The State of DIGITAL DENTISTRY in 2012

by Sameer Puri, DDS

Abstract

This article will showcase the current technologies that are in use today for in-office imaging and milling. Features of each system on the market will be highlighted. The article will describe the differences between systems that can only do digital imaging for the transfer of the final restorations to the laboratory versus those systems that can do in-office milling in addition to the digital impressions.

Educational Objectives

At the end of this program, participants will be able to:

a. Understand what current systems are available.
b. Understand the difference between digital impressions and in-office milling.
c. Compare the limitations of each available system.
d. Understand how in-office CAD/CAM works.
e. Appreciate the clinical indications of each system.

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For nearly three decades, CAD/CAM dentistry has evolved from a simple concept developed by Dr. Werner Mormann in Switzerland, who described the ability to digitally image a tooth in lieu of a traditional polyvinyl impression to fabricate a final restoration, to a full-blown clinical application that has grown to include numerous players in the field of digital dentistry. The CEREC system from Sirona has been one of the most researched systems in dentistry with hundreds of studies on everything from fit to longevity. Authors such as Fasbinder and others have found survivability rates in the 90-97 percentiles for 10 and five years respectively, with earlier generations of the CEREC system. Current systems can fabricate the same popular types of restorations that are created by laboratories, such as e.max and Bruxiz – lithium disilicate and full-contour zirconia-type restorations.

As CEREC has helped grow digital dentistry, the market has realized that CAD/CAM dentistry is not a fad or a technique for the fringe dentist. Competitors to the CEREC system have launched their own systems whether in the field of digital impressions or full-service CAD/CAM systems that allow not only digital impression-making but also the chairside milling of dental restorations utilizing an in-office milling unit.

This article will review the systems that are currently on the market, compare and contrast the capabilities of each system and give an overview of how each system works. With new systems attempting to come on the market in what seems like an almost monthly occurrence, we will limit our analysis to systems that are currently available to purchase either direct from the manufacturer or a dental supplier. Systems in the development or planning phases will not be discussed as its virtually impossible to predict if or when any of these systems will actually make it to market for sale.

The CAD/CAM market has been evolving ever since the first CEREC system almost 28 years ago. The company has approximately 35,000 users worldwide. Clinicians can design and mill a restoration in their offices in a single visit; however, digital impression systems are more commonly available than those systems that have a milling unit attached. While the concept of imaging teeth digitally has not overtaken traditional vinyl poly siloxane impression making, it is anticipated that this category of digitally capturing the preparations will continue to grow until it eventually does over take traditional impression making systems.

Digital impressions typically eliminate the steps of traditional impressions such as taking and removing the impression from the patient’s mouth, pouring models, trimming the dies, as well as eliminating the various properties of the different types of stones that are available. All of these steps are captured digitally with an intra-oral camera that records the hard- and soft-tissue surfaces.

Digital impression systems involve taking a digital scan of the prepared tooth, sending that scan to the laboratory and having the laboratory either fabricate a model from the digital scan on which a restoration can be constructed or digitally fabricate the restoration without a physical model. The accuracy that can be achieved with these digital scans is typically equal to or higher than what can be achieved by traditional impression techniques.

The currently available digital impression systems that we will first discuss in this article are the following:
- iTero from Cadent
- Lava COS from 3M
- CEREC AC from Sirona with Bluecam
- CEREC AC from Sirona with Omnicam

After the discussion of the systems that can only fabricate an impression and send that data to a laboratory, we will then discuss the systems that have a milling unit attached and can capture the data, fabricate a virtual model and mill the final restoration in one visit. The systems that we will discuss that can accomplish this are:
- CEREC AC from Sirona with Bluecam
- CEREC AC from Sirona with Omnicam
- E4D from D4D Technologies

While each of the systems works in a similar manner (an intra-oral camera is used to capture data) each system works with different technology to capture the digital data and record the information. With some of the systems, a thin layer of powder is sprayed on the teeth to opaque the inherent translucency of the dentin and enamel to make imaging easier. The CEREC Bluecam and the Lava COS both require a light dusting of powder prior to impression making. Other systems have eliminated the powdering step completely where no opaquing medium is needed. The iTero and the CEREC Omnicam systems do not require any powder. The third category is the E4D system where the majority of the time no powdering is needed but occasion-

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ally an opaquing medium might be necessary to opaque the translucency of the enamel.

