CAD/CAM technology has been around for more than 25 years. Although there are several digital imaging systems on the market today, the pioneer in this field has been the CEREC system by Sirona (Fig. 1). Thousands of clinicians worldwide have utilized the CEREC system to restore millions of teeth. It is estimated that a CEREC restoration is placed approximately every seven seconds.

Early generations of the CEREC system were difficult to use and required an extensive learning curve. No doubt these initial CEREC systems could create an acceptable restoration when properly utilized, as evidenced by the multitude of long-term studies completed by numerous private practitioners and universities alike; however, their limited indications (simple inlays and onlays) and the extended learning curve (up to six months or more for some practitioners) limited the field of potential users to a handful of clinicians who were more interested in the technology instead of having a system that was predictable and integrated easily into private practice.

In 2003, after 18 years of being based on DOS architecture, the software evolved to show the user the first 3-D rendition of a tooth by utilizing the now-popular Windows platform (Fig. 2). This software allowed the user to take individual images of the teeth to be restored and see the models generated in three dimensions. The clinician had the ability to manipulate the model in virtually any direction by moving the integrated trackball in the CEREC machine.

The new software platform allowed the user to fabricate more intricate restorations, such as full-coverage crowns (Figs. 3a, 3b). Further updates led to more indications, as users had the ability to not only design restorations chairside but, by using the laboratory version of the system, could design and mill their implant abutments and final restorations chairside (Fig. 4).

Advanced users used the system to fabricate their final bridges by milling the frameworks from zirconia and then milling the layering porcelain to go on top (Fig. 5). Those users who did not want to delve so deeply into their software had the option of taking a digital scan of their case and sending it off to the laboratory for the fabrication of a model, saving the time and expense of a physical impression (Fig. 6). Laboratories using the system quickly realized the advantages of being able to mill their own models in their milling units (Fig. 7).

All of these advances led to an increase in the number of users in the system; but still, the majority of dentists felt that CAD/CAM systems were not quite ready for their practices or were too difficult to use.

Since 2003, all subsequent updates to the CEREC software were based on a platform that was first developed in the early 2000s, and each new feature released yearly was simply stacked on top of the previous software features by the programmers. While the quality of the restorations that have been fabricated has always been well within clinically acceptable standards when properly done, all improvements and updates in the software allowed the user to improve only the speed and efficiency of their designs.

Initially, the developers were able to utilize the existing software platform to improve the software
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Clinical fabricating restorations

Features such as automatic thickness detection, automatic contacts and occlusion, as well as intraoral bite calculations, were all added. In fact, as the software evolved, the quality of the restorations did not necessarily get better (not that they needed improvement!); what improved was the user experience. What used to take 10 to 15 minutes to design a single restoration now took two to three minutes. Many of the features that initially required manual input were now automated.

The platform, however, eventually started to show its age. Despite the advances the engineers were able to program in the software, the fact remained that in 2011, the CEREC software was still being programmed on a 9-year-old software platform. In computer years, this may as well have been an eternity. This older platform limited what could actually be placed in the software, as the programmers were limited to working within the confines of the existing architecture.

Competitors of the CEREC system were able to come to the market and claim a competitive edge with their machines because of improvements in their own software architectures. The fact remained, however, that rival companies had the edge in that they could take the work of CEREC and reverse-engineer the software and not be limited by an older programming platform.

This supposed competitive edge appears to have ended with the release of the CEREC Software 4.0 (Fig. 8). Based on an entirely new programming language, CEREC Software 4.0 is every CEREC owner’s dream come true, with software features that users have been asking for for years that were not able to be programmed on the previous version.

Designed from the ground up starting in the fall of 2009, more than two years in the making, CEREC Software 4.0 shows an entirely reworked graphical user interface, or GUI, as referred to by insiders (Fig. 9).

While reworked, it still keeps features that will allow existing users to feel at home and not lose sight of the fact that this is still in fact the CEREC software. It will also allow new users to catch on more easily to its use, thereby reducing the learning curve. It allows for faster performance, more features and the ability to design an unlimited number of restorations (up to 32 teeth at once) if the user wishes.

Because the software is based on a new programming platform, future developments will come much faster because of the programmer’s ability to quickly and efficiently code these developments into the software.

This new upgrade for CEREC, planned for a September release, will no doubt contribute toward making CEREC dentistry more mainstream. Currently, there are approximately 11,500 CEREC owners in the United States and roughly 33,000 worldwide. While this may seem like a large user base, in reality, the number of users is still in its infancy.

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in line for hours, if not days, to get the first iPhone. The "early majority" comes next, and it is the group of people who realize the technology is ready for prime time and are more apt to purchase and integrate the new technology.

The "late majority" comes after that. These are the people who don’t want to be the first on the block with anything new, but they certainly don’t want to be the last on the block either.

