TECHNOLOGY INTEGRATION

The why, the how, and the now.

New Changes in CAD/CAM: Part 2 Lab Systems

Paul Feuerstein, DMD

Paul Feuerstein, DMD
General Practice
North Billerica, Massachusetts

While we wait for intraoral scanners to gain more acceptance, impressions and models can be sent to laboratories right now for these new processes. Laboratories are equipped with devices that look something like a small oven. A model is mounted inside and then, using lasers, cameras, or "touch devices," the models are moved in a pattern that allows the scanners to digitally copy the forms. The digital file is then sent to a computer, which creates the virtual model. Those readers who have used Invisalign® (Align Technology, Inc, Santa Clara, CA) are already familiar with this process. In the laboratory world, Procera® (Nobel Biocare, Yorba Linda, CA) (Figure 1 and Figure 2) was one of the first to use this technology. The scanner used is a probe that "feels" around the preparation to develop the digital model. In choosing a system for a laboratory, two things to consider are the detail and accuracy of the scanner. This of course will have a great impact on the final result, much like the intraoral impression's impact on the fit of a restoration.

SOFTWARE

The ideal situation is software that is "open," in that it can import files from other systems using standardized formats. For the technically oriented, these are ASCII, STL, and IGES. The software can be used to design and construct crowns, bridges, inlays, and implant restorations. In addition, there are modules to calculate the articulation as well as a system to create telescopic copings. The latter is intriguing as it is not always possible for the dentist to create a full arch of precisely parallel preparations. The computer can calculate, design, and build the copings, which can be cemented to yield a well-seating bridge. Any laboratory technician who has had to wax up multiple telescopic copings with a hand-adjustable surveyor would welcome this feature.

THE SECRET—GEOMAGIC SOFTWARE

This company has sophisticated custom software that is used by many of the dental companies mentioned here. Geomagic®'s (Research Triangle Park, NC) products and technologies support chairside and laboratory-side 3-dimensional (3-D) CAD/CAM solutions to streamline the dental reconstruction process. It can take the raw scan data from either impressions or models and, along with the Geomagic Studio software, reconstruct 3-D models, design restorations, build orthodontic models, and more. The president/CEO and co-founder, Ping Fu, is a legend in the computer world and has helped multiple industries with her expertise and dedication. The list of companies that use this software for their own 3-D designing is a virtual "who's who" across all industries.

MANUFACTURING MACHINES

Large 4- or 5-axis computer numerically controlled (CNC) milling machines with automatic tool changers and automatic material feeders weigh in at over 1,200 lbs and stand 5 ft high. These CNC units can run 24 hours a day because they are numerically controlled and can be remotely operated. They basically take a large block of biocompatible material and mill dental elements such as copings, crowns, and bridges out of them. There is a fair amount of waste with the unused material and filings, which could be relevant if using precious metals.

An alternative is 3-D printing or rapid prototyping/rapid manufacturing. In this system, a powder, either metal or ceramic, is layered one level at a time in the shape of the proposed framework, while a laser welds the particles into a solid state. If you think of a standard laser printer, envision the black powder melted on the paper, over and over again in a stack. Some examples of this are the 3-D systems imagen™ (imagen, Irwin, PA), EOSINT models (EOS GmbH Electro Optical Systems, Munich, Germany), and Phenix™ (Clermont Ferrand, France) systems.

MATERIALS

The materials that can be used have some superior properties to traditional laboratory systems. The metal blocks are precast and checked for porosity. Because many of these blocks are round, they are sometimes called "pucks." Titanium can be used because it is biocompatible and very strong, even in thin areas. Ceramics are pre-sintered and very dense—certainly more than stacked porcelain or pressed ceramics. Hand-fabricated restorations often show porosity when checked by electron microscopy. Materials such as aluminum oxide and zirconium dioxide can be used for crowns and bridges with great strength. Other zirconium-oxide mixtures using nano particles can even be used for non-metal bars and overdentures. A comprehensive article was recently published in the *Journal of the American Dental Association* in September 2006 by Dr. Russell Giordano.[1] This article can give detailed properties of the various materials used in CAD construction.