There are several other digital scanners available such as the 3Shape Trios system and the Glidewell IOS Scanner. These will be excluded from this article simply due to the fact that, at the time of press, they are either still in development or have not been fully released for commercial sale.

iTero by Cadent was originally designed as a digital impression system created as a substitute for traditional physical impressions. It was recently purchased by the Align Corporation so that it could be marketed as a scanner for Invisalign impressions in addition to being used as a digital impression system for crown and bridge work. The system was designed to eliminate guesswork of the impression procedure and helps to reduce the negative aspects associated with dental impressions.

With the iTero system, a prescription is filled out digitally which allows the case to be sent to any laboratory to fabricate any type of restoration. The system works on the principle of a guided scan where the software guides you through visual and voice prompts on where to take the scan in the mouth and what surfaces to capture.

The technology uses the concept of parallel confocal imaging, a technique that uses laser and optical scanning to digitally capture the surface of the teeth. Because of the confocal technology, no powder is ever necessary when scanning the teeth with the iTero system.

A foot pedal is used to activate the camera and this wireless dual-pedal control allows you to not only capture the appropriate images but also scroll through various menu items as you are taking the scan.

While the scanner is rather large, because you can place it in direct contact with the teeth, the operator is usually able to image anywhere in the mouth. Regardless, one common concern about the system from users that has been expressed is the large size of the scanning wand (Fig. 1).

The camera gives a preview of what the clinician is capturing in color, however the models are rendered in a monochromatic yellow color that is intended to simulate the dental stone used in laboratories (Fig. 2). Nine to 12 individual images are stitched together to create a virtual model. Once the virtual model has been previewed and approved, the 3D scan is sent to an iTero data export facility. The data is digitally cleaned to remove any artifacts that might have been incorporated due to the large number of scans that are taken. Once the data is cleaned, physical models can be milled out of a poly eurothane material and sent to the laboratory for final restoration fabrication. Typically the lab receives the model within 48-72 hours from receiving the scan data. Because no special software is required by the laboratory, iTero models can be sent to any laboratory and from the model, the lab can fabricate any type of restoration that the client wishes.

Lava COS

The Lava COS is the first digital impressioning system from 3M corporation. Known for its cements and composites, 3M purchased Brontes technologies in 2008 which was the original creator of the Lava camera. The camera was further developed by the 3M engineers to serve as an intra-oral imaging system for digital impressions. Similar to the iTero system, the Lava COS is intended to be used as a digital impression system only.

Unlike the confocal imaging of the iTero, the Lava COS uses a blue LED light and video imaging system to capture the data and create a virtual model. Video capture has its pros and cons; a pro is that the data that is captured is complete and accurate. By waving the camera over the teeth, the video feed fills in all aspects of the virtual model. The data is represented in a black and white preview and the areas that are filled in are represented as white on the virtual model (Fig. 3). This data replaces the traditional physical impression from PVS systems.
The clinical technique with the Lava COS requires proper isolation of the desired area to be captured and a light dusting of powder is placed on the teeth as the camera uses a blue LED light source to capture the data. This digital data capture has shown to be more accurate than traditional impression making.\(^{10}\) Without the powder, the translucency and reflectivity of the teeth cannot be captured by the camera. After the dusting with the powder, the camera is waved over the teeth, capturing appropriate areas to create the virtual model. Similar to the iTero system, a monochromatic model is created by the capture of the data from the Lava camera (Fig. 4).

After the virtual data has been captured and the virtual model created and verified for accuracy and completeness, the data is sent to 3M for processing of the data. Due to the nature of capturing a video stream, the file sizes that need to be sent to the processing center are large—sometimes in the gigabyte range—thereby requiring time to transfer data, sometimes even overnight.

Once the data is received by the 3M processing center, similar to the iTero, the data is “cleaned up” by removing artifacts and extraneous data, creating a virtual model. After verification of the virtual model, the data is sent to a stereo lithography (SLA) machine, which fabricates the physical model. SLA model fabrication is different than the milled models created by the iTero system. SLA models are created by taking a vat of resin and using a laser to cure microns of resin at a time (Fig. 5). Once a layer is cured, more resin is applied on top of the cured resin and the laser cures another few microns. This process continues until the entire model is built layer by layer and the model is complete. After model fabrication the models can then be sent to the laboratory and the laboratory can use those models, which are already trimmed and indexed, to fabricate any type of restoration that they wish. The turnaround time for a laboratory to receive the model is typically 48-72 hours.

