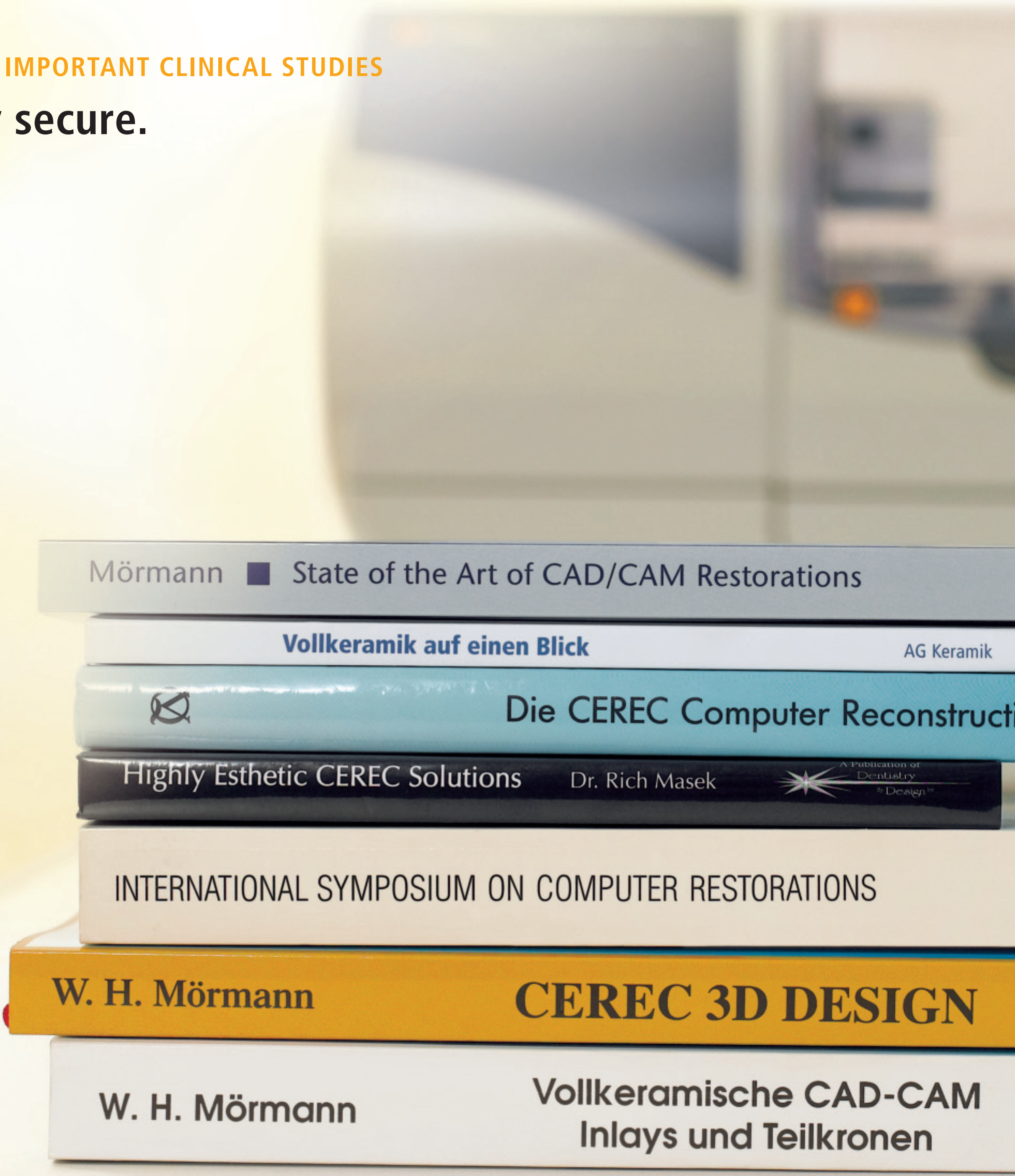
CEREC – THE MOST IMPORTANT CLINICAL STUDIES

Scientifically secure.



Contents

Foreword and word of thanks

Quod est est – What is, is.
In the final analysis it all comes down to hard facts and evidence. This is precisely the purpose of the present compendium. Our aim is to summarize the latest clinical studies relating to CEREC so that you are in a position to interpret and evaluate the scientific findings.
CEREC certainly ranks as one of the most intensively scrutinized dental procedures – as evidenced in numerous clinical studies and a wide range of scientific publications.
For example, universities and scientifically oriented dental practices are continuously monitoring the survival rates of CEREC restorations (inlays, onlays, crowns and veneers) which were created and placed during a single appointment. The projected long-term survival rates are as high as 84.4 per cent after 18 years.

In terms of quality CEREC restorations are at least on a par with cast gold – and clearly superior to composite fillings and other laboratory-produced restorations.
Computer-aided dentistry has progressed enormously. The marginal gaps have reached laboratory standards. The design of the proximal contacts has become very reliable. The occlusal surfaces contained in the dental databases have been compiled by universities and renowned dental technicians. The CEREC system makes allowance for the patient's articulation and antagonists.
All that is needed is a good dentist – someone like you.