Some dentists prefer composite blocks, which are much denser than the direct or even traditional indirect products that are currently in use. The reason is that the composites can be finished in the mouth easily with commonly used intraoral products and are also compatible with the light-cured materials, allowing some last-minute veneering or modification. Currently these are limited to single units and are machined as final restorations as opposed to copings.

Figure 1 Procera scanning unit.

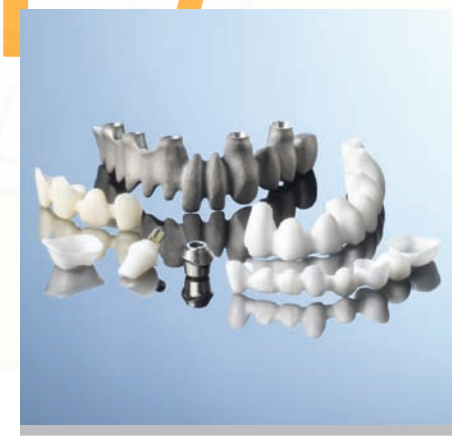

Figure 2 Procera family of products.

Figure 3 Everest scanning unit.

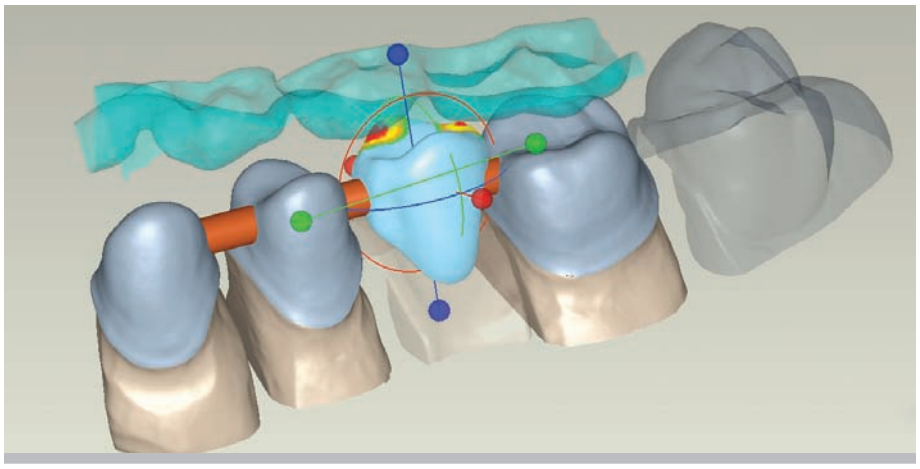

Figure 4 Scan made with Everest system using Geomagic software.

Figure 5 Lava milling unit.

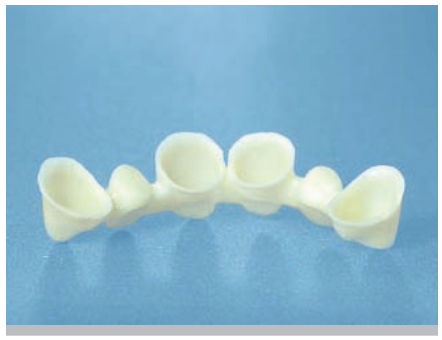

Figure 6 Lava 6-unit bridge frame.

Figure 7 inLab system.

CAN ALL LABS FABRICATE THESE CAD RESTORATIONS?

Because of the diversity and expense of the systems, most laboratories choose one or two systems that they will use for this process. Of course, at costs over $100,000, some smaller, lower-volume laboratories may not be able to justify this expense; however, there is an answer for the laboratory industry. Some enterprising owners, such as David Lesh of Dale Dental Lab in Richardson, Texas, have invested in several different CAD units and encourage other laboratories to send models to them for scanning and substructure manufacturing. This allows the smaller laboratory to offer all of the new technology to its dental clients while still maintaining its relationships by building the final restorations. Lesh has been using these CAD systems since their inception and has some interesting insight and is a good resource for the industry.

