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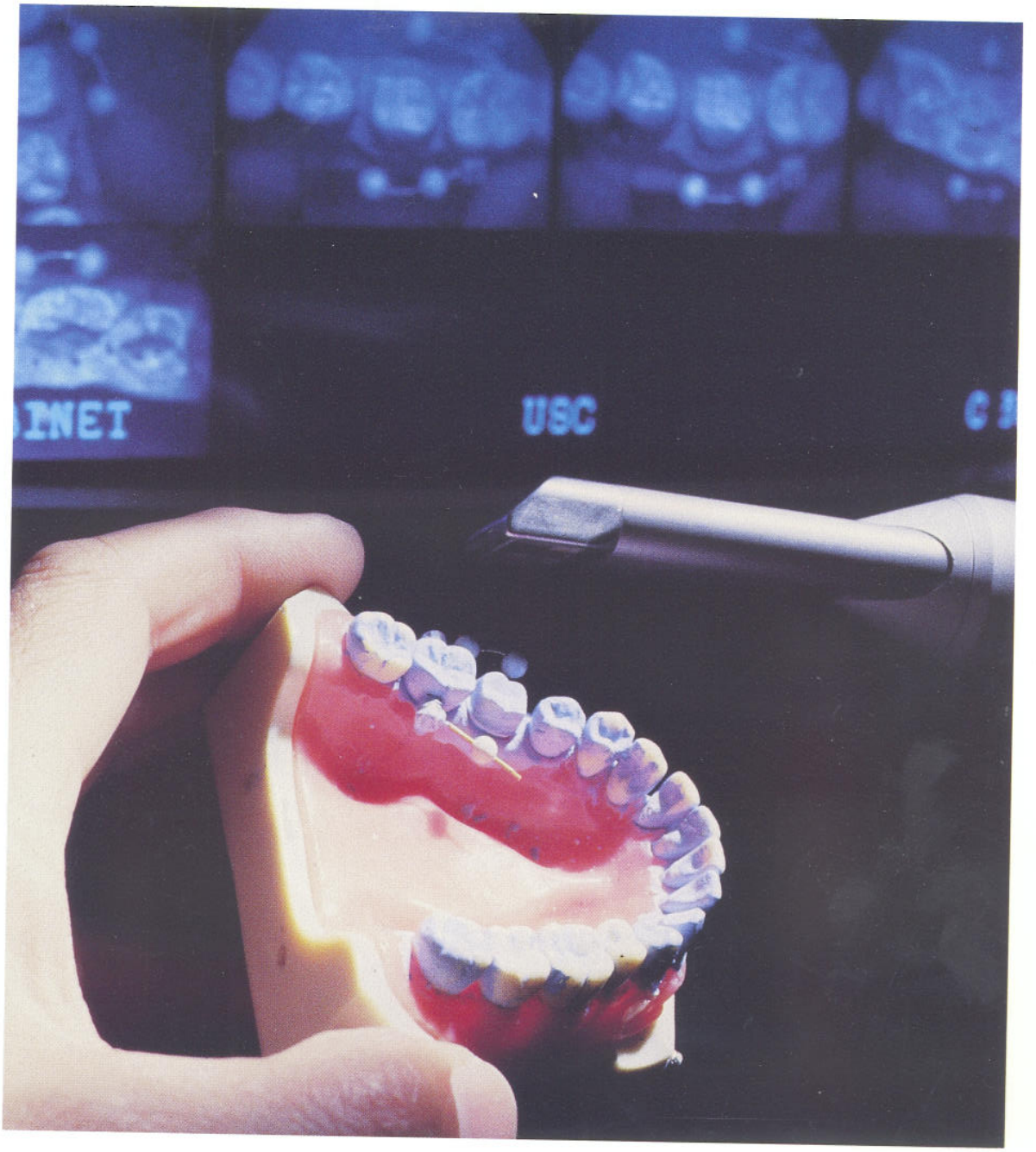