Both the iTero and the Lava COS require an initial purchase price in the $25,000 range and both require either a per-scan fee of approximately $25 or a yearly maintenance contract in the $4,000 range. It’s important to note that at the time of this article both systems are indicated for the capturing digital impressions only. There is currently no milling unit available for either system.

The next systems we will explore are sister systems as they share the same platform, the same software and are fabricated by the same company. The CEREC system has been in existence for close to three decades.\(^{11}\) Created by Sirona, the CEREC system now has two different systems that are currently available to the dental market—the CEREC Bluecam and the recently introduced CEREC Omnicam. It’s important to note that both systems utilize the exact same software and have similar clinical indications. The only difference is in how the data is captured. With the Bluecam, imaging is done via individual image stitching creating a monochromatic yellow stone-like digital model. Powder is required for imaging with the Bluecam. With the Omnicam, no powder is required and the image capture is done via digital streaming and is in full color.

Unlike the iTero and the Lava systems, which are indicated for the capture of digital data to be sent to the laboratory for the fabrication of models, the CEREC system can, in addition to sending data to the laboratory, also design and mill the final restoration utilizing a chairside milling unit.

10. Clin Oral Investig. 2012 Jul 31. [Epub ahead of print] Accuracy of digital models obtained by direct and indirect data capturing. Güth JF, Krul C, Stimmelmayr M, Beuer F, Edelhoff D. Department of Prosthodontics, Dental School of the Ludwig-Maximilians University Munich, Gießhautstraße 70, 80336, Munich, Germany, jan_friederik.gueth@med.uni-muenchen.de
The Bluecam was introduced in 2009 (Fig. 6) and similar to the Lava COS, requires a light dusting of powder to opaque the teeth.\textsuperscript{12} Individual images are captured by the Bluecam and used to fabricate a virtual model (Fig. 7). With this virtual model, the clinician has the choice to either send that data to the laboratory or design the restoration chairside.

If the data is sent to the laboratory, the main difference between the CEREC system and the iTero and Lava systems is that the data is sent directly to the laboratory and not a processing facility for artifact removal. Because so much data is captured with the iTero and Lava, the data needs to be post processed prior to model fabrication. Due to the different capture technique with the CEREC Bluecam, no post processing is required and the laboratory can receive the data in a few minutes instead of a few hours due to the smaller file size that is created with CEREC.

Once the laboratory receives the data, the lab can decide if it needs a model. The CEREC system has a laboratory version of its software that allows the technician to fabricate full contour and layered restorations without models. If the case requires the fabrication of a model, then the laboratory can order a model that typically arrives in 24-48 hours. Similar to the Lava system, the models with the CEREC system are fabricated via the SLA process described earlier.

For those cases that do not require a laboratory, once the images are captured by the CEREC system, the clinician has the ability not only to design the restoration chairside but also mill it with an in-office milling unit. Similar to capturing a physical impression, the scans for the preparation, opposing and a digital bite registration are captured digitally and the restoration is designed and can be milled in a number of materials, including lithium disilicate, feldspathic porcelain, leucite-reinforced porcelain and resin-based materials. Zirconia-based single-unit and multi-unit bridges can also be fabricated if the office is equipped with the appropriate ovens to sinter zirconia.

The software is robust enough to design and mill single-unit inlays, onlays, veneers, crowns and bridges, both temporary and permanent. Implant crowns, implant surgical stents and abutments can also be fabricated utilizing the CEREC system.

The CEREC Omnicam, launched in August 2012 is the newest imaging camera from Sirona (Fig. 8). The Omnicam shares all of the features of the Bluecam in all of its capabilities. With the Omnicam you can design any number of types of restorations chairside or send that data to the laboratory to fabricate models to have the lab create your restoration. Chairside design and milling are also possible utilizing the exact same software as the Bluecam.

The main difference with the Omnicam compared to the Bluecam is the manner in which it captures the data. Not only is the image capture with the Omnicam completely powder free but it’s also in a manner of streaming capture and in full color (Fig. 9). The image capture is in full color as are the virtual models that are created. Full color virtual models have the opportunity to serve both as a restorative tool for the clinician and as a diagnostic tool for new patient exams where the models can be used in 3D to serve as a patient education tool (Fig. 10). Because it is a streaming capture, the Omnicam only utilizes the virtual model that is created and discards the actual data stream, thereby keeping the file sizes manageable. Both Bluecam and Omnicam file sizes are in the 50-60MB range, which allows for relatively easy transfer to the laboratory when needed.

