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Computers

'Foolish' concept propels technology

Computers design, mill restorations

By Jim Pinkham
Managing Editor.

Eighteen years ago, Dr. Francois Duret lost his position on the University of Marseilles dental faculty because he was foolish enough to think that computers could help dentists design and make restorations.

Since then, Dr. Duret's ideas have found a foothold.

"You have to be around this man awhile to see how broad he is," said Dr. Jack Preston, a prosthodontics expert and restorative dentistry professor at the University of Southern California. "He's a true genius, and I don't use that term very loosely."

Siemen's Cerec system promises to accurately design porcelain inlays, onlays and veneers.

The dental imagination is now broad enough to envision systems that will make impressions and temporaries obsolete. In the not too distant future, a patient may require a crown, an inlay, an onlay or a bridge and leave the office with it an hour later.

Dr. Duret's system was scheduled for sale in France in late 1988 and is one of five that could reach the American market

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within the next two years.

Optical Probe

All of the systems involve an optical probe that captures an image of the tooth, measures boundaries of existing tooth structure and relays the information to a computer.

With varying degrees of user intervention, the computer then calculates the dimensions of the restoration.

The computer then sends that data to a milling machine linked to the system. The mill cuts and fashions the final product using conventional materials such as porcelains, ceramics, and semi-precious metals and alloys.

Dr. Preston said the Duret system can design and mill crowns in three dimensions with proper anatomical design and proximal and occlusal contacts.

Hennson International of Vienne, France, is marketing the Duret system in the United States, setting up offices in Los Angeles. Jean Claude Haas, chief executive for Hennson's U.S. operations, said the system will be introduced on a non-commercial basis at the Chicago Dental Society's Midwinter Meeting in February.

"We will have one system installed at USC to help us Americanize the product," he added.

A competitor, Siemens Dental, is developing its own computer-based system, Cerec. The Cerec system incorporates several years of research by University of Zurich developers. Siemens officials have also begun demonstrations of their model, which can do inlays, onlays and veneers.

At the University of Minnesota, Dr. Diane Rekow is developing the third prominent system. A biomedical engineer-turned-dentist, Dr. Rekow began exploring computerized manufacturing for orthodontics because "it was a nice synergy and a good challenge." She planned to demonstrate a system in early December that will initially be used to do full crowns.

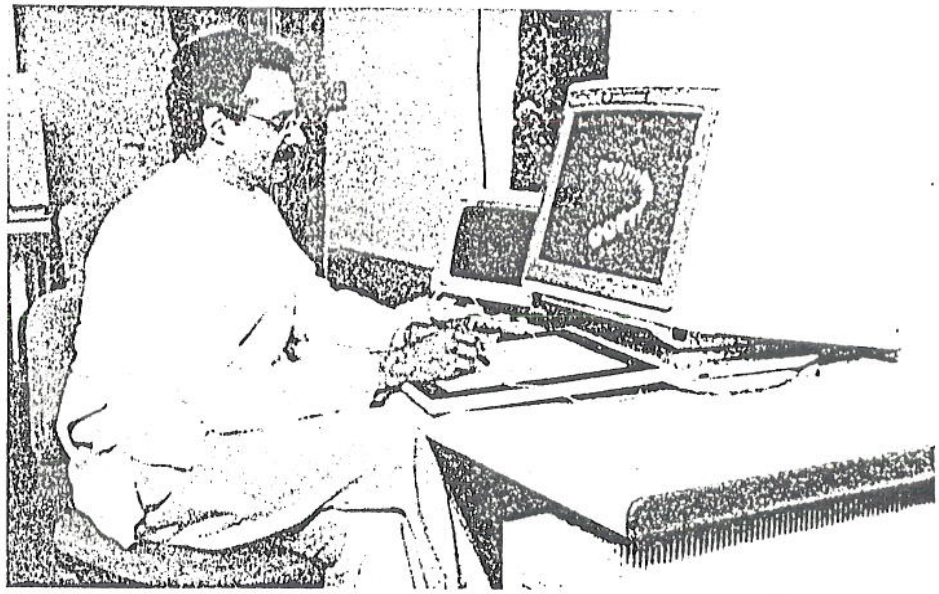
Dr. Reggie Caudill, a robotics expert and professor of mechanical engineering at the University of Alabama, is also working on a system that he hopes will initially be able to cut crowns. Caudill is collaborating on the project with Dr. Earl Hydrick, a local dentist with an engineering background. Several developmental questions still need answers and make it likely that Caudill will finish work later than the others.

The fifth developer, Air Force Col. Bruce Altschuler, enjoys a unique status in the dental CAD/CAM (computer-aided design, computer-aided manufacturing) effort. Dr. Altschuler is a liaison collaborating on dental research with Col. Lewis Lorton of the U.S. Army.

Dr. Altschuler's research originally paralleled the others. But it has since been diverted to a three-dimensional, forensic tooth-mapping project for NASA and all the armed forces. The project seeks to obtain maps for each individual that will enable post-mortem identification from a single tooth.

"Once we have that, we can very easily modify it from a forensic to a CAD/CAM system," Dr. Altschuler said.

Unless civilian interest in a technology-transfer project were to change things, however, Dr. Altschuler faces no constraints to see the technology quickly adapted to commercial dental restorations. When a military version is available, he indicated that it will probably have a sophistication far exceeding any system currently under development.



Dr. Francois Duret developed system to create dental prostheses.

Price Patterns

The price patterns of dental CAD/CAM devices may mimic the personal computer, VCR or compact disk player. Although very expensive at the outset, prices may taper.

"If you're looking at the technology we're dealing with," Dr. Caudill said, "the cost is going down exponentially."

For now, Haas said, the Duret system will be set up and priced on a case-by-case basis. He estimated a $200,000 cost for a complete system.