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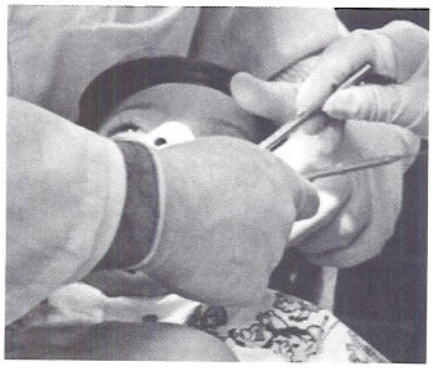
USC DENTISTRY

University of Southern California School of Dentistry Spring 1990



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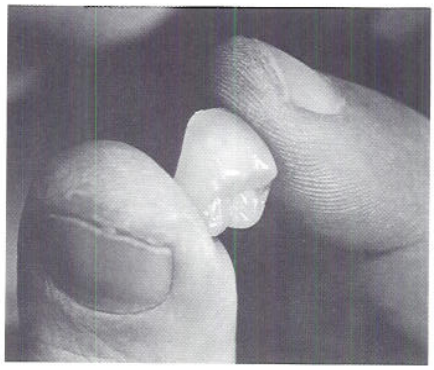

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FEATURES

DEPARTMENTS

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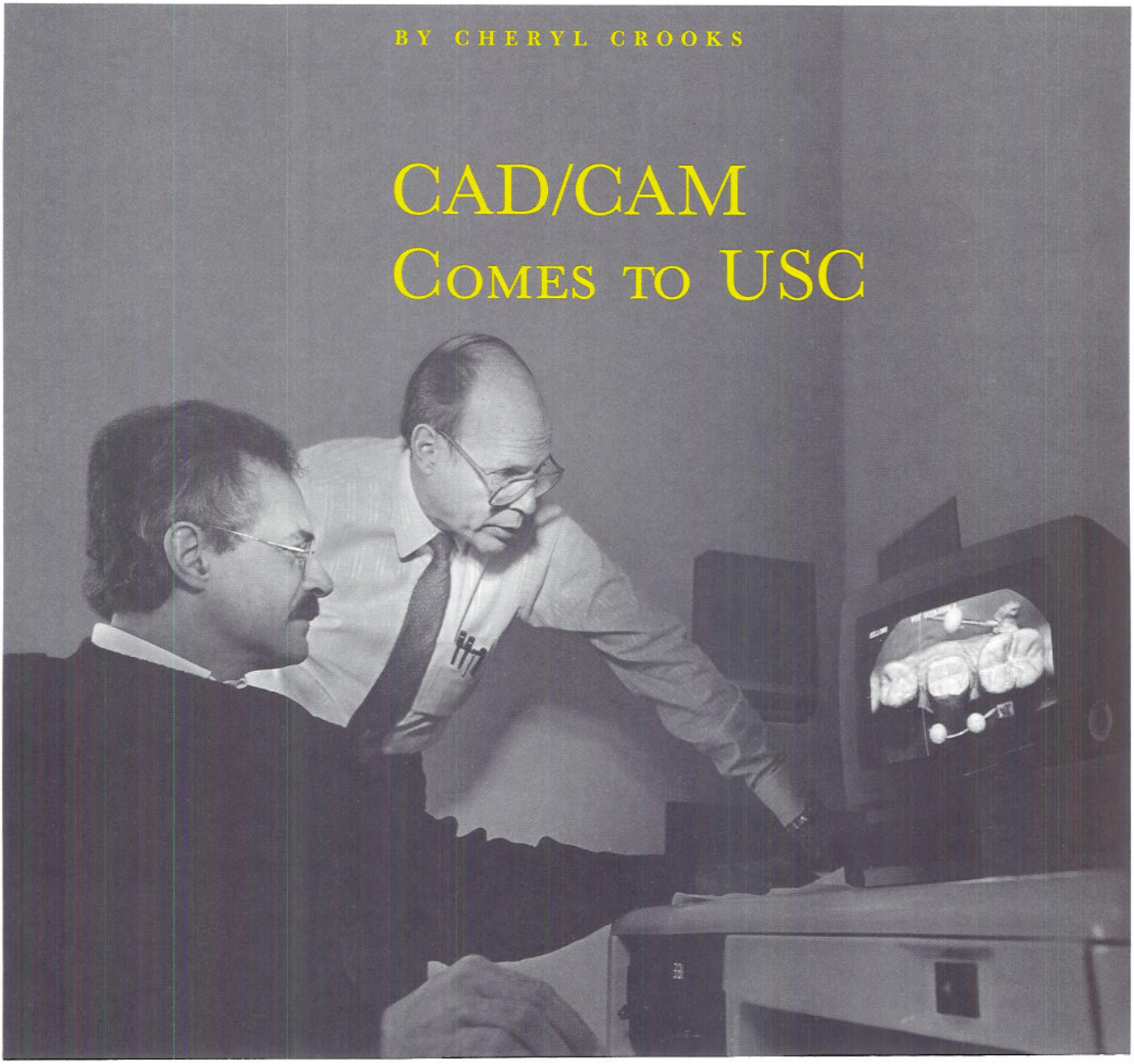
BY CHERYL CROOKS