The final system that we will explore in this article is the E4D system from D4D technologies. The E4D system is designed to be used similar to the CEREC system where it can be used as a digital impression system as well as a chairside milling system. However the company has not been able to successfully launch the digital impression capabilities of the system on a broad scale as of this writing, so in this article we will discuss the chairside milling aspects only.
The E4D system uses a laser scan to capture the dental data (Fig. 11). While the iTero and the Omnicam are truly powderless, (never requiring powder), and the Lava COS and the Bluecam both require a light dusting of powder, the E4D system is “mostly” powderless.

In most instances powder is not required by the E4D to capture the scan of the teeth. However, the company does sell “Accent,” which is an opaquing agent that can be used in times of imaging difficulty. Imaging difficulty can occur when there is a lot of enamel (which as we know is extremely translucent), which the E4D camera has a difficult time with. While some users report rarely, if ever, having to use the Accent powder, some users do indicate that imaging with the powder makes the entire process easier.

The E4D captures multiple images and uses that data to fabricate a virtual model. For a single tooth, generally eight to 10 images are needed to be captured. The models can then be used to design inlays, onlays, crowns and veneers for patients. As of this writing, implant abutments and bridges were not possible with the E4D system.

While this article serves to showcase the current systems that are available and highlights features of each, know that in the past 30 years since CEREC was introduced as a fringe technology, more and more systems are trying to make it to the dental market each year. Companies like 3Shape with its Trios system and IOS from Glidewell are just two examples of other technologies not yet covered in this article but are either just being released or on the verge of joining the ever-growing CAD/CAM market.

CAD/CAM dentistry, whether its something you choose to incorporate as just an imaging system or as an imaging and milling system, is now a mainstream dental procedure. No longer is this technology limited to the fringe dentists whose hobby is to tinker with computers. Current generation CAD/CAM systems are robust and allow all types of offices to participate in digital dentistry for the benefit of their patients.

Comment on this article!

Author’s Bio

Dr. Sameer Puri is the co-founder of www.cerecdentistry.com, a Web site dedicated to CEREC online education where clinicians can learn the ins and outs of CEREC dentistry from basic training to more advanced techniques such as anterior aesthetics. The Web site is the largest online CEREC resource in the world and is included in the purchase of each new CEREC system.

Dr. Puri has been published in numerous professional journals and magazines. His aesthetic techniques and results have been used in manufacturer brochures and advertisements. Dr. Puri is also a consultant to various manufacturers to help them improve their products and help develop new products for the dental industry.

He is married to his wife of 14 years and is the father to two beautiful girls.

Disclosure: Dr. Puri declares that he has a financial interest in Cerecdentistry.com and The Scottsdale Center for Dentistry which trains doctors in the use of the CEREC.

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1. The iTero system uses which technique for imaging:
   a. Laser
   b. Confocal imaging
   c. Blue LED light
   d. Streaming video capture

2. The E4D requires how many images to capture a single tooth?
   a. 2-3
   b. 8-10
   c. 25-30
   d. 30+

3. Which available systems are completely powderless and never require powder?
   a. iTero and Omnicam
   b. E4D and Lava COS
   c. Bluecam and E4D
   d. iTero and Lava COS

4. Which available systems use streaming capture to create a virtual model?
   a. Omnicam and Lava COS
   b. E4D and iTero
   c. Omnicam and Bluecam
   d. Lava COS and E4D

5. Which systems listed below are indicated for only digital impressions to transfer to a laboratory?
   a. Bluecam and E4D
   b. Omnicam and iTero
   c. E4D and Bluecam
   d. Lava COS and iTero

6. Which system below captures and renders models in full color?
   a. Omnicam
   b. Bluecam
   c. iTero
   d. E4D

7. When capturing digital impressions to transfer to the laboratory, which system(s) sends the images to a central facility for data processing?
   a. Bluecam
   b. Omnicam
   c. iTero and Lava COS
   d. E4D

8. The approximate number of worldwide CEREC users is:
   a. 500
   b. 5,000
   c. 15,000
   d. 35,000

9. iTero was purchased by which company recently?
   a. Align
   b. Dentsply
   c. Straumann
   d. Nobel

10. Which available system(s) cannot function without powder when imaging?
    a. Bluecam
    b. Lava COS
    c. Omnicam
    d. a and b
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The State of Digital Dentistry in 2012 by Sameer Puri, DDS

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