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New
Technology
and Trends

# EXPANDING DENTAL PRACTICE WITH COMPUTER TECHNOLOGY

Princeton Dental
Resource Center

Introduction of a new software program to fabricate laminates shows promise for expanding the CEREC system's capabilities. The laminates are produced from either Dicor Machinable Glass Ceramic (MGC) or Vita Mark II porcelain blocks, which is advantageous since the wear patterns of these materials are similar to those of enamel. In addition to a significant savings in production time, a major advantage of using the CEREC system for veneer fabrication is that staining procedures are easier than with conventional methods.

The CEREC system has no design capability beyond that described. The diamond wheel that machines the restoration limits its use, and the system is not adaptable for crown fabrication.

### *THE SOPHA SYSTEM*

The Sopha system is comprised of three components: an imaging/recording system, a CAD station and a CAM unit. The imaging system uses a laser camera with a self-contained, charge-coupled device and complex optics. Eight to twelve exposures of all aspects of the preparation are made. To allow the computer to correlate the images, three special spheres are attached to an adjacent tooth, one on the lingual and two on the facial surfaces. Using these spheres for orientation, the computer superimposes all images to form a three-dimensional composite view.

Information about the opposing arch is also imaged and related by the computer to the preparation. After all the images are completed, the operator furnishes the computer with any other information essential to the design of the restoration, including data obtained from a special mandibular motion tracking device.

The CAD computer's memory stores 96 tooth forms, one for each tooth and class of occlusion (Angles Class I, II or III). Selecting a tooth from this library, the computer "places" it within the previously delineated interproximal, faciolingual and occlusal borders. The operator may either accept the proposed tooth or make alterations. To allow for final cementation, for example, the tooth image may be expanded, similar to painting a die with die-spacing material. The zone around the margin may be retained at its original dimension while the tooth image is dilated to provide a specified amount of space on the occlusal surface and axial walls. The margin may be viewed in linear or cross section and corrected if necessary. The operator can also design any type of occlusion.

**Sopha CAD/CAM System**

Courtesy of Sopha Bioconcept, Inc.

When any point is moved to affect a contour change, the CAD program smooths out that change in three dimensions. The redesign of the proposed restoration may be as complex or as simple as desired. In this respect, the procedure is not unlike waxing a crown—the process it replaces.

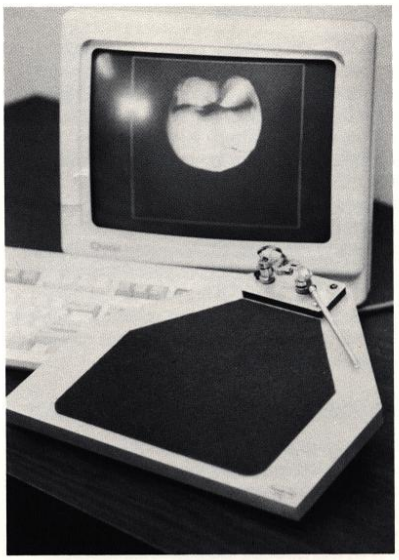
The restoration design is transmitted to the CAM unit, a five-axis milling machine with up to 12 milling tools. These range from larger instruments for bulk removal to needle-fine burs for refining secondary morphology. All tool changes are automatic, and from the time the machine is activated, no operator intervention occurs. Milling time can take from approximately 45 minutes to more than one hour, depending on design complexity.

The completed product needs only to have the retaining wings removed and surface color applied. The Sopha system can fabricate restorations of machinable ceramic, composite resin and metal, as well as a composite resin material reinforced by glass fibers and designed specifically for CAD/CAM.

Preston and Duret (1992) stated that in a study of 50 crowns and five margin designs, the marginal adaptation at the facial and lingual averaged 35 microns. The internal axiogingival transition area requires further development, and software modifications are currently being made.

