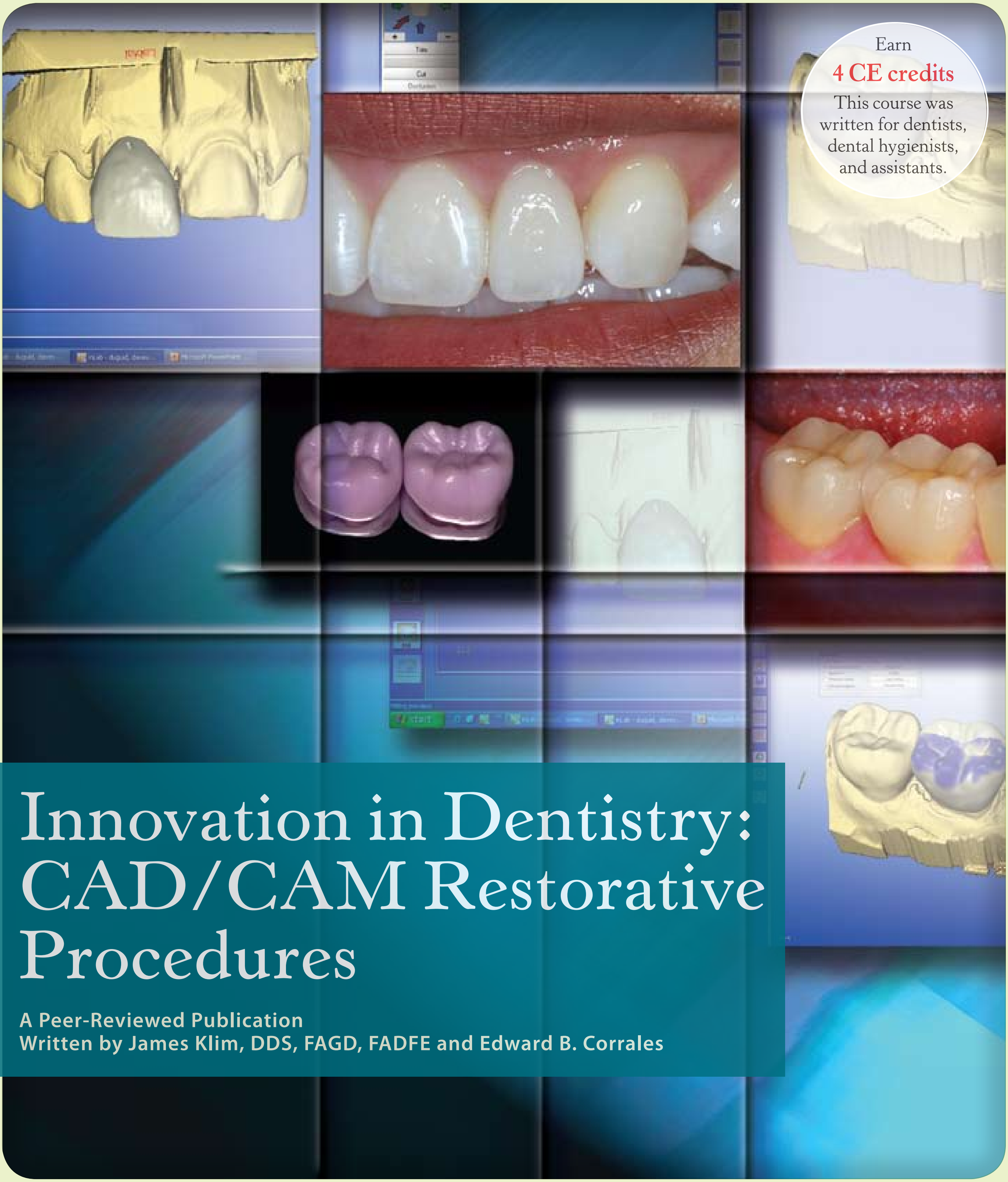

Innovation in Dentistry: CAD/CAM Restorative Procedures

A Peer-Reviewed Publication

Written by James Klim, DDS, FAGD, FADFE and Edward B. Corrales

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Educational Objectives

The overall goal of this article is to provide information on restorative procedures and materials using CAD/CAM technology.