LABORATORY CAD/CAM SYSTEMS

There is not enough space here for a comprehensive review of each system, so the list in this article comprises some of the most well-known. The systems listed have the ability to create copings, frameworks, and final restorations from a variety of materials. Some allow the technician to design the frameworks on the computer, and some allow a wax-up to be made and then scanned, while others allow both. The latter gives a technician who is more comfortable with years of training with wax, and who perhaps has a little computer insecurity, another option. Some require the laboratory (or dentist) to send the models to the facility, while others require or encourage the laboratory to have its own scanner and export the files to the milling center. The systems, in no particular order, are:

- Procera (Nobel BioCare) (Figure 1 and Figure 2)
- Everest (KaVo Dental Corporation, Lake Zurich, IL) (Figure 3 and Figure 4)
- Lava™ (3M ESPE, St. Paul, MN) (Figure 5 and Figure 6)
- inLab® (Sirona Dental Systems, Charlotte, NC) (Figure 7)
- etkon System (etkonUSA, Arlington, TX) (Figure 8)
- Cercon® (DENTSPLY Ceramco, York, PA) (Figure 9 and Figure 10)
- DCS Precident® System (DCS Dental AG, Allschwil, Switzerland)

Figure 8 Etkon system.

Figure 9 Cercon eye.

Figure 10 Cercon bridge.

Figure 11 ZENO 4030 M1

- ZENO®Tec (Wieland Dental & Technik GmbH & Co KG) (Figure 11)
- Hint-ELs® DentaCAD Systeme (Hint-ELs, Griesheim, Germany) (Figure 12 and Figure 13)
- CeraSys (CeraSystems, Buena Park, CA)
- Wol-Ceram (XPdent Corporation, Miami, FL)
- BEGO Medifacturing® (BEGO Medical GmbH, Bremen, Germany)
- Katana (Noritake Dental Supply Co, LTD, Aichi, Japan)
- TurboDent System (U-Best Technology Inc, Anaheim, CA)

Some of the systems are essentially turnkey systems for the laboratories while others allow a laboratory to pick and choose components, much like building a stereo. This requires what is known as "open architecture." This means that the output from the scanner and/or the software has to be in an "STL" format. 3Shape (Copenhagen K, Denmark), for example, sells scanners and design software that allow the laboratory to export the designs to many CAM milling units as well as outsourced milling centers.

When the author interviewed Stefanie Siebert, product manager of CAD/CAM for KaVo Dental North America, she summed things up nicely: "CAD/CAM does not eliminate the need for skilled dental technicians with an understanding of the anatomy and functionality of the jaw. It provides a solution, however, to both needs in today's marketplace—the need for automated production as well as accurate, esthetic results. Each system has a focus on one or the other objective, and technology decides how well it is accomplished. The buzzword 'CAD/CAM' does not cover the span between the milled results—there are big differences in horizontal fit, flexibility of preparation design and range of applications. Now that we have been exposed to CAD/CAM technology for several years, it is time to learn more about the strategic focus and capabilities of the different systems in order to take advantage of the technology that works best with the alignment of the individual office."

CAD IMPLANT ABUTMENTS—ATLANTIS

The laboratory procedures in setting up implant abutments are quite challenging. If the implant is not perfectly posisitoned, in many systems the laboratory has to cast

