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Dentistry and CAD/CAM: Another French Revolution

Dr. Francois Duret, with the development of the laser probe, has now brought to dentistry computer-assisted design/computer-assisted manufacturing.

Arthur G. Williams, D.D.S., F.A.C.D., Editor

At the 40th International Educational Congress of Dental Technology, I believe that I experienced a preview of the future technology of our profession. Dr. Francois Duret, a dentist from France, made his first American presentation of his "Computer-Assisted Design of Dental Restorations" and the "Computer-Assisted Manufacture of Dental Restorations;" the CAD/CAM of Dentistry.

As trite as it may sound, as I sat waiting for the start of the program, I had the opportunity to observe Dr. Duret, a highly animated man. I could not help but compare Dr. Duret, a slight man with metal Ben Franklin glasses, a small mustache, rumpled dark hair, and a cane to aid in walking, with another Frenchman who changed the course of the world's health, Dr. Louis Pasteur. It may be that Duret's impact on the field of dentistry may be as profound as Pasteur's was on medicine.

Duret has developed, over the past 15 years, a technology that combines the computer and milling machine. In brief, the CAD/CAM system allows for the use of a computer to design and a milling to form a crown, inlay, onlay, or denture.

A laser or scanner probe about 10 inches in length and 3/4 of an inch in diameter, developed by Dr. Duret, is directly attached to a computer. There are two techniques that can be used with the laser probe and computer.

When using the first technique, the probe is placed in the patient's mouth and various "pictures" are taken of the area to be treated. In this instance, Duret is about to prepare a lower right second bicuspid for a crown, so the probe is placed over each area, buccal, lingual, lateral, and various angles of the marginal area. "Pictures" are taken and sent to the computer for storage in the memory bank. The tooth is then prepared in the normal manner using diamonds and burs. After the preparation is complete, the probe is reintroduced into the patient's mouth, and a series of "pictures" of the preparation are taken. These pictures are fed into the computer for storage in the memory bank. Duret then operates the computer to design the crown that is to be fabricated by the milling instrument that also is attached to the computer. He makes various entries as he designs the crown, connecting various points so that the crown will be compatible with

the environment, leaving a predetermined amount of space for the cementing media.

When using the second technique, the tooth is prepared in the usual manner, and "pictures" are taken of the preparation. The computer is instructed by the dentist as to which tooth is being prepared. In the case of the example which was shown in New York, it is a lower left second bicuspid. The computer has stored in its memory the configurations of 32 adult teeth. It then takes out the one for the lower left second bicuspid and alters this ideal configuration to meet the size of the space in the patient's mouth. If the dentist wishes, he or she can alter the design on the screen. In the example, it is shown that moving the interproximal contact points, as well as the altering of the occlusal surface, could be accomplished.

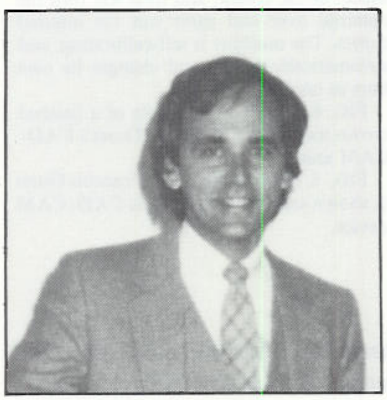
In the example, the tooth is designed as if on an Hanau articulator. If the dentist prefers, the computer can modify the way it designs the restoration so that the results are exactly the same as if it were made on any other type of articulator.

In fact, if the dentist wishes, it is possible to go beyond the static bite relationship which was demonstrated and take a dynamic occlusal record. It is possible for the computer to track the actual movements of the mandible. As such, it can go beyond any present day articulator using the equivalent of an infinitely adjustable articulator.

This ability alone is enough to insure that the restorations being created by the CAD/CAM will transcend the present limits of day-to-day dentistry for the majority of dentists.

After the design was finalized, the computer activated the attached milling machine and, from a solid block of Dicor material, a crown was fashioned. The milling machine changed cutting tools automatically, and fabricated not only the external surface, but the internal surface as well. The fit of the CAD/CAM crowns have a tolerance of 2–20 microns, whereas the average fit of the lost wax technique has a fit tolerance of up to 200 microns. Various materials, including metal, can be used in the milling machine.

The crown preparation, milling machine operation, and insertion that were seen on video tape was completed in 50 minutes from beginning to end. No impression is taken, no temporization, no bite registration, no second visit. It is a fact that I did not see the actual procedure, but, rather, a video tape. I did not test the fit, the margins, or the occlusion, but the impact made by this CAD/CAM procedure was tremendous. Its affect on the field of dentistry and the allied dental laboratory will, I believe, cause a revolution of a monumental nature. It is with this thought in mind that I conducted an interview with Dr. Gerald McLaughlin, American dentist, who has more knowledge and background in CAD/CAM than any other person on the American dental scene.



In September, 1981, Dr. McLaughlin was the first to publish the technique of etched metal bridges in the scientific press. He was also the first to publish the etching recipe against which all others are currently measured (that of Rexillium III and sulfuric acid). He also developed the One Step etch technique, slotted technique, and a number of other innovative procedures.