The final group of people is considered “laggards.” Laggards are the ones who only buy a touch-tone phone now because rotary phones are no longer available; in other words, you have to drag them kicking and screaming into purchasing and integrating anything new.

In relation to CEREC users, the early adopters can be considered the few thousand CEREC owners who integrated the technology in the first 20 to 25 years of its existence. In relation to the roughly 140,000 practicing dentists in the United States, 11,000 CEREC owners is a small number of users who have decided to integrate the technology. One can surmise that we have yet to see the early majority of CAD/CAM users, simply because we are still in the infancy of adoption, even after 25 years.

Clinical example

A new patient presented to the office as an emergency, with the chief complaint of a broken tooth (Fig. 10). The clinical history stated the patient had received an all-ceramic restoration on tooth #31 at another office a number of years ago. The restoration had fractured and needed replacement. Several treatment options were presented and discussed with the patient, and it was decided the treatment would be to restore tooth #31 with an IPS e.max CAD restoration (Fig. 11) fabricated chairside with a CEREC unit.

Because the radiograph also showed that #30 had interproximal decay under the existing amalgam, the patient opted to have both teeth restored in a single visit to save time.

The clinical challenge was not in the restoration of either tooth; the CEREC can handle that with ease. The challenge was that multiple design techniques were needed to restore both teeth because, in addition to needing a new restoration, #30 was also the retaining tooth for a clasp that was attached to a retainer the patient wore nightly and did not wish to replace, as it might not fit with the placement of a new crown on #30.

To avoid having to replace the retainer, the Biogeneric Copy technique was used to restore the tooth. A photo of the existing tooth contours was captured with the CEREC system and used to replace the restoration.

With tooth #31, an entirely different approach was taken, simply because there was no existing tooth structure present to copy. With tooth #31, the tooth was prepared and an image of the preparation was taken with the CEREC Bluecam camera (Fig. 12). An image of the opposing dentition was also captured, along with the intercuspalation of the upper and lower jaws utilizing the Buccal Bite technique.

The tooth was designed by using the contours
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and anatomy of the adjacent teeth as a guide, in a technique known as Biogeneric (Fig. 13). The CEREC software utilizes mathematical analysis of the teeth that are present in the patient’s jaw to determine what the proposal on a preparation should look like in the Biogeneric process. By analyzing the anatomy, the contours, the cusp tips and the grooves, the software is able to precisely calculate how the final restoration should appear.

Once the restorations were designed, each restoration was milled in the CEREC MC XL milling chamber, which takes anywhere from four to 10 minutes per restoration, depending on its size.

Since IPS e.max CAD was used as the restorative material, it must be processed to its final color and strength by crystalizing the material in an oven. By placing the restoration in the oven for approximately 19 minutes, the lithium metasilicate crystals undergo a phase transformation and grow in size. This converts the lithium metasilicate to lithium disilicate, which gives IPS e.max CAD its final color and strength. Once crystallized, the restorations achieve a final strength of roughly 360-400 MPa. In relation, regular feldspathic porcelain is roughly 90-140 MPa in strength. This increase in strength makes IPS e.max CAD restorations a good choice of material for molars.

After crystallization, the restorations are bonded in place, the occlusion adjusted and the patient is dismissed. The advanced CEREC software allows the entire process to finish in approximately 90 minutes (Fig. 14).

Advances in programming technology have allowed the CEREC system to enter its next phase of evolution. The ability to design multiple restorations at once, the ability to mix and match design techniques, the ability to mill restorations in minutes, and the ability to choose from a multitude of materials allow the user to utilize the CEREC system not just as a limited-use machine but one that can be an integral part of any dental office.

The end result of this evolution of the software is that CEREC users are able to go way beyond simple restorations. Users are able to fabricate permanent bridges by milling both the framework as well as the overlying porcelain. In addition, the user can completely control the planning, design and fabrication of implant restorations from the abutment to the final restoration by integrating the CEREC system with the GALILEOS cone beam (Fig. 15).

There is no doubt the evolution of this technology will lead to a surge in utilization by dentists everywhere as the system gets easier to use, has an increased range of indications and can provide restorations that rival the quality of a good laboratory. It appears we are at the point where the early majority of users will soon be CAD/CAM-ing their restorations chairside._

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**Fig. 12** The appropriate images are captured with the CEREC camera intraorally.

**Fig. 13** Multiple restorations are designed simultaneously with the CEREC Software 4.0.

**Fig. 14** The final restored case.

**Fig. 15** The CEREC can be integrated with the GALILEOS cone beam.

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Dr. Sameer Puri serves as the director of CAD/CAM at the Scottsdale Center for Dentistry, and he is the co-founder of the website www.cerecdoctors.com. He is a certified trainer and educator on CEREC proficiency. After graduating from the University of Southern California School of Dentistry, he finished his AEGD residency at the University of Tennessee. Puri has been published in numerous professional journals and also serves as a consultant to various dental product manufacturers.