CAD/CAM Comes to USC



Co-directors of the Dental Imaging Section at the USC School of Dentistry Francois Duret, D.C.D., Ph.D., research professor of dental imaging (left), and Jack D. Preston, D.D.S., the Don and Sybil Harrington Foundation Professor of Esthetic Dentistry, inspect computer image of a restoration in progress.

For the past fifteen years, a revolution has been quietly brewing in the remote country village of Le Grand Lemps, 45 kilometers northeast of Grenoble, France.

The agent of this revolution is Francois Duret, D.C.D., Ph.D., USC research professor of dental imaging, who—with his wife, Elisabeth Duret, D.C.D., and a friend—formerly conducted the only dental practice in that peaceful Alpine farming community of 2,000. His revolutionary concept constitutes a contribution to dentistry that will likely change the practice of restorative dentistry throughout the world.

Duret's objective was to assist dentists in crafting precision-fitting dental restorations, by combining the latest innovations in the realm of computer sciences with the decades-old artistry of dental reconstruction. The system he has developed makes creative use of recent technological advances in computer-assisted design/computer-assisted machining (CAD/CAM), which were initially developed for use in the tool and die industry.

Applying these techniques to the field of dentistry, however, was no

simple matter. Indeed, in its earliest stages of development, Duret's notions were considered so innovative that his former superiors at the French University of Lyons dismissed them as sheer nonsense. Today, in its final stages of development, Duret's system promises to reduce or eliminate the need for many dental impressions, while enabling dentists to produce better-fitting restorations in less than half the time traditionally required.

In place of the impression customarily used to determine the shape and dimensions required for a restoration, Duret's system employs a computerized laser optical imaging device called an 'electronic moire system.' To establish the proportions of a restoration, the dentist begins by taking a series of 'snapshots' of the prepared tooth, using a hand-held laser imaging probe triggered by a foot-pedal. Typically, ten images are needed for a single crown; as many as twenty may be required for a fixed bridge.

Data gathered by the laser probe is automatically digitized—translated to a series of numerical values—and entered into the system's computer, where specially designed software selectively records only those coordinates that will accurately orient the image. "Input errors are virtually non-existent, since the computer will accept only those images that have been accurately recorded," says USC Professor of Restorative Dentistry Jack D. Preston, D.D.S., the Don and Sybil Harrington Foundation Professor of Esthetic Dentistry and co-director of the new Dental Imaging Section of the school's Department of Postdoctoral Studies.

Once the data has been recorded, the computer compiles and unifies the information of each 'snapshot' to generate a single visual representation which may be displayed on a monitor. The resulting image uses a moire information pattern to establish the surface boundaries of the tooth, following its curves and edges precisely to create a three-dimensional projection resembling a wire mesh.