The CEREC-Team

Over the past 20 years numerous persons have contributed to the further development of Professor Mörmann's original idea – i.e. to create high-quality ceramic restorations during a single appointment. This applies firstly to the members of the research teams at Siemens, Sirona, Vita Zahnfabrik, Ivoclar Vivadent, Merz, Zeiss and at numerous small and medium-sized enterprises. Secondly, more than 200 universities worldwide have conducted detailed research and made countless improvements – both large and small – to the CEREC procedure. Mention must also be made of the CEREC users, the CEREC instructors, the International Society for Computerized Dentistry and its national organizations. All these persons and organizations have played a pivotal role in ensuring that CEREC has become an integral part of modern dentistry. We would like to express our sincere thanks to all concerned.
We would also like to thank the German Society for Computerized Dentistry for its expert help in the preparation of this compendium as well as the selection and interpretation of the scientific studies.

Bart Doedens

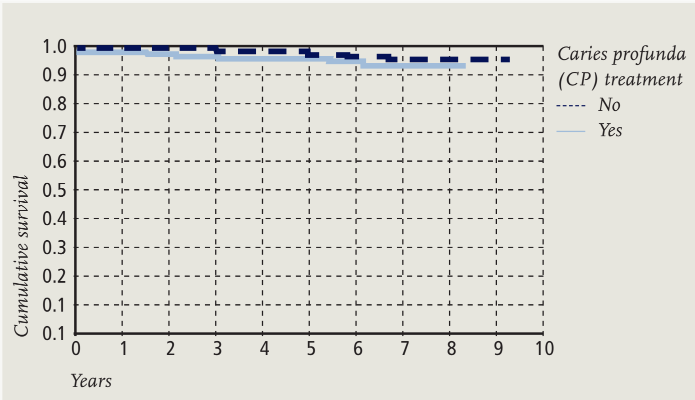
1 | Long-term performance of CEREC restorations

1.1 Inlays/onlays

1.1.1 Long-term study of 2,328 chairside inlays/onlays

This extensive study centred on 2,328 chairside CEREC inlays and onlays which had been fitted to a total of 794 patients in a dental practice. Between 1990 and 1997 the CEREC 1 system had been used; between 1997 and 1999 the CEREC 2 system was used. Forty-four teeth were randomly selected and examined under a scanning electron microscope. The average margin width was 236 µm ± 96,8 µm.

The success rate after nine years was 95.5 %. Only 35 restorations failed, due mainly to the extraction of the teeth. There was no correlation between failure and the size or location of the restorations.



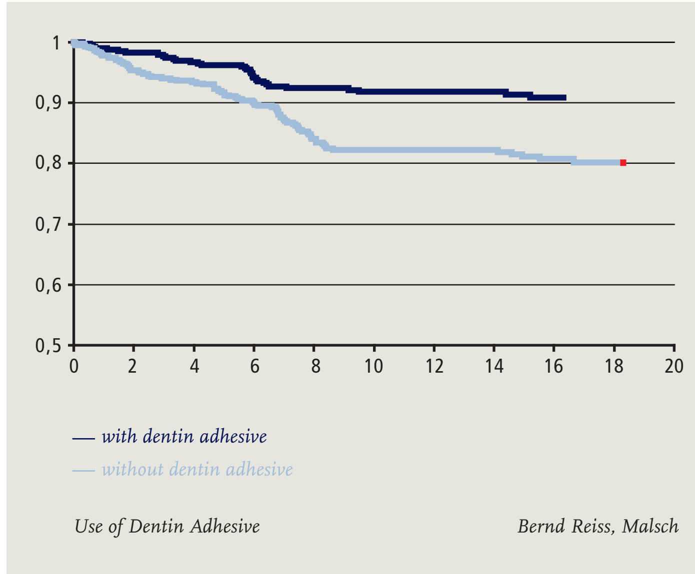
Survival curve with regard to CP treatment

Conclusion:
The long-term results (95.5 % survival after nine years) are excellent, although CEREC 1 and CEREC 2 do not achieve today's level of clinical precision and the quality of the margins (created using macrofilled luting materials) does not conform to today's standards.

Source: Posselt A, Kerschbaum T, Longevity of 2328 chairside CEREC inlays and onlays, Int J Comput Dent; 6: 231–248

1.1.2 Eighteen-year study of 1,011 inlays/onlays

This study centred on 1,011 CEREC inlays/onlays which had been fabricated for 299 patients between 1987 and 1990 using the CEREC 1 system. The majority of the restorations were made of VITA MK I ceramic; only a small number (22) were made of Dicor MGC. As from 1989 enamel etching (phosphoric acid) was deployed in combination with the dental adhesive Gluma. Glass ionomer cement was no longer used as the base layer. Areas close to the pulp were protected by means of a $CaOH_2$ liner. The follow-up criteria were as follows: margin quality, change in vitality, tooth anatomy, complications, and failures. The findings were categorized according to the following parameters: restoration size, restoration location, initial tooth vitality, and the use of dentin adhesive. During the 18-year observation period 86 of the 1,011 restorations were lost. Ceramic fractures were the main cause (38 %). According to the Kaplan Meier estimator, the probability of success after 18 years was extremely high (84.4 %). Premolars perform slightly better than molars, and 2- and 3-surface inlays better than 1-surface inlays. There is a significance between non-vital teeth (50 %) and vital teeth (88 %). The application of a functional dentin adhesive increased the success rate by 10 % to 90 %.