### *THE DENTICAD® SYSTEM*

Another example of CAD/CAM technology, the DentiCAD® system uses a miniaturized robot arm with a pointer to capture surface data, which is then transformed into a computer image. As the dentist traces the preparation with the probe tip, sensors record its location and transmit this information to the computer. The data is displayed simultaneously on a graphics terminal. An advantage of this tracing technique is its ability to record the tooth preparation without the need for conventional tissue displacement.



**The DentiCAD® robot arm digitizer is used to acquire the 3-D data.**

Courtesy of Dianne Rekow, D.D.S.

The system produces crown and coping restorations with minimal interaction between the computer and operator. The user simply specifies the patient data file, type of restoration and restorative material to be used. The restoration, which can be fabricated from machinable ceramics or metal, is designed in three parts: an internal and external configuration and the occlusal surface. The automated milling of internal and external contours is accomplished in separate steps with the milling machine automatically repositioning the restoration between milling sequences. Initial assessments of this system's accuracy are encouraging, measuring adaptation gaps of approximately 40-60 microns.

### THE CELAY® SYSTEM

The CELAY® system, which produces ceramic inlays, is unique in that it circumvents imaging the prepared tooth, using instead a replication or copy milling technique. A resin pattern is made in the prepared cavity, either by the dentist directly in the mouth or in the laboratory on a die. This pattern embodies all of the characteristics desired in the final ceramic restoration, including margins, contours and occlusal morphology. The CELAY system traces the internal and external surface of the inlay pattern, recording it in the computer, which then drives a milling machine that carves a ceramic replica of the pattern.

### CAD/CAM SYSTEMS FOR TITANIUM COPINGS

Titanium and titanium alloys are well-established materials for endosseous implants. As a result, interest in developing a restorative system using titanium as a substructure for resin or ceramic veneering led to the Procera system. This complex system is notable because it uses CAD/CAM technology to replicate the die. Micropalpation tracings of the prepared tooth are used to form a carbon electrode, which then shapes the internal contours of a titanium coping using an electro-milling technique (spark erosion).

Another CAD/CAM system designed to produce titanium copings, the Titan system also uses a micropalpation tracing technique.

### MATERIALS FOR CAD/CAM

Dental restorative materials have been limited in the past by processing techniques that generally require materials to be reformed physically during fabrication, either by melting and casting, or by firing. CAD/CAM, however, brings machine-milled precision restorations from blocks of solid material to dentistry. As such, it promises to overcome the limitations of earlier technology and perhaps spur development of new materials with enhanced physical properties.

"CAD/CAM PROMISES TO OVERCOME THE LIMITATIONS OF EARLIER TECHNOLOGY AND PERHAPS SPUR DEVELOPMENT OF NEW MATERIALS WITH ENHANCED PHYSICAL PROPERTIES."

### FUTURE APPLICATIONS

CAD/CAM technology can be applied both to direct intraoral use and indirect laboratory use, but it will find widespread acceptance only when intraoral applications are made truly practical. The potential for time and labor savings, including elimination of temporary restorations and reduction of patient visits, provides economic incentive to the quest for improved and affordable systems. Ideally, CAD/CAM systems will incorporate laser machining and robotics technology. One can envision a robotic system that can carve a preparation according to a prefabricated restoration, thereby reducing crown placement to a one-visit procedure.

Now in its infancy, CAD/CAM technology for dentistry holds potential for many more applications than are readily apparent. But to make the most of its potential, CAD/CAM technology should be integrated with other computer-based dental applications, such as mandibular movement recording, expert systems, digital radiography and video imaging.

"ONE CAN ENVISION A ROBOTIC SYSTEM THAT CAN CARVE A PREPARATION ACCORDING TO A PREFABRICATED RESTORATION, THEREBY REDUCING CROWN PLACEMENT TO A ONE-VISIT PROCEDURE."

# INTRODUCTION

Virtually nonexistent in dentistry 25 years ago, today the computer is an increasingly common fixture, both in the front office and the operatory. A powerful tool used for a variety of practice management and clinical applications, the computer is revolutionizing the dental profession.