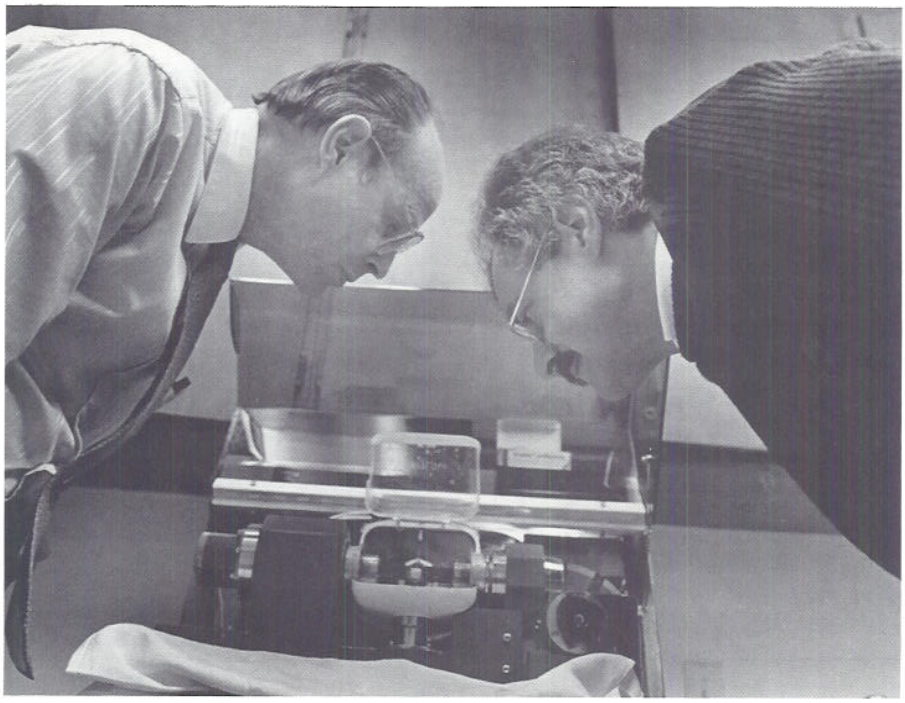
The system's software also enables the dentist to design and produce a complete restoration entirely by computer—a capability unique to Duret's system, according to Preston. By manipulating the visual image of the restoration onscreen, the dentist is able to make extremely fine adjustments in the shape and size of the eventual product. Once the image has been adjusted to allow space for cement, it is then overlaid onto the image of the proper tooth stored in the computer's memory, and is altered as necessary for contouring and contact with adjacent and opposing teeth.

When the dentist has completed creating the restoration on the computer, the information is transmitted to a computer-assisted micro-milling machine, which automatically forms the three-dimensional restoration from a block of dental material. To produce the restoration, the system's milling machine uses a series of specialized cutting tools ranging from coarse, for rapid cutting, to fine, for greater detail. Duret recently added two more tools to the machine's armamentarium, making it possible to carve even the secondary anatomy or supplemental grooves on the occlusal surface.

Although the system's micro-milling machine might have used any dental material that can be machined, Duret's creativity did not stop here. "We chose a traditional material for testing," he explains, "but with CAD/CAM, you can use any material. I decided to see what was possible."

The result of his investigations is a new prestructured organo-ceramic that is more easily fabricated than other types of materials, and yet is structured to withstand oral forces. Called 'Ariste,' and manufactured by the French firm, Spad, the new material is made of polyurethane acrylic resin using a siliceous filler. It more closely resembles the structure of a natural tooth because glass fibers running through the material are oriented in the proper direction to take the stresses of biting. "Casting methods would destroy this useful orientation; but micro-milling techniques respect the integrity of the material," notes Duret.