Upon completion of this course, the clinician will be able to do the following:

1. Know the origins of CAD/CAM and its introduction into dentistry.
2. Understand the CAD/CAM technique used for chairside and integrated chairside—laboratory CAD/CAM procedures.
3. Describe the advantages and disadvantages of both traditional and CAD/CAM restorative procedures.
4. Know the types and properties of ceramic CAD/CAM blocks, and the considerations in selecting them for restorations.

Abstract

Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) was first introduced to dentistry in the mid-1980s. Both chairside and chairside—laboratory integrated procedures are available for CAD/CAM restoration fabrication. In selecting which procedure to follow, consideration should be given to esthetic demands, chairside time, laboratory costs, number of visits and convenience and return on investment associated with CAD/CAM equipment. Depending on the method selected, CAD/CAM ceramic blocks available for restoration fabrication include leucite-reinforced ceramics, lithium disilicate, zirconia, and composite resin. In order to determine which type of ceramic to use, the practitioner must take into account esthetics, strength, and ease of customizing milled restorations. CAD/CAM gives both the dentist and the laboratory technician an opportunity to automate fixed restoration fabrication and to offer patients highly esthetic restorations in just one or two visits.

Introduction

The genesis of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) occurred during the 1950s. After the U.S. Air Force developed an air defense system using graphics in the mid-1950s, the PRONTO was subsequently introduced as the first commercial use of system programming using numerical controls. CAD/CAM's first commercial introduction was at the end of 1962, when the Auto-trol was used to manufacture a digitizer.[1] During the 1970s and 1980s, CAD/CAM transformed design and manufacturing with widespread use of this method across industries.[2] The introduction of CAD/CAM to dentistry took place during the 1980s.[3] The first CAD/CAM devices introduced were CEREC (Sirona) and Procera (Nobel Biocare). CEREC was originally introduced strictly as a chairside technique; the objective was to perform a one-visit procedure for fixed restorations, with a focus on the provision of inlays and onlays.[4] In contrast, Procera was introduced as a nonchairside CAD/CAM device. The dental laboratory sent models to a Procera lab, where they were scanned; metal copings were then milled before being sent back to the dental laboratory for fabrication of ceramics on the copings. Since that time, dental CAD/CAM has evolved to include more sophisticated techniques, improved esthetic results, and a wider variety of options for the clinician and the laboratory technician.

Esthetic inlays, onlays, veneers, copings, substructures and full-coverage crowns can all be fabricated using current techniques. It is estimated that in 2007, more than 33 million crowns, 10 million bridges, and 3 million veneers were provided to patients in the United States.[5] Inlays represent a very small portion of all fixed restorations, an estimated 3% in 1999.[6] While all these fixed restorations can be fabricated using current CAD/CAM technology, using traditional chairside techniques followed by traditional laboratory techniques to fabricate the restoration continues to be more common.

Table 1. Types of CAD/CAM restorations

Inlays and onlays
Veneers
Copings
Substructures
Full coverage crowns

Traditional Restorative Techniques

Traditional restorative techniques for fixed restorations require the use of impression materials to record the contours and dimensions of the preparation. This is followed by the pouring of stone models and dies prior to laboratory fabrication of the definitive fixed restoration. Taking an accurate impression is one of the more difficult procedures in dentistry, requiring careful retraction or removal of soft tissue around preparation margins, hemostasis, and selection of an appropriate impression material and tray for the technique used. Materials developments have resulted in impressions that are more accurate and more dimensionally stable after setting and prior to the pouring of models. Nonetheless, even when the appropriate materials are used, care is required to avoid the introduction of voids, inaccurate margins, recoils, tears, and other inaccuracies. After the impression has been recorded, a temporary restoration must be provided that dimensionally matches the space created; has an anatomical contour with good marginal fit; has sufficient strength for the length of time it is to function; is not an irritant; and is esthetically acceptable.[7,8] Subsequently, dies and models are poured, with care taken to ensure that no dimensional inaccuracies are introduced and that all contours and margins are fully represented. The laboratory technician then waxes up and casts a metal fixed restoration or substructure, and/or incrementally places and bakes ceramic material for an esthetic restoration. In either case, attention to detail and precision are required. The use of contemporary ceramic materials has enhanced the esthetics that can be achieved for ceramic restorations.