Kaplan-Meier estimator: Use of dentin adhesive, n = 1,011

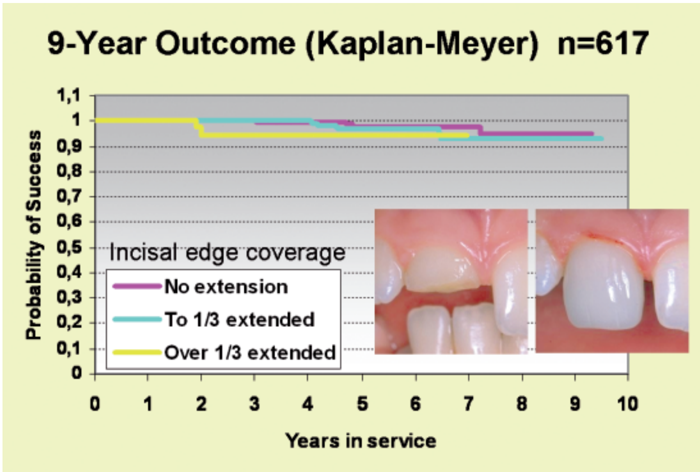
Conclusion:
CEREC restorations (including those of a larger size) display outstanding longevity. In many cases defect-oriented restorations and careful adhesive bonding provide the basis for dispensing with full crowns.

Source: Reiss B, Eighteen-Year Clinical Study in a Dental Practice. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 57–64

1.2 Veneers

The durability of laboratory-produced ceramic veneers has already been extensively researched. A group of CEREC veneers and partial anterior crowns was observed over a period of 9.5 years. These restorations had been produced on the CEREC 1 and CEREC 2 systems using VITA Mark II (mainly) and Ivoclar ProCad. 509 of the veneers had been bonded to natural teeth; 108 had been used to repair/replace existing PFM or gold-composite restorations. After 9.5 years the restorations attached to prosthetic elements had a success rate of 91 %, while those placed on natural teeth showed a success rate of 94 %.

Conclusion:
In terms of their longevity CEREC veneers do not differ from laboratory-produced veneers.



Ceramic build-ups comprising up to 2/3 of the veneer length do not fair worse

Source: Wiedhahn K, CEREC Veneers: Esthetics and Longevity. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 101–112

1.3 Crowns

Following the introduction of CEREC 2 dentists were in a position to produce full crowns in addition to inlays and veneers. In a further scientific study 208 CEREC crowns made of VITA Mark II were fitted to 136 patients using the adhesive bonding technique. Seventy of these crowns were placed on conventionally prepared teeth; 52 were placed on teeth with reduced stump preparations (low macroretention); and 86 crowns were placed on endodontically treated teeth. In this case the crowns included an additional post extending into the pulp cavity in order to achieve improved retention (endocrowns). The main causes of failure were fractures, presumably due to inadequate dentin adhesion. The "classic" crowns performed best of all (97.0 % survival rate), followed by the "reduced" crowns (92.9 %). The survival rate of the endocrowns was acceptable in the case of molars (87.1 %) and relatively poor in the case of premolars (68.8 %).

Conclusion:
CEREC crowns made of VITA Mark II and Ivoclar ProCad achieve success rates which are comparable to those PFM crowns.

CEREC crowns also performed well in a study conducted in a dental practice. This study centred on 65 full crowns made of VITA Mark II which had been manually polished after the milling process and then bonded using dual-curing composite. Three failures were observed in the period up to four years (two ceramic fractures, one debonding). The success rate according to Kaplan-Meier was 95.4 %.

Source: Bindl A, Survival of Ceramic Computer-aided Design/Manufacturing Crowns Bonded to Preparations with Reduced Macroretention Geometry. Int J Prosthodont; 18, 2005: 219–224
Otto T, Computer-Aided Direct All-Ceramic Crowns: 4 Year Results. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: Poster

1.4 Comparison with other restoration types

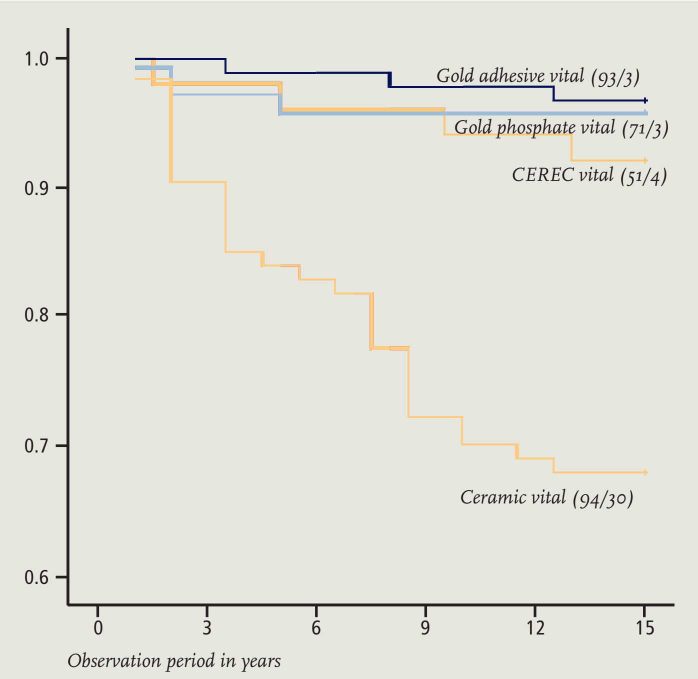
1.4.1 Clinical comparison

Long-term comparison of CEREC, laboratory-fabricated ceramic and gold inlays over a period of 15 years.