John Schweiker, division sales manager for Siemens, estimated their system

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will cost $40,000 to $45,000.

Dr. Rekow projected costs for a complete version of her system between $100,000 and $150,000.

Dr. Caudill placed costs for his equipment at $80,000 to $90,000—an estimate that will ultimately depend on still uncertain variables of precision, size, and data storage and management capacity.

Dr. Preston and many of his colleagues anticipate that a dentist may simply buy components of the systems that acquire data, capture an image and display it. The data would then be sent, perhaps via modem, to a lab facility for milling. A group of dentists might jointly own the milling equipment in order to diminish costs.

Expect the partial systems to begin in the range of $5,000 to $30,000.

FDA Review

The Duret system is in the final pre-application stages for FDA approval, which will take at least three months to obtain. Haas said it will be late 1989 at the earliest. Dr. Preston said it could take two years or more.

The Siemens system is pending FDA review. Agency spokesman Dave Duarte said he could not comment on the progress of any pending application, but Schweiker said it will take at least until July and could take until mid-1990.

Dr. Rekow said she hoped her design would be on the market in 1989 and planned to approach the FDA after her December 1988 exhibition. The product will be marketed by Digital Dental Systems, a company formed for the CAD/CAM device and working in conjunction with the University of Minnesota.

Dr. Caudill has made no commitments for marketing and has no definite plans for when he will approach the FDA. "We are probably 1 1/2 to two years from the marketplace," he said.

Dr. Altschuler said he had no idea when his research may translate to a CAD/CAM dental restoration system reaching the market.

Gathering Data

A critical component of each system is the optical sensor that gathers initial data.

The Duret system employs a laser-imaging device that captures a picture of the tooth in three dimensions and also measures mandibular movements across time, according to Dr. Preston. The computer can look at a series of cross sections of the work area and blow up any sections that the user wants to examine further.

Haas said the Duret system employs holography and a derivative of the Moret technology. The Moret system is analagous to several others in that it involves projecting a three-dimensional grid of dots onto an object, viewing it through the grid and obtaining measurements based upon how the object distorts the otherwise flat surface of the grid.

But purely Moret-based systems can be ambiguous. Making surface distinctions, such as between an indentation of the tooth or a transient saliva bubble, can be difficult, Dr. Rekow said.

Dr. Rekow's system also allows cross-sectional, three-dimensional views, using a camera with a specially designed lens and a stereophotogrammetric device. It captures an image that can be digitized and resolved into pixels—yielding 16 million microscopic pieces of data for every view of the tooth. She crafted the system without using a Moret pattern and designed it so that the camera can be replaced as new technology becomes available.

Siemens' Cerec system is another Moret-based product, according to Dr. Karl Lienfelder, a member of the biomaterials faculty at the University of Alabama School of Dentistry. Although it also offers three-dimensional viewing, it does not have the cross-sectional view capacity of some of the other systems, he said. Its miniature camera makes its calculations by obtaining 70,000 pixels, Schweiker said.

Dentists may buy components of the system to acquire data, then send the data to a lab for milling.

Dr. Caudill's optical probe is still in the design phase, but will also employ a camera, he said. It, too, will be Moret-based, but will use a Fourier transform to measure the way in which the object distorts the flat grid surface. He does not know how many reference points the final design will have. He is working on the design with Electro-Optical Systems of California.

Dr. Altschuler's three-dimensional system completely rejects cameras and Moret technology. His system generates thousands of reference points using "structured light." Dr. Allschuler likens it to creating an array of dots and projecting tiny laser beams onto the decayed or broken tooth. His method of coding the beams of light offers a precision impossible with Moret, he said.

Unlike the others, the structured-light sensor can obtain measurements at a distance. It need not be placed in the mouth. Since all of the sensors must be placed in the mouth, they must be sterilizable and fall under the approval jurisdiction of the Food and Drug Administration.

Establishing precision levels has also been a complicating developmental factor.

Accuracy Standards

When it comes to measurements inside the tooth, the accuracy standards are in microns—millionths of a meter.

The internal measurements of the Duret system are reportedly accurate to within 20 microns. Researchers behind the Cerec system suggest a final accuracy of fit should be 50 microns, which requires the Siemens imaging system to be accurate to within 15-20 microns in obtaining measurements. Dr. Caudill is also aiming for that accuracy level. Dr. Rekow hopes to prove her system already possesses that level. Dr. Altschuler said his technology can obtain an accuracy level of 13 microns.

Each system allows the dentist to intervene as desired.

The Duret system, according to Hennson's Haas, is the most automated system available, but the dentist must answer at least 11 questions for the computer.

The Siemens system is designed for the dentist to intervene to check the accuracy of the computer design and to make final decisions about such factors as marginal fit.

The Rekow system allows for user intervention, but it is fully-automated and requires no guidance except in rare cases, which might occur only once in a dental career. They were omitted from the design for cost-effectivness.

The Caudill system, similarly, can be almost fully automated.

Dr. Altschuler said he would seek an entirely automated system, particularly for the initial design phases.

Hennson expects the Duret system to soon adapt to large-scale bridges, pin crowns, attachments, splints and brackets.

The Siemens system may eventually be able to do full crowns and bridges, Dr. Lienfelder said. Schweiker said this is probably five to 10 years away.

The Rekow system will soon be able to do onlays, inlays, partial-coverage crowns, short-span bridges and eventually long-span bridges and maybe denture work, Dr. Rekow said.

Dr. Caudill said his system may eventually do bridges and dentures.

Dr. Altschuler anticipates an unprecedented ability for baseline data that could provide a definitive occlusal theory and a means for wear studies, dental medication evaluations and cleft palate research. In addition, his technology could do crowns, bridges and dentures and virtually eliminate impressions. ■