He has lectured in eight universities and presented over a hundred seminars all over the world.

He is the author of two books, "Questions Patients Most Often Ask Their Doctors," published by Bantam Books, Inc., N.Y., in 1983, and "Direct Bonded Retainers—The Advanced Alternative," published by the J.B. Lippincott Company, Philadelphia, in 1986.

He is a Clinical Instructor, Department of Pediatrics, New York University College of Medicine, since 1982, and a Clinical Assistant Attending, Department of Oral Surgery, Bellevue Hospital, New York University College of Dentistry, since 1985.

He attended New York University College of Dentistry from 1968 to 1972. Dr. McLaughlin has been in private practice since 1975. He is a member of the International Academy of Dental Research, American Academy of Dental Research, and American Dental Association, among numerous other affiliations.

Interview with Dr. Gerald McLaughlin

1) *How long have you been involved with this work?*

I first became involved with computer-assisted dentistry in 1977, when a friend of mine in a computer club described a process which he was developing, known as "solid photography." Using his "solid photography," it was possible to eliminate the casting process of making crowns. To do this, the dentist would prepare a tooth for a restoration and take an impression in the usual manner. Next, a model was poured. A wax-up was then made, and a computer "photograph" was taken of the wax-up. The computer then operated a milling machine to cut a duplicate of the wax pattern from a block of metal. This finished crown would be a "solid photograph" of the original wax-up.

Then in January of 1986, while teaching in France, I met Dr. Duret. After talking for several hours, Dr. Duret asked me to collaborate with him on his CAD/CAM project.

2) *Why does Duret seem to look down on the use of the x-ray to check fit, since it is a basic tool used by dentists at this point to do it?*

You must remember that the x-ray is simply a sophisticated shadow picture and subject to all the distortions of shadows. Just as your shadow changes length depending

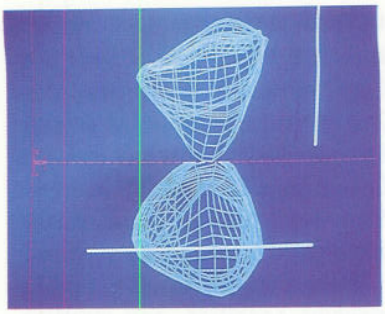
on the time of day, so too are there changes in the apparent size of objects being x-rayed. The distance between the film and the tooth, the tube and tooth, and the angle of the central beam all conspire to make for variations in the apparent size and shape of objects being x-rayed. In situations where direct observation is not possible (such as in the mouth), dentists must settle for this type of indirect and relatively inaccurate information for diagnosis. When direct measurement is possible, however, it is far more accurate.

3) A) *What are cost factors of the equipment both for the lab and the dental office? B) How can this system be used when part of it is in the dental office and part of it is in a commercial laboratory?*

A) The final cost factors have not yet been determined. Fortunately, however, there has been a clear pattern over the last 20 years regarding the cost of high technology. Every year the technology gets better, and less expensive. I would expect the costs of this type of equipment to follow the same pattern. What is an equally good question is "what is the value of this equipment"?, and for that question I think only the individual dentist or laboratory can answer.

For the dentist, what would it mean to your practice to be able to have a completed denture that need fewer adjustments completed in, possibly, a single visit? What would be the effect on your practice if your bridges could be completed in a single day? What would be the effect on your practice when patients find out that impressions are no longer necessary at your office?

And for the technician, what would be the effect on your costs if you didn't have to have any pickups, but instead had the "impression" and bite that the dentist's optical scanner took sent over the telephone? What would be the effect on your business if you could have crowns, bridges, and dentures delivered less than an hour after the order came in over the telephone?



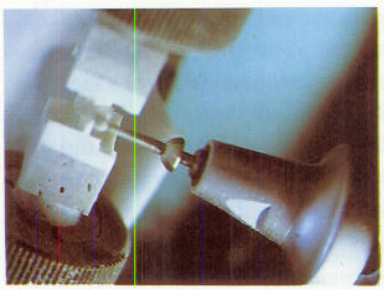


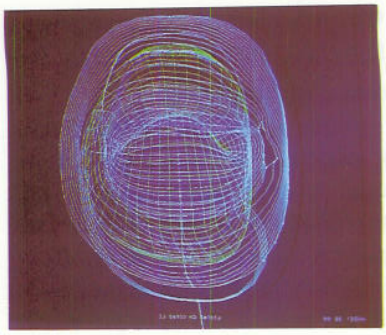
FIG. 1. (*top left*) Two computer views of the suggested tooth design. This can be used as suggested, or modified by the dentist via the keyboard.