For the past 15 years 358 two- and three-surface inlays have been under observation at Graz University in Austria. The following restorations were placed on vital teeth: 93 gold inlays cemented with zinc phosphate cement (= control group); 71 adhesively bonded gold inlays; 94 laboratory-fabricated ceramic inlays (Dicor, Optec, Duceram, Hi-Ceram); and 51 CEREC inlays (VITA Mark I). In addition, a number of non-vital teeth were treated: gold/cement (5); gold/adhesive (14); laboratory-fabricated ceramic (22); and CEREC (8).

The restorations were assessed according to the following criteria: loss or complete fracture; partial fracture of the restoration, the tooth or the cement/adhesive bond; secondary caries; loss of tooth vitality. A Kaplan-Meier survival analysis was carried out for each group. In all groups inlays placed on non-vital teeth performed worse than inlays placed on vital teeth.

Initially the study included a group of indirect composite inlays. However, these were excluded prematurely on account of their very poor performance.



Probability of failure in the four subgroups

There was no significant statistical difference between the gold inlay groups and the CEREC inlays (success rate of approx. 93 % after 15 years). The laboratory-fabricated ceramic inlays were clearly inferior (68 %).

Conclusion:
In terms of longevity CEREC inlays are on a par with gold restorations. The laboratory-fabricated ceramic restorations performed worse.

The following ductile filling materials are used for posterior cavities: amalgam; glass ionomer and derivative products; and composites. In addition the following restoration types are available: gold inlays/onlays; composite inlays/onlays; laboratory-fabricated ceramic inlays/onlays; and CEREC inlays/onlays. Long-term studies have been carried out for each group. These have revealed significant differences in longevity. The annual failure rate was determined for each restoration type. The ranking (from bad to good) is as follows:

7. Glass ionomer and derivative products (7.7 %)
6. Amalgam (3.3 %)
5. Composite fillings (2.2 %)
4. Composite inlays/onlays (2.0 %)
3. Ceramic inlays/onlays (1.6 %)
2. Gold inlays/onlays (1.2 %)
1. CEREC inlays/onlays (1.1 %)

Conclusion:
The success rates of CEREC restorations are marginally better than those of gold inlays/onlays.

Sources: Arnetzl G, Different Ceramic Technologies in a Clinical Long-term Comparison. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 65–72
Hickel R, Manhart J, Longevity of Restorations in Posterior Teeth and Reasons for Failure. J Adhesive Dent 2001; 3: 45–64

1.4.2 Longevity and cost-effectiveness

In times of financial constraint it makes sense to evaluate the longevity and cost of dental restorations – not in isolation but in combination – in order to develop cost-effective restoration options for patients. On the basis of billing data provided by a major German insurer the average fees and laboratory costs were determined for gold inlays (62), laboratory-fabricated ceramic inlays (87) and CEREC inlays (91). A meta analysis was then performed of ten suitable long-term studies from the period 1994 to 2003. This provided the basis for determining the statistical longevity of the various inlay types.

1.4.3 Longevity and production costs

Due to their higher production costs and slightly lower survival probability, laboratory-fabricated ceramic inlays are the least cost-effective option. Gold inlays and CEREC inlays have similar success rates. However, given the higher laboratory costs of gold inlays, CEREC inlays emerge from this study as the most cost-effective restoration type.

Conclusion:
From an economic viewpoint CEREC inlays are preferable to all other inlay types.

Sources: Kerschbaum T, A Comparison of the Longevity and Cost-effectiveness of Three Inlay-types. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 73–82

2 | Precision

2.1 Image Precision

The precision of a milled CEREC restoration depends to a large extent on the quality of the data derived from the digital optical impression. The intraoral CEREC Bluecam has an innovative optical lens emitting blue light with a short wavelength.

2.1.1 Single tooth

The scanning accuracy of CEREC Bluecam is approx. 19 µm. This high degree of precision is equivalent to that of the reference scanner*. Repeat measurements were in the region of 10 µm and the user influence was less than 12 µm. The results were not dependent on the type of preparation.

2.1.2 Quadrant

The images with CEREC Bluecam were taken in auto capture mode and approx. 4–6 exposures were required per quadrant. The software automatically triggers the exposure when the camera is positioned absolutely still above the tooth. CEREC Bluecam demonstrates a significantly improved quadrant precision in comparison to the CEREC 3D camera (34 µm as opposed to 42 µm). The low values of repeat measurements of approx. 13 µm demonstrate the high accuracy of the CEREC Bluecam. The user influence on the precision of the measurement results was extremely low (approx. 15 µm).

