CEREC IN DENTISTRY

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ABSTRACT
Advances in technology continually challenge dentists to re-evaluate their current techniques for patient treatment. Computer Assisted Design/Computer Assisted Machining (CAD/CAM) is a technological innovation for dentistry that has significantly affected materials and processes in both the dental laboratory and clinic. A number of digital systems have been introduced that offer dentists the opportunity to deliver restorative treatment without the need for impressions and stone casts. The CEREC System (Sirona Dental Systems) is one such digital system that applies CAD/CAM technology for restorative dentistry that has undergone a number of recent innovations. CEREC 3 (Sirona Dental Systems GmbH, Bensheim, Germany) divided the system into an acquisition/design unit and a separate machining unit. Three-dimensional software makes the handling illustrative and easy both in the office and in the laboratory.

KEYWORDS: Growth Factors; Pulp Regeneration; Scaffolds; Stem Cells; Tissue Engineering

INTRODUCTION
CAD/CAM technology was introduced to the dental world now over 20 years ago. CEREC (Chairside Economical Restoration of Esthetic Ceramics, or CEramic REConstruction) is a dental restoration product that allows a dental practitioner to produce an indirect ceramic dental restoration using a variety of computer assisted technologies, including 3D photography and CAD/CAM. With CEREC, teeth can be restored in a single sitting with the patient, rather than the multiple sittings required with earlier techniques. The CEREC 1 machine with its large diamond milling wheel allowed the clinician to fabricate all-ceramic inlays and onlays from a monochromatic block of ceramic in a single appointment. The CEREC system has evolved through a series of software and hardware upgrades since its introduction to the dental trading as the CEREC 1 system. There have been several significant changes in the system since its introduction. The separation of the milling chamber from the image captures and design hardware led to a significant improvement in clinical efficiency by allowing for simultaneous design of one restoration while milling a
second one. The change from a two-dimensional design program to a three-dimensional (3-D) design program occurred as the speed and memory of computers improved.

Advantages of 3-D5:

- Improved the immediate understanding of the 3-D program because dentists were able to view the designs in a way similar to what they were used to seeing with stone models.
- It also improved the clinical work flows of chair side system use.

The most recent evolution, the CEREC Acquisition Center (Sirona Dental Systems) unit, has introduced a newly developed light-emitting diode (LED) camera called the Bluecam. This camera is based on a blue LED that replaces the infrared-emitting camera in the CEREC Acquisition Unit (Sirona Dental Systems) system.

Until recently, data recorded by the CEREC camera could be used to design restorations with only the CEREC system. With the introduction of CEREC Connect (Sirona Dental Systems), the digital impression data acquired by dentists also can be transmitted via the Internet to a dental laboratory, where it can be used to complete any number of CAD/CAM restorations with the CEREC inLab system (Sirona Dental Systems). The dental laboratory also can use the data to order a model from infiniDent (Sirona Dental Systems).

History:

The CEREC procedure was developed in the 1980s by Prof. Dr. Werner Mörmann and Dr. Marco Brandestini. The underlying idea was to create all-ceramic restorations directly in the dental practice during a single treatment session. The CEREC System was initially developed in the early 1980s specifically to deliver ceramic restorations by a dentist during a single appointment. The initial CEREC 1 unit was used to deliver a ceramic inlay for the first time in 1985. Since then, the system has evolved through a series of hardware and software upgrades to expand the restorative capabilities of the CEREC 3 system to include posterior inlays, onlays, and crowns, as well as anterior crowns and veneers.