Advantages of the traditional technique include the use of a proven method that does not require any procedure-specific capital equipment for fixed restorations. In addition, there is no learning curve beyond staying current with the use and handling of materials. Further advantages include the ability to provide patients with fixed restorations that, in the past, were esthetically superior to those fabricated using a chairside CAD/CAM milling technique.

Disadvantages of the traditional technique include the opportunity for material and operator error at the impression making, model- and die-pouring, and laboratory stages of the procedure. In addition, it is never possible to provide a custom-fabricated, single-visit fixed restoration, and temporary restorations must be fabricated whether or not they are required to provide a healing period, promote gingival form, or help plan the final restorations for complex cases.

CAD/CAM Restorative Technique

Using a CAD/CAM restorative technique, a number of steps can be simplified or eliminated. Traditional impressions can be replaced by use of a handheld scanning device that digitally records the form and margins of the preparation. Care must be taken to ensure that the whole preparation is scanned, to avoid introducing errors. As with a traditional impression, soft tissue retraction and hemostasis are prerequisites for an accurate result. In fact, these steps are more critical for CAD/CAM preparation scanning than with traditional impressions. While impression material has some tolerance for small amounts of sulcular fluid, and light-body material can flow into deeper subgingival margins, scanners require a dry field and soft tissue that must be thoroughly separate at the level of the margin from the hard tissue. For this reason, it has been suggested that a soft tissue diode laser (Odyssey Navigator, Ivoclar Vivadent; GENTLEray 980, Kavo; DioDent Micro 980, HOYA ConBio) be used to expose subgingival margins. The soft tissue diode laser has been found to offer precision, to result in a narrow band of lased tissue, and to produce good hemostasis.[9] Good healing has also been the case following use of diode lasers on gingival tissues.[10] Selecting a laser with sterilizable sleeves assists with infection control, and portability and precut laser tips aid convenience (Odyssey Navigaetor). Alternative soft tissue management techniques include electrosurgery and one of the standard manual retraction techniques. In addition, a modified preparation design may be necessary.

Figure 1. Soft tissue diode laser

Depending on the system used, the clinician can see the preparation magnified on the computer screen as the scan is being processed. This visualization – also available with intraoral cameras and operating microscopes – enables early detection of any preparation design defect, which can then be adjusted before the preparation is rescanned. In addition, the interocclusal distance and space created by preparing the tooth can be assessed by the software, enabling the dentist to make adjustments, if necessary.

Two basic techniques can be utilized for CAD/CAM restorations. One is strictly chairside – a single-visit technique – while the other involves an integrated chairside—laboratory CAD/CAM procedure. One factor for the clinician considering CAD/CAM is the capital costs associated with purchase of a unit: Will monthly production support the investment? It is important to take into account both the potential for reduced laboratory costs and chairside time as well as the consumable costs for each technique, such as cements, temporaries, impression materials, and trays for the traditional technique – or in the case of CAD/CAM, the consumable block of ceramic material.

Chairside CAD/CAM Technique

The chairside technique involves scanning the preparation and then fabricating the restoration in the milling device (CEREC 3, Sirona; E4D, D4D TECH). Prior to scanning, a very thin layer of powder is distributed over the preparation using the CEREC system. During scanning, the clinician must ensure that all margins of the cavity are captured by the scan and visualized.[11] The CEREC 3 uses still images, while the E4D uses a laser in the handheld scanning device. A third system, CICERO, was developed in The Netherlands and used a pressing, sintering, and milling technique prior to laboratory finishing of the restoration.[12]

From the patient's perspective, there are several potential advantages of chairside CAD/CAM fabrication of fixed restorations. No impression is required, which removes a source of discomfort and gagging; the restoration is ready in one visit, removing the need for an additional appointment or anesthetic; there is reduced potential for tooth sensitization; and a temporary restoration is not needed. CAD/CAM also helps project a state-of-the-art, high-technology image for marketing the dental office.