Conclusion:
The CEREC Bluecam generates digital optical impressions with an unprecedented degree of measurement precision.

* *Laserscan 3D Pro (Willytec, Munich).*

Source: Mehl A. Investigation of the optical measurement precision of a new intraoral camera. Unpublished study carried out by the Department of Computer-aided Restorative Dentistry, Zurich University.

2.2 Milling precision

2.2.1 Camera/milling unit

The precision of the CEREC system is determined by the resolution of the CEREC camera (25 µm) and the reproducibility of the milling unit (± 30 µm). Excluding user-induced influences (e.g. preparation, powdering and exposure technique), the precision of CEREC 3D is in the range ± 55 µm.

2.2.2 Marginal fit of restorations

The marginal accuracy of milled CEREC restorations has continuously improved with each successive software version (from CEREC 1 to current version of CEREC 3D). With regard to the hardware, the introduction of the step bur (tip diameter: 1 mm) represented a major improvement. Within the framework of this multi-centre trial (seven universities) the marginal fit and internal adaptation of CEREC full crowns were measured and compared with laboratory-fabricated ceramic crowns. A group of trained CEREC dentists and a group of non-trained assistants each designed and milled ten molar crowns on the basis of standard models. The crowns (made of the VITA Mark II and Ivoclar ProCad materials) were placed with the aid of Variolink. Empress ceramic crowns sourced from a reputable dental laboratory were also placed.

The marginal fit of the dentist's crowns (61.6 ± 27.9 µm) and the assistants' crowns (60.8 ± 20.5 µm) did not differ significantly. The margins of the laboratory-fabricated crowns were slightly wider (69.1 ± 26.9 µm), which, however, was not statistically significant. With regard to their axial wall adaptation the CEREC crowns were clearly better than the laboratory crowns, whereas in terms of occlusal wall adaptation the laboratory crowns performed better.

Conclusion:
The marginal fit of CEREC crowns tends to be better than that of laboratory-fabricated ceramic crowns.

Operator	Margin	Axial Wall
Dentist	61.8 ± 27.9 a	86.6 ± 20.9 b
Assistant	60.8 ± 20.5 a	88.2 ± 19.1 b
Lab Tech	69.1 ± 26.9 a	125.4 ± 29.9 a

Mean values in microns ± standard deviation. Groups that are significantly different are indicated by letters P < 0.05.

* *This study has been carried out with the CEREC 3 camera. The improved image precision of CEREC Bluecam has therefore not been taken into consideration.*

Source: Fasbinder DJ, Multi-Center Trial: Margin Fit and Internal Adaptation of CEREC Crowns. In: Mörmann WH (ed.), State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: Poster

3 | Marginal gap

3.1 Adhesive interface

The performance of the luting materials and the chosen bonding technique have a decisive impact on the success of all-ceramic restorations.

3.1.1 Materials

Metal restorations rely principally on macroretention. By contrast etchable all-ceramic materials (silicates/disilicates) are luted directly to the hard dental tissues and rely on microretention. The bonding of CEREC restorations (VITA Mark II, Ivoclar Empress CAD) does not differ from the bonding of laboratory-fabricated inlays, onlays and veneers made of comparable materials. This procedure has remained virtually unchanged since the introduction of dentin adhesives in 1991.

The first step is the CONDITIONING (e.g. etching) of the enamel, dentin and ceramic with the goal of creating a clean microroughened surface. This is followed by the application of a PRIMER, the function of which is to make the clean surface wettable for the hydrophobic bonding material. The third logical step is BONDING – i.e. the application of an unfilled bonding resin, which forms an intermediate layer between the tooth surface, the luting composite and the ceramic material. Older adhesive systems consist of separate products for each of these steps. The newer systems try to reduce the number of bottles needed. High-strength oxide ceramics such as inCeram, aluminium oxide and zirconium oxide do not lend themselves to etching and hence can be conventionally cemented. Self-adhesive luting materials have meanwhile become available.

Conclusion:
The adhesive bonding of silicate ceramics has been proved over a period of many years. The various materials must be carefully matched.

	Enamel	Dentin	Etchable Ceramic	Non-Etchable Ceramic	Composite
1. Conditioner	35 to 37 % H_3PO_4	Self-conditioning Primer	5 % HF	Coe Jet/ Al_2O_3 powder	Al_2O_3 powder
2. Primer	Hydrophobic Bond	Self-conditioning Primer	Organic Silane		
3. Layer-forming Component	Hydrophobic Bond	Pre-cured Amphiphilic Bond	Hydrophobic Bond		
4. Luting Material	Luting Composite				

Luting composites fall into three different categories: chemically cured, light-cured and dual-cured.

This ten-year study compared CEREC 2 inlays which had been luted either with chemically cured or dual-cured composites.

The success rate after ten years was 77 % in the case of dual-cured composite and 100 % in the case of chemically cured composite.

Conclusion:
Dual-cured composites should be used only in situations in which chemically cured or light-cured composites are unsuitable.