The concept of grinding inlay bodies externally with a grinding wheel along the mesiodistal axis suggested itself (Figures 1B and 1C). In this arrangement, we could turn the ceramic block on the block carrier with a spindle and feed it against the grinding wheel, which ground from the full ceramic a new contour with a different distance from the inlay axis at each feed step. This solution proved itself in a prototype arrangement in 1983, and we implemented it in the same year in the CEREC 1 unit (Sirona Dental Systems GmbH, Bensheim, Germany) (Figures 1B, 1C and 1D). A CEREC team at Seimens (Munich, Germany), equipped the
CEREC 2 with an additional cylinder diamond enabling the form-grinding of partial and full crowns (Figure 1E). CEREC 3 skipped the wheel and introduced the two-bur-system (Figure 1F). The “step bur,” which was introduced in 2006, reduced the diameter of the top one-third of the cylindrical bur to a small diameter tip enabling high precision form-grinding with reasonable bur life (Figure 1G)².

Figure 2: Evolution of CEREC hardware

A. 1985: the CEREC 1 prototype unit, the “lemon,” with Dr. Werner Mörmann (left) and Marco Brandestini, Dr. sc. techn. ETHZ. B. 1991: CEREC 1, as modified by Siemens (Munich, Germany) with E-drive and CEREC Operating System 2.0. C. 1994: CEREC 2, with an upgraded three-dimensional camera. D. 2000: CEREC 3, with split acquisition/design and machining units.

Major milestones in CEREC* CAD/CAM development²

<table>
<thead>
<tr>
<th>Year</th>
<th>System</th>
<th>Dimensional</th>
<th>Functions</th>
<th>Manufacturers</th>
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<tbody>
<tr>
<td>1980</td>
<td>Basic concept</td>
<td>Two-dimensional</td>
<td>Inlays</td>
<td>Mörmann (University of Zurich) and Brandestini (Brandestini Instruments, Zurich)</td>
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<tr>
<td>1985</td>
<td>CEREC 1</td>
<td>Two-dimensional</td>
<td>First chairside inlay</td>
<td>Mörmann and Brandestini (Brains, Zurich)</td>
</tr>
<tr>
<td>1988</td>
<td>CEREC 1</td>
<td>Two-dimensional</td>
<td>Inlays (1), onlays (2), veneers (3)</td>
<td>Mörmann and Brandestini</td>
</tr>
<tr>
<td>1994</td>
<td>CEREC 2</td>
<td>Two-dimensional</td>
<td>1-3, partial (4) and full (5) crowns, copings (6)</td>
<td>Siemens (Munich, Germany)</td>
</tr>
<tr>
<td>2000</td>
<td>CEREC 3 &amp; inLab</td>
<td>Two-dimensional</td>
<td>1-6 and three-unit bridge Frames†(inLab‡)</td>
<td>Sirona (Bensheim, Germany)</td>
</tr>
<tr>
<td>2003</td>
<td>CEREC 3 &amp; inLab</td>
<td>Two-dimensional</td>
<td>1-6 and three- and four-unit bridge frames†(inLab)</td>
<td>Sirona</td>
</tr>
<tr>
<td>2005</td>
<td>CEREC 3 &amp; inLab</td>
<td>Two-dimensional</td>
<td>1-5 automatic virtual occlusal adjustment</td>
<td>Sirona</td>
</tr>
</tbody>
</table>

The CEREC 3 System is designed for dental operatory use and consists of two separate hardware pieces. The Acquisition Unit consists of an intraoral camera, computer, color LCD monitor, keyboard, and trackball assembled in a mobile unit. The primary functions of the Acquisition Unit are to optically record a digital image of the cavity preparation to the computer and design the restoration with the CEREC 3D software program. The second piece of hardware is the Milling Chamber. It consists of two milling arms containing diamond instruments as well as a water reservoir for irrigation of the diamonds during the milling process. The primary function of the Milling Chamber is to mill the designed restoration from
blanks of ceramic or composite restorative material as directed by the CEREC 3D program on the Acquisition Unit¹.

The introduction of the step milling diamond with its 0.9mm diameter tip may prove to be one of the most brilliant changes to CEREC technology in recent history. The advent of the step milling diamond redefined tooth preparation design required for the CEREC system. The outcome is the ability to prepare teeth as conservatively as required for commercial laboratory manufactured all-ceramic restorations. Also, the latest version of CEREC software version 3 has been re-designed to create 0.9mm milling steps so that the step diamond and milling software work in unison to produce the smallest overmilling pattern in CEREC history⁴.

