Digital Doc	DigiDoc AIntroral	http://www.digi-doc.com
Doctor Direct Sales	Opticam	None
Integra Medical	ViperCam	http://www.vipersoft.com/(under construction)
Planmeca	Intracam	http://www.planmeca.com/eng/prod/prodcat/crframes.html
RF Syste Lan	Satellite Scope	None
Schick	CDR Cam	http://www.schicktech.com/techspec.htm#cdrcam
SpectraVU	Spectra Vu 1000,2000	Web site not operational currently
Sullivan-Schein	Easy Cam Ultralite II	http://www.henrytschein.com (Web site not specific for camera)
Trophy	STV	http://www.trophy-imaging.com
Ultracam	Ultracam	http://www.ultracam.com/products.html
Video Dental Supply	Quickcam 4.1 Oral Videoscope ViperCam	http://www.videodental.com/cameras/htm
Welch-Allyn (Patterson)	Reveal SLR Reveal MLR	None

requested. Video images and radiographs may also be sent to other dentists to whom the patient might be referred.

The absolute ease of appending images to e-mail messages should not be overlooked by practitioners. In moments an image can be acquired, filed in the patient's record, and sent to another dentist, the dental laboratory, or to the third party payer. There are many additional methods of transmitting images via computer, and as modem speeds increase, the time of transmission becomes more reasonable.

Dentistry is a very "visual" profession and the intraoral camera is a valuable communication tool. Patients become interested in how, rather than if, to treat their condition, resulting in increased practice income. Image acquisition and storage is also a useful tool for documentation, and provides a record of the sequence of therapy.

Periodontal Devices

Crevicular depth probing is an essential diagnostic procedure to determine relative periodontal health. It is also time-consuming and often neglected. It would seem that a device that could automate this procedure would meet with rapid clinical acceptance. Even though such devices have been available for years, they have yet to find substantial commercial success. Several such devices are available, and have documented accuracy.[9] Many devices have been marketed under different names, as some companies have failed to maintain economic viability and have been acquired by others.

Perhaps as the computer finds its way into the clinical operatory for other applications, the automated periodontal probe will finally become more feasible. Certainly, the digitization of probing facilitates recording, since a single individual can make the record without picking up a writing instrument or calling out the probing depths to an assistant. Automated probes deliver a calibrated probing pressure. Furthermore, the results are charted, and the various systems have differing methods of presenting the results to the patient. With at least one system, the computer calls out the recordings in either a male or female synthesized voice, obviating the need for the operator to look up at the monitor during probing. Bleeding and suppuration are also entered.

Patients have a much better comprehension of the procedure when they can see a graphic result, which seems to result in a greater interest in their periodontal health. Three web sites are worth checking for further information on periodontal probing:

- Florida Probe http://www.floridaprobe.com/
- Interprobe http://www.interprobe.com/
- Probe One, Interprobe americandentaltech.com/probe.html

Some devices are dependent upon the computer for recording information while others offer a stand-alone solution. The most effective use is the total integration into a virtual patient record.

Conclusion

There are many other devices that are available for use in the dental operatory. The success of the ventures underwriting these devices is dependent upon the migration of the computer into the treatment area. As this happens, the individual devices become less onerous to incorporate into the treatment regimen. This paper has not addressed the subject of practice management or clinical record software. Dental software acceptance is critical to the overall implementation of digital devices. Integration of all devices with the patient record should be seamless, transparent, and obvious. As more dentists become comfortable with computer use, the integrated use of digital devices should escalate, and patient care should be simplified and improved. The Internet is a valuable tool for accessing information on many dental topics and should be used by any dentist that wishes to obtain current information on a wide variety of topics. The half-life of knowledge is increasingly shorter and it is the obligation of all practitioners to update the information upon which their practice is based.[10] The opportunities for electronically refreshing one's knowledge base are rich and deep. No professional person should overlook this resource.

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Superior Service With a Smile

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I'm fidgeting in the produce section of the supermarket, palpating melons with the density of bowling balls, trying to extract an edible tomato from a three-foot pyramid without causing an avalanche, and wondering on which agricultural disaster I can blame the $1.69 unit price of the adjacent avocados.

"May I help you with something, Sir?" I look up just in time to catch the full impact of an employee-generated million-kilowatt smile. Looking behind me, I conclude the full force of all 32 teeth is beamed directly at me since there's no one else nearby. What would you do? Of course, me too; we're all dental professionals here. I nimbly close the distance between us, peer intently at her teeth and reply, "You have a lovely smile. What did you have in mind?" That's when she calls the manager.

I'm willing to take a little of the heat here since dentists have been plugging cosmetic smiles as a raison d'etre, but the blame for this aberration of our good intentions must be placed on the corporate shoulders of Safeway, North America's second-largest supermarket chain. I could have saved myself the humiliation of being ejected into the market's parking lot if I had only read the Associated Press article appearing in the paper the other day.

It appears that some bright MBAs convinced Safeway management about five years ago that a "Superior Service" policy should be implemented as the alpha weapon in the perpetual supermarket's battle for customer attraction. Double Coupons wasn't enough; Reward Cards and Three's A Crowd didn't do it. Even strict enforcement at the "10 Items or Less" checkout station was failing to cement customer loyalty.

So Safeway began phasing in its new policy in which employees are "expected to anticipate customers' needs, take them to items they can't find, make selling suggestions, thank them by name if they pay by check or credit card and offer to carry out their groceries."

Obviously, this 180 degree shift in the traditional customer/clerk relationship that has existed since World War II (Wassamatta witchoo? Don't you know there's a war on?) has not been entirely satisfactory from the service personnel's standpoint.

Since January, the market chain began to enforce compliance with the "Superior Service" directive by using undercover shoppers waving sheaves of manufacturers coupons, caroming off each other with their square-wheeled carts. Bosses warned employees that negative evaluations could be serious enough for them to be given the sack and they didn't mean paper or plastic.

Recently a dozen women and one lonely male expressed their disapproval of company policy to Safeway executives. Richelle Roberts, a produce clerk, said she is hit on every day by startled men

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who think she is coming on to them. The lone male who smiled too well, if not too wisely, was pursued by a middle-aged lady pushing a walker. She offered to buy him anything he wanted from the shaving cream and after-shave section.

"You can't make eye contact with these guys," the women clerks averred, "and no way we're going to carry groceries out to a man's car." Roberts complains, "Let me decide who I am going to say hello to with a big smile." The workers' union has filed charges with the Labor Relations Board and battalions of lawyers are smiling without being asked.

This is a sobering turn of events. We dentists had no idea when we started pushing the Perfect Smile as the logical entitlement for every man, woman and child that it could turn out to be a two-edged sword. Are we going to have to issue an owner's manual with every set of porcelain veneers warning about the potential for misuse? What's our legal liability here? Perhaps we should consult the Maybelline people who must have had similar problems with eye enhancement.

In the meanwhile, if approached by a clerk intent on implementing the Superior Service policy, beat a hasty retreat to the automotive section and protect yourself the best you can with the $7.98 ball-peen hammer with the genuine simulated walnut handle and hand-forged pot metal head ($6.75 with your card).