Source: Krejci I, Bonding of Ceramic Restorations – State of the Art. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 39–45
Sjögren G, Molin M, A 10-year prospective evaluation of CAD/CAM – manufactured (CEREC) ceramic inlays cemented with a chemically cured or dual-cured resin composite. Int J Prosthodont 2004; 17: 241–246

3.1.2 Marginal seal

Shortly after the introduction of CEREC there were naturally no long-term studies to draw upon. It was therefore necessary to establish whether the width of the luting interface (i.e. the thickness of the luting composite layer) had any influence on the marginal seal. All the investigations showed that it was advantageous to locate the restoration margin in the enamel. This in vitro study (which involved dye penetration tests) showed that the thickness of the luting composite layer did not have any influence on the marginal seal.

Subsequent long-term studies of CEREC 1 and CEREC 2 restorations confirmed these findings.

Conclusion:
The thickness of the luting composite layer does not have any influence on the marginal seal.

In relation to deep cavities the question is whether a liner plays a beneficial role for the protection of the pulp.

According to a study carried out by N. Krämer/Erlangen the occurrence of initial hypersensitivity doubled in cases where a liner was laid. The failure rate of ceramic inlays (in this case Empress) trebled when a liner was deployed.

Conclusion:
The placement of liners under ceramic inlays/onlays is contraindicated.

3.1.3 Wear of the adhesive interface

Various Empress inlays placed using Variolink low (low viscosity) and Tetric (high viscosity) were measured in order to determine the wear of the luting composite in highly loaded areas. After six years the mean interfacial width had increased from 176 µm to 207 µm. The two different composites did not exhibit any significant statistical differences.

Conclusion:
Low-viscosity and high-viscosity composites are suitable for the placement of CEREC inlays and onlays.

Source: Magne P, An in Vitro Evaluation of the Marginal and Internal Seals of CEREC Overlays. In Mörmann WH (ed.) International Symposium on Computer Restorations, Berlin: Quintessence, 1991: 425–440
Krämer N, Frankenberger R, IPS Empress inlays and onlays after 4 years – a clinical study. Journal of Dentistry 1999; 27: 325–331
Krämer N, Frankenberger R, Leucite-reinforced glass ceramic inlays after six years: wear of luting composites. Oper-Dent. 2000; 25: 466–472

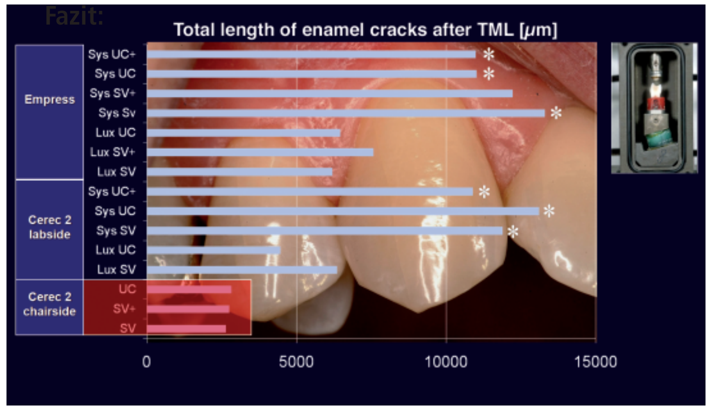
3.2 Comparison of other Restoration Types

Temporaries and methods of bonding labside and chairside produced ceramic inlays have a decisive influence on enamel defects and the margin quality.

3.2.1 Enamel Integrity
Inlay cavities treated with temporaries demonstrate, after simulated temporary wear in a chewing simulator, a deterioration of the enamel integrity. In particular in both oral and vestibular surfaces cracks developed. By cavities treated immediately with chairside produced ceramic inlays no such enamel defects arose.

Conclusion:
Chairside produced CEREC inlays offer the treated tooth a reduced risk of enamel cracks, due to there being no provisional.

3.2.2 Margin Quality
The analysis of bonding systems demonstrated that conventional bonding is still superior to self-adhesive systems. Selective enamel etching as used with CEREC inlays enhances the bond with the hard tooth tissue and improves the quality of the enamel margin. In contrast to the general assumption a broader adhesive gap does not result in inferior margin quality.



Measurement results of damage to the enamel marginal edge (with or without temporaries). Chairside ceramic treated cavities show fewer enamel cracks [TML: thermocycling and mechanical loading].

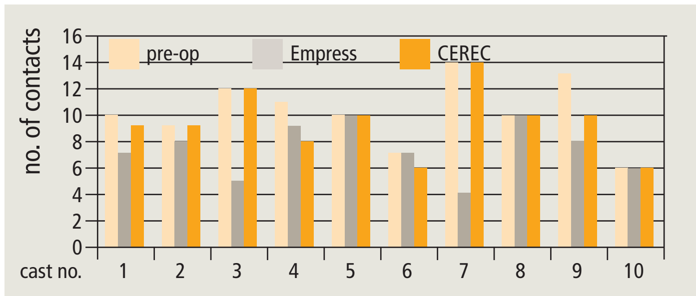
Conclusion:
Immediate treatment without temporaries has a stabilizing effect on the tooth substance. Attainable bonding technology takes into account a broader adhesive gap.