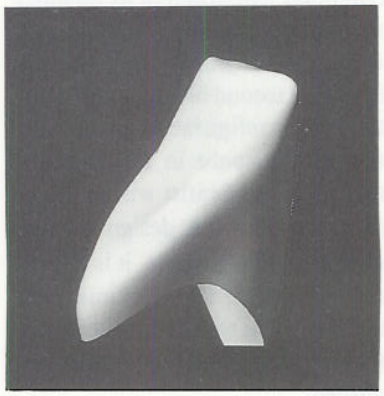
FIG. 2. (*top right*) On occlusal view of the suggested design of the crown. Both the internal and external views are superimposed. The operator can determine the exact amount of space which will be left for cement.

FIG. 3. (*left*) The milling machine has begun to carve the crown from a solid block of material. It will first carve out the external aspect of the crown, and then will turn the material over and carve out the internal aspect. The machine is self-calibrating, and automatically selects and changes its own burs as needed.

FIG. 4. (*right*) An example of a finished crown manufactured by Dr. Duret's CAD/CAM unit.

FIG. 5. (*bottom right*) Dr. Francois Duret is shown seated in front of his CAD/CAM device.





These are all very exciting questions, and their answers will only come with time.

B) If a laboratory is working with a dentist that has none of the equipment, it will be possible for the laboratory to simply scan the impressions with the laser probe, and have the computer do the rest. If the dentist invests in a laser probe, computer, and modem, it is possible to eliminate the impressions. In this case, the dentist would scan the teeth with the laser probe, and the data would be sent to the laboratory over the telephone lines. The laboratory would then be able to return the finished restoration that same day.

4) *What is the time needed for dentists and technicians to learn the use of the probe, components, and milling machine?*

It takes about 2 days.

5) *What is the future of the laboratory technician in dentistry? Are their days numbered?*

You have asked a very important question. I think the future of the laboratory technician will continue to be exactly what it has been in the past. In other words, the future will be whatever the laboratory technicians make it to be.

The situation which the technicians face with this marvelous new technology is the same one which dentists have been facing for the last decade.

So, I predict, will be the future of dental technicians. Those who choose to utilize the amazing new power of "laser- and computer-guided dentistry" will surely profit from it, and those dental technicians who choose not to utilize this technology can also have a significant place in dentistry. Not all dentists will own a laser probe. Many practices will simply not be big enough to warrant owning such equipment. Other dentists will prefer to work with the old familiar materials and methods. Many dentists will simply feel more comfortable writing laboratory prescriptions than having a dialogue with a computer.

Those labs who choose to use the new technology will also be able to provide a unique and valuable service. Accuracy can be improved, speed can be enhanced. Further, the decrease in adjustments, remakes, and pick-ups, as well as the use of newer, cheaper materials, should allow for a lowering of fees at the same time. The development of such a "high-tech" laboratory will allow a formidable advantage in the marketplace over the laboratory of today.

I would also confidently predict that the most successful laboratories of all will be the ones who learn to use the new technology to provide faster, more accurate service, but utilize the time that the machinery frees for them to create a close relationship with the dentists they serve. This "high-touch/high-tech" combination will not be for every laboratory. But those laboratories that manage to create such a combination will be the biggest winners of tomorrow.

In short, the introduction of this marvelous technology has simply accelerated the changes that are already taking place in the dental laboratory industry. Everyone knew that this sort of thing was coming. What most technicians have not realized is just how soon and how great the changes will be in tomorrow's laboratory. The introduction of this new technology has made it clear that, just as in the broadway show "Annie," tomorrow is always only a day away.

6) *How will CAD/CAM effect the dentist and his future?*

It is clear to me that CAD/CAM will be an important part of the future of dentistry. It will allow the dentist to provide a faster, more comfortable, and more accurate service for his or her patients. It can also lead to a higher level of satisfaction on the part of those dentists who seek greater control over the fabrication process of dental prosthesis.

The amount of time necessary for certain procedures will diminish dramatically, and this will either allow the dentist to be more productive or have more leisure time. In addition, it may prove cost-effective for dentists to lower the fee for some services, while, at the same time, receiving more profit. This, in turn, may have the effect of increasing the patient demand for certain services.

As CAD/CAM in dentistry continues to develop, machines will be made which are capable of assisting the dentist in preparing teeth for prosthesis, or even taking over the tooth preparation itself. When these units become practicable, the impact of CAD/CAM will be even greater. The role of the dentist will increasingly become one of diagnostician and treatment planner, and less of tooth mechanic.

We must also remember that there surely will be many other developments beside CAD/CAM which will impact on the future of the dentist. And none of these changes will occur overnight. Still, it is clear that change is occurring at an ever-increasing rate, and the future is now closer than ever before. It is a very exciting time.

Future Notes from Dr. Williams

In the April/June, 1987, issue of the JDPA, I will have further information on this exciting new idea. I attended a 2-day meeting sponsored by Dr. Omer Reed that featured Dr. Francois Duret, as well as other men and women representing some of our dental schools that are involved in this type of research. I will bring reports from these universities, and possibly from the Armed Forces that are also working in these areas.

In addition, I have had the opportunity of listening to Dr. Werner Mormann and Dr. Marco Brandestini of Zurich, Switzerland, present a paper, "Chairside Computerized Dentistry." This paper, though similar in approach to Duret's, has significant differences.