Chairside CAD/CAM has been found in numerous studies to offer accuracy. One study comparing the CEREC 2 and later-generation CEREC 3 found that both milled inlay and onlay restorations met the American Dental Association's standard of fit within 50 micrometers.[13] In 2003 a second study, however, found 47% of 2,328 restoration margins were underfilled and had a 95% probability of nine-year survival.[14] Using Vita Mark I feldspathic ceramic as the restorative material, Otto and Schneider found an 88.7% success rate up to 17 years after placement for 187 inlays and onlays placed using an early-generation chairside CEREC between 1989 an 1991. There were 21 failures, for which the most common reason was ceramic fracture (13 failures).[15] Sjögren et al. found that the success rate depended on the etching and luting cement used. The success rate for 61 inlays examined 10 years after placement was 100% for those luted using chemically cured resin composite cement, compared to 77% for those luted with dual-cured resin composite cement. Of seven inlays requiring replacement in one study, four involved inlay fracture and were all in dual-cured restorations on molars.[16] Wiedhahn et al. found that CAD/CAM veneers offered good clinical results and success rates. Of 617 veneers placed over an eight-year period (1989-1997) and then reevaluated, the survival rate was 94% after up to nine years; of these veneers, 98% were clinically acceptable.[17] In a one-year study of 20 crowns milled chairside using CEREC 3, Otto found all were clinically acceptable at the one-year follow up, with no fractures or loss of retention.[18] In a 2002 study, Bindl and Mörmann found a 100% success rate for 19 milled Vitabloc In-Ceram Spinell core crowns (4 premolars and 15 molars) and a 92% success rate for 24 Vitabloc In-Ceram Alumina core crowns (2 premolars and 22 molars); each of these were milled using CEREC 2 and were in place for 28-50 months.[19] It is worth noting that by virtue of the time horizon of some studies, the CAD/CAM methods and luting cements were earlier variants.

Table 2. Chairside CAD/CAM technique

Advantages
One-visit fixed restorative procedure
No impression making
No temporary restoration required
Reduced potential for tooth sensitization
No laboratory costs
No model or die pouring
Accuracy
Less opportunity for error compared to traditional technique
Aids prep visualization
Projects a state-of-the-art image
Disadvantages
Soft tissue management more critical than with traditional technique
Depending on the material and patient, customization may be required
High learning curve
Higher production required to cover capital investment

Traditionally, one drawback of chairside milled, finished restorations was inferior esthetics compared to a custom laboratory-fabricated restoration. CAD/CAM materials have included IPS Empress (Ivoclar Vivadent), a leucite-reinforced ceramic; Vita Mark II (Vita Zahnfabrik), a feldspathic ceramic; and Paradigm (3M ESPE), a composite resin-based material. A ceramic block is inserted into the machine and is milled using diamonds. CAD/CAM restorative materials are currently available in many shades and translucencies, including multiple shades within one dense gradated restorative block. The material used depends on functional and esthetic demands and on whether a chairside or laboratory CAD/CAM restoration is fabricated.[20]

For chairside CAD/CAM restorations, an esthetic, strong material requiring minimal post-milling esthetic adjustment to minimize chairside time is needed. Leucite-reinforced glass ceramics (IPS Empress CAD, Ivoclar Vivadent; Paradigm C, 3M ESPE) and lithium disilicate glass ceramics (IPS e.max, Ivoclar Vivadent) can be used for chairside and laboratory CAD/CAM single restorations. Composite-resin blocks are also available (Paradigm MZ100, 3M ESPE). Leucite-reinforced material is designed to match the dentition for strength and surface smoothness and to offer esthetic results by scattering light in a manner similar to enamel. Traditional ceramic crowns fabricated with leucite have been found to offer a survival rate of 95% after 11 years.[21] The blocks are available in a number of sizes, in high or low translucency. High translucency is indicated for inlays and onlays, enabling transmission of the tooth's shade through the material. Low translucency is indicated for crowns and veneers, providing superior masking of the underlying tooth structure. Leucite-reinforced blocks with multiple shading created within the block to match the chroma shading and shading gradations of a natural tooth from the incisal edge to the gingival margin are also available and offer a natural shaded and translucent appearance (IPS Empress CAD Multi, Ivoclar Vivadent). After the tooth has been milled, the clinician can quickly polish or glaze the restoration before seating it. For chairside cases where strength is a consideration, lithium disilicate CAD restorations offer a strength of 400 MPa as compared to leucite-reinforced ceramic with an MPa ranging from 120-160, and still provide good esthetics. Lithium disilicate is used as a monolithic (single layer) material, providing strength.