Source: Frankenberger R. Chairside and labside produced ceramic inlays – Influence of temporaries and bonding on the enamel integrity and margin quality. Unpublished study. Publication in preparation.

4.1 Software

The current version of CEREC 3D includes a variety of tools for mapping the patient's occlusion and articulation (static and functional) and for the automated design of the occlusal surfaces.

- The DENTAL DATABASE contains various sets of data which can be selected according to the specific situation.
- CORRELATION creates a precise and adjustable copy of the existing situation.
- REPLICATION enables the dentist to create an optical impression of any chosen occlusal surface (either contralateral in the patient's mouth or from a separate model). This optical impression can then be placed manually on the preparation.
- ANTAGONIST maps the static occlusion of the antagonists.
- ARTICULATION maps the surface of a functionally generated path (FGP).



Number of occlusal contacts of the casts before and after placement of the different crowns (contacts of the restorations excluded!)

By combining DENTAL DATABASE, CORRELATION / REPLICATION with the ANTAGONIST and ARTICULATION tools the dentist is in a position to create functional occlusal surfaces on the computer monitor – manually, semi-automatically or automatically. These occlusal surfaces require only very little subsequent adjustment. The manual reworking requirement can be reduced from approx. 400 μm (DENTAL DATABASE) to approx. 5 μm (CORRELATION plus ANTAGONIST).
Provided that the equipment parameters are set properly, the dentist can dispense entirely with manual corrections.
To determine the occlusal contact precision of CEREC crowns and laboratory-made Empress crowns respectively, models of natural teeth were measured prior to preparation and after placement of the restorations. This comparison did not reveal any significant differences between the CEREC and Empress crowns.

Conclusion:
Precise occlusal surfaces can be designed on the computer monitor. These require practically no subsequent adjustment in the patient's mouth.

Sources: Fasbinder D J, Predictable CEREC Occlusal Relationships. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 93–100
Reich S, Static occlusal precision of two all-ceramic systems. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: Poster

5.1 Posterior teeth

CEREC inlays and onlays can be characterized with the help of ceramic stains. After they have been glazed they can be placed in the same way as laboratory-made ceramic restorations. Due to the special qualities of the CEREC ceramics (chameleon-like shade adaptation; wide choice of lightness, translucency and colour shades), staining is not necessary in most situations. The CEREC ceramics are easy to polish. In most cases the surface finish is in no way inferior to that of a glazed restoration.
Various studies testify to the good shade adaptation of CEREC ceramics. According to the criteria of the California Dental Association (CDA) 87 % of the restorations were rated as excellent. According to the USPHS, the surface characteristics and shade adaptation of all the tested restorations were judged to be excellent or clinically good.

Conclusion:
If the ceramic materials are correctly chosen and properly polished, laboratory staining and glazing are unnecessary in most cases.

Sources: Sjögren G, Molin M, A 10-year prospective evaluation of CAD/CAM-manufactured (CEREC) ceramic inlays cemented with a chemically cured or dual-cured resin composite. Int J Prosthodont; 17/2004: 241–246

5.2 Anterior teeth

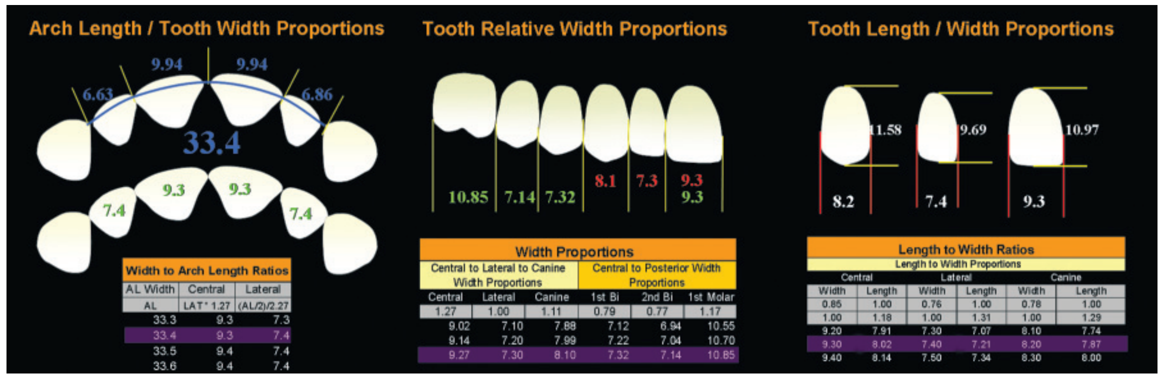
After they have been milled CEREC anterior crowns can be stained and glazed. Alternatively, they can be incisally trimmed and then layered using a transparent ceramic material (in cases where especially transparent incisal surfaces are required). Thanks to their graduated shading intensities, polychromatic blocks (e.g. VITA Triluxe or Empress CAD Multi) make it easier to imitate the natural teeth. Shading pastes (e.g. VITA Shading Paste, Ivoclar Shade and Stains Kit) and shading powders (e.g. VITA Akzent) permit the rapid characterization of anterior crowns. In simple applications shading and glazing can be combined in a single operation. Multiple firing operations are possible. The CORRELATION programm allows the shape of the restoration to be simulated prior to milling. In many cases it is possible to create and place chairside anterior crowns during a single appointment. More sophisticated layering techniques are possible. However, these usually necessitate an indirect procedure using a physical impression and a cast model. Highly complex characterizations can be achieved in this way.