Duret's is one of three CAD/CAM dental systems currently under development. According to Preston, a Swiss system being developed by Mormann and Brandestini is more restrictive in what it enables the dentist to do. It is not fully three-dimensional, is meant only for porcelain inlays, and is linked to a milling machine with only a single cutting tool. This system is presently being used by dentists in the United



Drs. Preston and Duret watch the CAD/CAM's computer-assisted micro-milling machine in action. The machine uses a series of specialized cutting tools to form a complete restoration from a block of dental material.

States and Europe.

Another system, under study at the University of Minnesota School of Dentistry, in Minneapolis, is still a research effort, and there is no projected date for its commercial availability.

Duret's CAD/CAM system is the furthest along and closest to market. In fact, 40 Duret-designed units are currently in operation in France, producing approximately 300 crowns every day.

Duret first considered the feasibility of applying CAD/CAM technology to dentistry in 1971, while he was a student at the dental school of the University of Lyons. His training in biochemistry and physiology, in addition to his dental degree, gave him the ideal broad scientific background necessary to conceive and carry out his complex invention. For the next eighteen years, Duret painstakingly shaped his idea, giving up his original notion of using holography and moire to obtain an impression in favor of laser techniques. He spent ten years refining his concept before beginning to tackle the hardware it would require.

"For me, it was better to work on the concept first, because life can reduce the imagination," says Duret. "I prefer to take a more scientific approach: to develop the concept first, and solve its problems, before proceeding to try the system on patients." Finally, before a large audience at a 1985 dental congress in Paris, Duret used the CAD/CAM system to make a crown for a patient.

As Duret's idea evolved from concept to reality, he began to gain the attention of dental research schools—particularly those in the United States. Among those following his progress was Preston, who first learned of Duret's research three years ago. Through a mutual friend, the two began to correspond. Then, two years ago, they met for dinner on Thanksgiving evening at Los Angeles International Airport. They spoke several times later at professional meetings where Duret was lecturing. Finally, Preston invited Duret to visit and observe the work being conducted at USC.

Changing the practice of restorative dentistry throughout the world

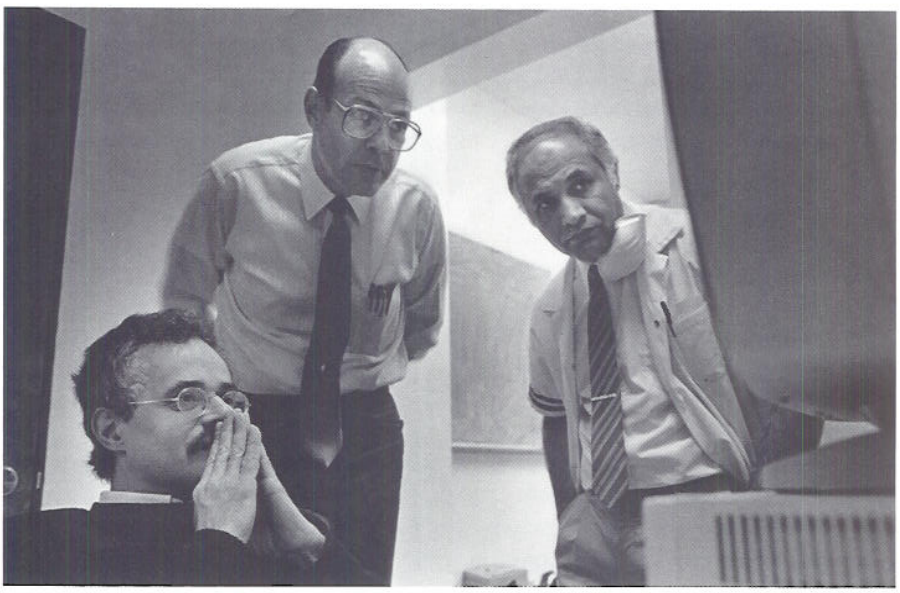
"I had seen the progressive application of computer technology in the dental profession," explains Preston. "It bothered me that no one in the United States was seeking to establish policies for integrating instruction in CAD/CAM dentistry into the dental school curriculum, and there was no American work underway other than the Minnesota system—which was not clinically available."