Figure 12 Hint-Els titanium milling product

Figure 13 Hint-Els ceramic milling product

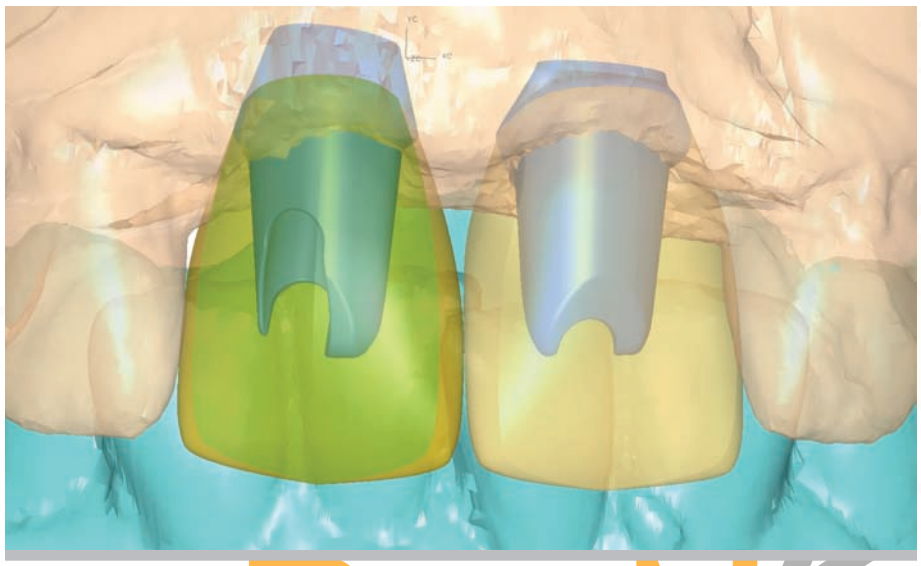

Figure 14 Scan made with Atlantis system

or mill custom abutments. If the esthetics require a ceramic (zirconia) abutment, the laboratory has a lot of work ahead of it. Atlantis Components, Inc (Cambridge, MA) uses patented computer-based technology to produce patient-specific abutments so that each abutment delivers optimal results. A choice of materials and compatibility with multiple brands of implants means that clinicians can use the same protocol with every case, no matter which implant is selected. Atlantis scans the models (Figure 14) and, using proprietary CAD software, designs and fabricates the abutments with the proper emergence and parallelism, using sophisticated industrial machining techniques. The laboratory and dentist save time and can be assured of great accuracy with this process, and crown fabrication is simple and predictable.

...THESE EXCITING NEW (CBCT) UNITS ALLOW AN OFFICE TO TAKE 3-D X-RAYS OF THE PATIENT'S JAWS WITH STARTLING RESOLUTION. SOFTWARE RECONSTRUCTION OF THE SCANS ALLOWS A FULLY ARTICULATED RENDERING OF UPPER AND LOWER ARCHES WITH RESOLUTION APPROACHING 300 µM TO 400 µM.

COMMUNICATION WITH THE LABORATORY

Using these systems requires clear instructions from the dentist. Because of the potential of the prescription information going to several places, a typical handwritten laboratory slip might not be the ideal format for this workflow. Some of the systems described have the laboratory slips embedded in the software. The dental office is guided though a series of leading questions to help both the dentist and the laboratory create the proper restoration. One such product is Cercon Coach, helping with DENTSPLY's entry.

A universal program is Dentist Rx Online™ (Transcend, Inc, Chestnut Hill, MA). This service provides a complement to a paperless office by guiding data entry, interacting with dental laboratories, archiving prescriptions, and storing and managing digital attachments.

DRO guides the dentist through data entry to ensure that critical information for any type of laboratory service is complete and standardized. In addition, the online program, which provides multiple dentists in multiple locations the ability to work with multiple laboratories, allows for all types of digital attachments and for bidirectional communications. Currently DRO has 15,000 registered dentists, a lengthy list of participating laboratories, and several dental schools.

WHERE DO WE GO FROM HERE?

One area that has been discussed in previous articles is the new cone beam computed tomography (CBCT). These exciting new units allow an office to take 3-D x-rays of the patient's jaws with startling resolution. Software reconstruction of the scans allows a fully articulated rendering of upper and lower arches with resolution approaching 300 µm to 400 µm. Implant planning becomes very predictable. If we can merge the 3-D intraoral scans mentioned above with the 3-D CT scans, it seems feasible that we could have full-arch upper and lower models vitually delivered to the laboratories without taking an impression. And as the CBCT scans increase their resolution, who knows—we may not even need the intraoral scans. Never say never.

ACKNOWLEDGMENT

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DISCLOSURE

The author is a current consultant for 3M ESPE.

REFERENCE

1. Giordano R. Materials for CAD/CAM-produced restorations. *J Am Dent Assoc.* 2006; 137(Suppl):14S-21S.