Conclusion:
Anterior crowns pose a challenge which can be accomplished during a single appointment with the help of polychromatic blocks and various characterization techniques.

5.2.1 Veneers

More and more CEREC users are offering veneers as part of their treatment repertoire. Partial anterior crowns and veneers are frequently used as a tooth-conserving alternative to a full crown. Characterization can be performed using the methods described for anterior crowns (ceramic stains in combination with transparent ceramic layering materials). In addition, "background shading" can be used in order to achieve natural-looking results. In this case composite shading materials are applied to the rear surface of the milled veneer. After the veneer has been placed this shading is visible through the thin sliver of ceramic material. Fine-tuning, contouring and high-gloss polishing are performed after the veneer has been bonded to the tooth. The time input corresponds to that of a CEREC inlay.

Conclusion:
CEREC veneers are a fast, tooth-conserving alternative to anterior crowns.



Mathematical Proportion Guides

Sources: Masek R, Ultimate CEREC Creations – Comprehensive Single Visit Esthetic Dentistry. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 131–138
Reich S, The effect of multicoloured machinable ceramics on the esthetics of all-ceramic crowns. J Prosthet Dent 2002; 88: 44–49
Tsotsos S, Single-appointment, all-ceramic anterior restorations. Int J Comput Dent 2001; 4: 263–272
Wiedhahn K, CEREC Veneers: Esthetics and Longevity. In Mörmann WH (ed.) State of the Art of CAD/CAM Restorations, 20 Years of CEREC, Berlin: Quintessence, 2006: 101–112

6 | Ceramic materials

VITA Mark II is the CEREC material with the longest track record. This feldspar ceramic is available in monochromatic blocks in a variety of 3D Master shades. This same material is also available in a polychromatic version (VITA Triluxe) with differently shaded layers.

The monochromatic CEREC Blocs as well as polychromatic CEREC Blocs PC available from Sirona are also made of feldspar ceramic. They are available in the most popular Classical and 3D Master shades.

The Ivoclar Empress CAD blocks (formerly called ProCad) consist of a leucite-reinforced glass ceramic material. They are available in the shades A-D, with two degrees of translucency respectively. Ivoclar also markets polychromatic blocks ("Multi").

The lithium disilicate glass ceramic blocks (e.max CAD LT) can be conventionally cemented.

6.1 Strength

Dental ceramics can be divided into two categories according to their microstructure:

1. Aesthetic enamel-like ceramics with a glass content in excess of 50 %. The physical characteristics (e.g. strength, hardness, abrasion properties, opacity, and colour shade) can be modified by the addition of fillers.
2. Polycrystalline ceramics for frameworks. These consist of particles with an identical crystalline structure. These relatively opaque materials are much stronger than glass ceramics.

Nearly all these versions are available as conventional laboratory ceramics and as machinable CEREC ceramics. Polycrystalline zirconium oxide and aluminium oxide ceramics are reserved exclusively for CAD/CAM systems.

Aesthetic ceramics	CEREC/inLab
Feldspar	Sirona Blocs, VITA Mark II
Glass/leucite	Empress CAD, Paradigm C
Lithium disilicate	e.max CAD LT, HT
Framework ceramics	
Lithium disilicate	e.max CAD MO
$MgAl_2O_4$/lanthanum	inCeram Spinell
Al_2O_3/lanthanum	inCeram Alumina
Al_2O_3/ZrO_2/lanthanum	inCeram Zirconia
Al_2O_3 (polycrystalline)	inCoris Al, AL-Cubes
ZrO_2 Ytt	inCoris ZI, YZ-Cubes, e.max ZirCAD

Conclusion:
CEREC and inLab systems can machine all the relevant types of dental ceramics and hence are future-compatible and universally deployable.

6.2 Abrasion

Veneering ceramics in particular have been criticized for causing wear to the antagonists and for being more abrasion-resistant than tooth enamel.
As long ago as 1991 Krejci demonstrated that VITA Mark II displays the same abrasion properties as natural enamel. The surfaces of CEREC do not need to be polished or glazed. There is no difference with regard to abrasive wear and tear of the tooth enamel.

The abrasiveness of VITA Mark II does not differ significantly from gold. The material itself is abraded at the same rate as gold.

Conclusion:
CEREC ceramics do not damage the antagonists and display abrasive properties that are similar to gold.

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CEREC publications

The following list of publications relates to the CEREC procedure and to specific materials and methods for inlays, partial crowns (onlays, overlays), crowns and veneers. It does not include the inEOS scanner or inLab bridge restorations.

1 | Adhesive bonding

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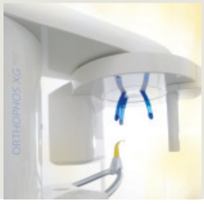

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