Duret's research excited Preston. "Why should USC be second to bring it to the United States; why not first?" he wondered. At the same time, it was clear that if the USC School of Dentistry were to play a role in pioneering this new technology, it would require the talents of Francois Duret.

Much to Preston's delight, the school's administration, under the direction of Dean William H. Crawford, Jr., D.D.S., agreed to offer Duret a special appointment as research professor and co-director of the newly created Division of Dental Imaging. Duret accepted the offer, and formally signed a two-year contract with the school in November, 1988. Last August, Duret moved himself and his family to Los Angeles and began setting up his research program at USC.

Duret's first year at USC is devoted to training dental school faculty to use his CAD/CAM system, adapting the system for American use and translating its software from French, writing protocols for patient trials to begin in early 1990, and conducting bench tests of prepared teeth. Training activities in CAD/CAM applications may begin as early as the winter 1990 semester, when the Section of Dental Imaging is scheduled to offer selective courses for USC dental students. Beginning in the fall 1990 semester, the school will also offer a structured curriculum of continuing education courses in computer dentistry, through its Department of Postdoctoral Studies.

Under its agreement with Duret and Hennson International Technologies, the French company manufacturing Duret's CAD/CAM system, USC will have exclusive access to the system's equipment for educational instruction in computer-assisted dentistry. In return, USC will assist Hennson in 'Americanizing' the system and obtaining federally re-



Drs. Duret and Preston demonstrate imaging capabilities of the CAD/CAM system for Fereidoun Daftary, D.D.S., M.Sc.D., clinical associate professor and chairman of the Section of Fixed Prosthodontics at the School of Dentistry (right). Training USC faculty to work with the new CAD/CAM system is among the first challenges to be taken on by Dr. Duret as co-director of the school's new Section of Dental Imaging.

quired approvals and licenses. Hennson will also pay USC to train dentists who purchase the units. The agreement is, as Preston describes it, "mutually beneficial."

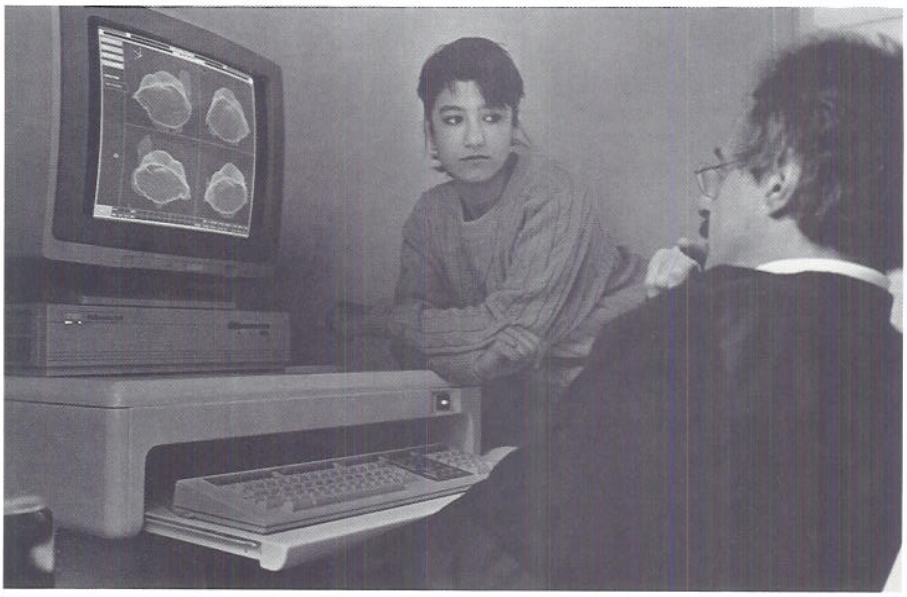
Duret's appointment and the cooperative effort with Hennson is sure to establish USC as the center for CAD/CAM dentistry in the United States, says Preston. "But the credit belongs to Francois; he's the man who has done all the work," he adds. "USC's role in completing development of this system is to help him and to facilitate other aspects of his work."