**Digital impressions**

The core of the CEREC procedure is digital impression scanning. The CEREC Bluecam operates on the principle of stripe-light projection, combined with active triangulation.

1. A pattern of parallel lines is projected onto the tooth. These lines are distorted by the tooth contours.

2. The distortions can be viewed from an angle (triangulation). This delivers precise information about the various elevations of the tooth. If the line pattern is shifted, by moving the grid during the exposure, the measuring points can be clearly assigned.

The accuracy of the optical impression depends on the wavelength of the light source. Short-wavelength blue light ensures greater accuracy than e.g. red or infrared light.
The automatic exposure system eliminates substandard optical impressions. In these examples, the left-hand image is blurred; the right-hand image is correct.

The CEREC impressions achieve very high levels of precision – inlay preparations: 19 µm.

**The advantages of the CEREC system**

- Treatment of single-tooth defects with high-quality ceramic restorations in a single treatment session
- Broad spectrum of applications, ranging from inlays to full crowns and veneers
- Direct monitoring of the preparation on the computer screen
- No need for temporary restorations
- No need for conventional impression materials
- No post-operative oversensitivity
- Fast, highly automated design process
- Patient-specific restorations
- Integration of X-ray data for implant planning and the production of surgical guides
- Integration into digital workflow – CEREC Connect
- Fabrication of temporary crowns and full-size bridges with up to 4 units as long-term temporaries
  - e.g. in connection with implant therapy

**CEREC 3D Software**

A unique feature of the CEREC 3D software is the biogeneric occlusal surface design function. The biogeneric process is based on the scientific finding that a patient’s teeth share common morphological characteristics. These characteristics can be analyzed and then expressed as mathematical functions. The “Biogeneric Tooth Model” is the outcome of extensive research carried out by Prof. Dr. Albert Mehl and Prof. Volker Blanz.
The patient’s individual tooth morphology is analyzed. This provides the basis for the automatic computation of the occlusal surfaces.

Patient-specific CEREC restorations can now be created “at the touch of a button”. The restoration is adapted automatically to the residual tooth and the neighboring teeth.

The biogeneric tooth model implemented in the CEREC 3D software streamlines and speeds up the computer-aided design process. The resulting restorations are rated very highly by dentists.
Soft tissue management

The basic rule for optical impressions is the camera can detect only those areas which are clearly visible. Before the non-reflective powder coating is applied the entire preparation margin must be clearly revealed. Depending on the specific situation, various techniques can be applied.

In the case of supragingival and equigingival preparation margins no additional effort is required. In the case of equigingival proximal boxes the preparation margins can be separated additionally by means of wooden wedges.

An intrasulcular or subgingival preparation margin is often desirable for crowns and bridge restorations. The simplest way to displace the gingival tissue is to deploy a retraction cord.

To achieve additional haemostasis the dentist can apply an iron sulphate gel (e.g. Astringent, Ultradent) or ammonium chloride products (e.g. Expasyl).

In some cases it may be necessary to perform a gingivectomy procedure with the aid of an electrosurgery device or a laser in order to reveal the preparation margin.
Powdering

In order to obtain an accurate optical impression an opaque powder coating must be applied evenly to the preparation. Various products are available for this purpose – e.g. CEREC Optispray (Sirona).

Begin by powdering the outer tooth surfaces. Rotate the nozzle in such a way that you can access the buccal surfaces while holding the spray can in a vertical position. Apply the coating in short bursts, from mesial to distal. Rotate the nozzle and powder the oral tooth surfaces. Finally, you should coat the occlusal surfaces and the tooth cavity. An even and thin coating in the cavity is a prerequisite for the optimum fit of the restoration. The optimum thickness is 40 - 60µm (150 µm in the case of excessive application).
Operating the camera

The CEREC Bluecam is equipped with an automatic acquisition control system. In the so-called “continuous measuring mode” the system triggers a series of optical impressions as soon as the camera is held steadily. Alternatively, the optical impressions can be acquired in the manual mode. In this case, the user determines the moment when the optical impression is captured, irrespective of whether the camera is held steadily or not. The camera is activated either via the left mouse or alternatively the foot control.