The earliest computer applications in dental office management were a logical extension of existing business and data base software applications. Now that the computer is well-established as a dependable — some might say indispensable — dental business tool, it is only natural to explore the potential clinical applications of computer technology.

With abilities to perform complex calculations quickly, to manage and organize large amounts of information and to produce and manipulate graphic images, computers simplify practice management procedures and offer professionals new options for the imaging, design and fabrication of dental restorations and for diagnosis and treatment planning.

This monograph, which explicates established and emerging computer applications in dentistry, provides an overview of the ways in which computer technology is revolutionizing the practice of dentistry and will continue to do so in the future.

*"The computer enhances forecasting, performing in fractions of seconds what could otherwise be tedious…When metal ceramic procedures arrived on the dental scene, they were problematic and the esthetic result was often unacceptable. Failures were experienced, and the restoration was often denigrated. Today, the metal ceramic restoration is the most widely used and accepted fixed restoration. Similarly, it will take time for computer use in clinical dentistry to produce commonly accepted, broadly used applications. Computer-assisted clinical care will eventually alter dental procedures and office structure."*

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## CAD/CAM

Perhaps the most dramatic computer application in dentistry is CAD/CAM technology. CAD/CAM, the acronym for "computer-assisted design/computer-assisted manufacture," has been adapted from industry, where virtually every machine shop and production line relies on computer technology to design and fabricate products.

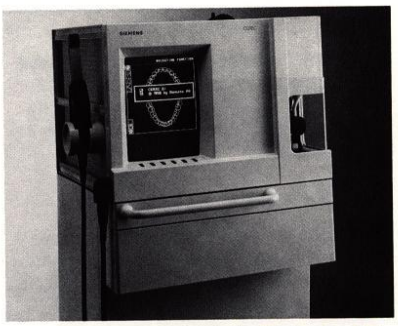
> "CURRENTLY, CAD/CAM IS USED IN DENTISTRY TO DESIGN AND FABRICATE INLAYS, ONLAYS, VENEERS, CROWNS AND SHORT-SPAN FIXED PROSTHESES."

Information for making dental restorations using CAD/CAM may come from traditional casts or dies, or from a computer-generated image. In either case, detailed information on the prepared tooth must be supplied to the computer. A traditional impression is a three-dimensional replica of the prepared tooth; the equivalent digital impression, stored in the computer, accurately relays three-dimensional data acquired either by optical imaging or by tracing the prepared tooth with a micropalpation device, which records surface morphology as it is moved over the prep. Data gained from optical imaging or tracing is stored in the computer as a series of points in three dimensions.

Currently, CAD/CAM is used in dentistry to design and fabricate inlays, onlays, veneers, crowns and short-span fixed prostheses. Future uses may include more complicated prostheses such as complete dentures and implants.

### *THE CEREC® SYSTEM*

One widely available CAD/CAM system for fabricating ceramic inlays, onlays and veneers is the CEREC® system. (CEREC is an acronym for *c*eramic *r*econstruction). The self-contained system uses an intraoral imaging probe (camera) for capturing images, a monitor and a computer-controlled electric milling machine.



Courtesy of Siemens Medical Systems

**The CEREC® system's features include the ability to make optical impressions, design restorations directly on the monitor and fabricate inlays and onlays all within a single integrated unit.**

Since the system is not designed to accept more than one image or to correlate multiple images, a single image is made with the intraoral laser camera. The internal and external margins of the preparation are outlined using a track ball*. A four-centimeter diamond disk then machines the fit surfaces of the restoration from a ceramic block. The occlusal surface is not developed and must be carved by the dentist after the inlay is seated on the tooth. The manufacturer states that the system is capable of producing restorations with a mean marginal space of 60 microns.

***TRACK BALL***

*A stationary input device, with a movable ball, that relays positioning information to the computer (see "mouse").*