For the school, Duret's decision to continue his research at USC is a significant leap into the future. Even so, notes Preston, "We have to admit that we cannot yet envision the actual way computer technology will be best applied to dentistry, because computer application is proliferating in many, many respects. But this gets USC in on the ground floor to develop those applications."

USC's ambition to become the nation's leading center for computer applications in dentistry, however, is not without its problems. Oddly, one of the biggest challenges is training faculty to work with the CAD/CAM system. Initially, Drs. Duret and Preston will handle the program's teaching duties. As the program grows and more faculty are trained, additional members will gradually be named to the dental imaging section.

Dental students will also experience an awkward period of transition, during which they will need to learn both the old and new technologies. "The educational system will be severely stressed to teach both at the same time," says Preston. "But it is essential that the nation's best dental schools keep pace with the latest technology. Sophisticated systems such as Duret's must be in the schools so that faculty can be trained, students can be exposed to them, and appropriate courses can be introduced into the curriculum."

In addition, dentists already in practice will have to be taught how to use Duret's system. Not everyone will readily embrace the new technology; some, undoubtedly, will prefer to stick to the older methods. "I imagine that many dentists who have been in private practice for twenty years or more aren't going to want to learn it," Preston acknowledges, "but the person who has been in practice only ten years will undoubtedly seek to overlay abilities with the new technology onto what they already know."



Francois Duret, D.C.D., Ph.D., and research technician Koitherine Pitiot, look over three-dimensional wire-mesh projections of an imaged tooth. The CAD/CAM system developed by Dr. Duret enables the dentist to design and produce a complete restoration entirely by computer.

One factor likely to inhibit dentists from switching to Duret's system immediately is the initial price tag of its equipment, expected to run as high as $150,000. Preston suggests, however, that dentists will find ways to solve this difficulty. "Individual dental practices might be physically clustered around a shared milling machine; or they might share the services of a milling machine located at a centralized laboratory to which they could telecommunicate the specifications of their restorations," he notes. "In the latter case, dentists would need to purchase only the laser probe and desk computer for their own office. These solutions may not be as far away as we think."

Either way, Duret's system is certain to increase efficiency and productivity for the dentist. Because the milling machine can work around the clock, the need for a temporary crown or bridge is eliminated, and the number of patient visits to the office is reduced.

The system also promises benefits to the patient, beginning with an imaging procedure that is less cumbersome and more comfortable than conventional dental impressions. Because the CAD/CAM system individualizes each crown, the method will dramatically improve upon traditional standards for determining a 'good fit.'

Preston thinks that Duret's imaging system will promote better communication between patient and dentist. "The dental office of the not-too-distant future will have two monitors; one for the dentist and one for the patient," Preston predicts. "It's not out of the question that dentists will one day perform the procedure by watching the monitor rather than directing it by hand."

Duret's application of CAD/CAM technology to the dental profession, dismissed as nonsense just a few years ago, is today set to revolutionize the practice of dentistry—both in concept and in the way it is physically structured. As Preston puts it: "This technology provides us with a great deal to think about. It literally takes us into a new era of practice."

OnSite

Harold C. Slavkin Named First Holder of Boone Chair in Craniofacial Molecular Biology

Harold C. Slavkin, D.D.S., professor of biochemistry at the USC School of Dentistry and chief of the school's Laboratory for Developmental Biology, has been named the first holder of USC's George and Mary Lou Boone Chair in Craniofacial Molecular Biology.

The endowed chair, established in 1984 as one of the first endowed chairs of the Campaign for USC, is administrated by the vice president for Health Affairs, Joseph P. Van Der Meulen, M.D., in collaboration with the deans of dentistry, medicine and pharmacy.