Digital impression scans

Position the camera over the preparation. The C-Stat support helps you to position the camera on the occlusal surface without damaging the powder coating. In automatic mode as soon as the camera is steady it will take an image. In manual mode you either have to release the left mouse or touch the foot control. The image is immediately displayed on the monitor.

Optical impression of the preparation

The optical impression of the preparation captures the entire cavity. Position the camera in such a way that the entire preparation margin is visible. The optical impression is then triggered and is displayed immediately as a 3D preview in the image catalogue and as an image (icon) in the docking bar.
Capturing the bite situation

The CEREC 3D software can automatically adapt the restoration proposal to the antagonist. To this end it is necessary to capture the position and morphology of the opposing teeth. This can be performed in two different ways.

1. Buccal registration

Buccal registration entails a series of angled and supplementary impressions acquired from the occlusal, buccal and oral direction. These supplementary impressions should extend as far as the canine.

2. This is followed by the application of the powder coating and the acquisition of the antagonist quadrant. In this case supplementary buccal impressions are an absolute must. Here as well, the optical impressions should extend as far as the canine region.

• The patient then closes his or her jaw in permanent habitual occlusion. The camera is placed horizontally in the vestibule and an impression is acquired in the area of the premolars at the height of the occlusal plane. To continue press the green icon “Next”.

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Attention:
The camera must not compromise the patient’s terminal occlusion. For this reason the camera should be placed in the canine-premolar region, where there is sufficient space.

- The next step is to assign the preparation model, the antagonist model and the buccal impression to each other. The three images are arranged one above the other on the monitor.

- Move the cursor onto the buccal impression and click on the cervical area of the upper canine. While keeping the left mouse pressed, drag the buccal impression onto the upper canine of the preparation model and release the left mouse.

The bite occlusion image is superimposed on the basis of the buccal surfaces. This is why it is so important to capture the angulated images of the preparation and the antagonist.

Click on the cervical margin on the antagonist canine and keep the left mouse pressed. Drag the buccal impression and the preparation model onto the canine of the antagonist model.
The outer contour of the model is now superimposed on the buccal impression. The preparation and the antagonist have now been spatially assigned to each other according to the specific clinical situation.

To view the occlusal contacts on the 3D model click the “Contact” button.

The bite occlusion image is superimposed on the basis of the buccal surfaces. This is why it is so important to capture the angulated images of the preparation and the antagonist. Click on the cervical margin on the antagonist canine and keep the left mouse pressed. Drag the buccal impression and the preparation model onto the canine of the antagonist model. The outer contour of the model is now superimposed on the buccal impression. The preparation and the antagonist have now been spatially assigned to each other according to the specific clinical situation. Via the “Settling” function the CEREC software attempts to achieve an even distribution of contact points across the entire model. This function should be deployed only with great caution due to the fact that the software cannot allow for the real-life contact situation (position relative to the TMJ, resilience of the individual teeth, clinical non-occlusion, etc.). On the basis of our clinical experience the assignment of the models on the basis of the buccal impression is very precise, so that “Settling” is not required. “Settling” can be used to create evenly distributed contacts on whole-arch stone models. This function should not be used for intraoral impressions.
Conclusion

Today, the CEREC method has been proven internationally and has a sibling in the dental laboratory, the CEREC in Lab. However, its unique feature in dental CAD/CAM technology is that it enables the dentist to capture the tooth preparation directly in the mouth of the patient allowing the dentist to create and seat a ceramic restoration in one appointment. It appears that the CEREC CAD/CAM concept is becoming a significant part of dentistry.

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