In announcing the appointment, Dr. Van Der Meulen said, "It is fitting that the first appointee to the Boone Chair is one of our most distinguished researchers in the School of Dentistry. George Boone, an illustrious graduate of that school, was a practicing orthodontist for many years and has been deeply interested in craniofacial research."

The Boone Chair will support the work of Dr. Slavkin and his Laboratory for Developmental Biology—widely regarded as one of the most important research facilities of its type in the nation. Under Slavkin's direction, a half-dozen faculty and a dozen staff members collaborate on research projects that seek answers to fundamental questions about genetics and postnatal craniofacial growth.

George N. Boone, a member of the USC Board of Trustees, is a 1946 graduate of the USC School of Dentistry and a former San Marino, California, dentist. He closed his practice in 1969 and formed George Boone Associates, a Southern California real estate investment and development firm. He is currently chairman of the board of Boone Fetter Associates and president of the USC General Alumni Association. At USC, he is a presidential member of Dental Associates, and a member of the board of councilors of the School of Medicine. He is a founding member of the Widney Fellows, the support group of the USC Health Sciences; a member of the board of directors of the USC Friends of Fine Arts; and a charter member of the Lusk Center for Real Estate Development in the School of Urban and Regional Planning. He and his wife, Mary Lou Boone, are founding members of USC Presidential Associates. Mrs. Boone, an expert in French faience ceramics and an active volunteer, earned a bachelor of science degree in dental hygiene at USC. Her father, David Lynn Openshaw, and her uncle, Rulow W. Openshaw, both graduated from the USC School of Dentistry.

William H. Crawford, D.D.S., dean of the USC School of Dentistry, said: "Professor Slavkin has spent more than fifteen years seeking answers to fundamental questions in craniofacial molecular biology. In his pursuits, Slavkin has used an easily accessible complex organ—the tooth—and its surrounding tissues as a primary focus for his research."

Dr. Crawford added: "Dr. Slavkin has made and maintained strong professional contacts with orthodontists, oral and plastic surgeons, and other scientists. He will call upon these contacts to assist him in developing activities within advanced orthodontics at USC that will lead to significant clinical research. Faculty members and students will benefit from his leadership. Both groups will have the opportunity to gain access to the considerable resources of the Center for Craniofacial Molecular Biology for the purposes of developing individual and group research capabilities."

Slavkin and his colleagues in the Center for Craniofacial Molecular Biology

Discovery of 'Enamel-Like Proteins' May Aid in Preventing Tooth Loss

Proteins closely resembling tooth enamel have been discovered in a part of the human tooth where tooth enamel is not supposed to be—the root.

They've been named enamel-like cementum proteins. Enamel-like because they share properties with crown enamel yet differ from it in the composition of their amino acids. Cementum because they're found in the cementum, the extracellular tissue that forms the outer layer of the root and anchors the tooth to the gums.

"America's steadily aging population has a growing need to extend the life of teeth," says Harold C. Slavkin, D.D.S., of the USC School of Dentistry. "To a large extent, that means sustaining the life of the cementum that holds those teeth in place or finding a way to use biotechnology to replace defective cementum. Both goals require an understanding of cementum's chemical composition."

Dr. Slavkin and a USC research team discovered the enamel-like cementum proteins by using advanced techniques in protein chemistry to identify proteins on the basis of their sequence of amino acids, the size of their molecular mass, their isoelectric qualities, and their antigenicity (ability to arouse a specific antibody).

"Dental science researchers have spent years investigating the biology of the tooth crown," Slavkin notes. "Very little biochemical research has been done on the root. Very little has been accomplished in that area since the discovery, in the late nineteenth century, of a tissue called HERS—Hertwig's epithelia root sheath—which is responsible for the number of roots on a tooth, for the shape of roots and for the induction of cementum. Though HERS has been known all these years, virtually nothing has been discovered about the substances it produces."

Slavkin says he and his colleagues became interested in the biochemistry of cementum because of two dental