For specific cases, milled restorations can be characterized by staining and/or layering ceramic material (IPS Empress Esthetic Veneering Materials, Ivoclar Vivadent) on top, with or without cutting back the milled restoration, then placing the glaze and firing the material. In the case of veneers, as with traditionally fabricated veneers, the final shade of the bonded restoration is influenced by the selected shade of luting cement. If additional characterization is required, a thin layer of color shading can be applied and light-cured in the internal surface of the veneer. The cases below courtesy of Dr. Klim show the results of chairside CAD/CAM for inlay and crown restorations.

Case 1. Anterior Esthetic Zone

CAD/CAM anterior tooth design is very similar to posterior capture and design protocols and is ideal for recreating tooth harmony for anterior esthetic demands. This case shows the esthetics achieved using color, translucency and multi-layered blocks. In recent years, CEREC veneer design and milling has also been simplified. The final restorations are equal to laboratory-fabricated restorations in function and esthetics.

Figure 2. Maxillary incisors pre-treatment

Figure 3. CAD/CAM milled and finished restorations

Figure 4. Finished CAD/CAM restoration placed

Case 2. Replacement of Failing Amalgams

CAD/CAM conservative preparation design preserves more of the natural tooth structure compared with a crown and offers the clinical longevity of gold without the esthetic drawbacks. When using the current generation bonding adhesives according to the manufacturer's instructions, the CEREC ceramic will re-create a toothlike strength.

Figure 5. Amalgam restorations and caries pre-treatment

Figure 6. Preparations

Figure 7. Completed esthetic CAD/CAM restorations (IPS Empress CAD)

Case 3. Replacement of Posterior Restorations

CAD/CAM produces high strength ceramics for functionally demanding areas such as molars. The software is designed to precisely stitch together multiple digital images and propose an effective virtual die for multiple restoration design (CEREC). With proper design, digital image, and bite registration, the operator has control in occlusal design resulting in minimal adjustments.

Figure 8. Failed molar restorations

Figure 9. Preparations completed with partial subgingival margins

Figure 10. Hemostasis and margin exposure following laser troughing

Figure 11. Virtual design of posterior crown

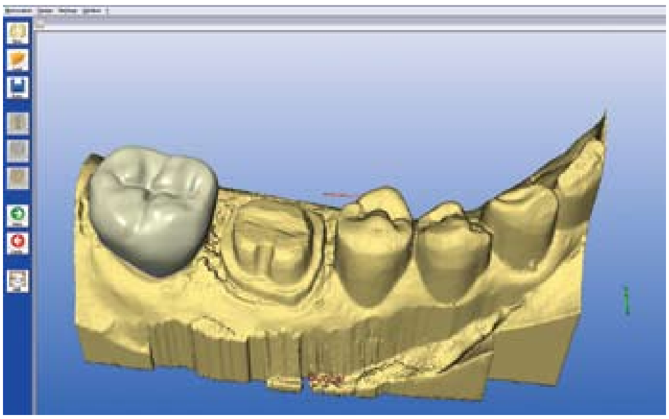


Figure 12. Digital image of occlusal virtual contact placement (light blue) designed from bite registration

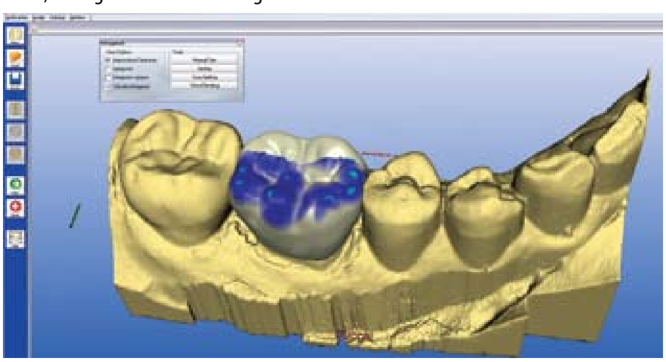


Figure 13. Milled crowns ready for strength crystallization and esthetic finish

Figure 14. Completed esthetic restorations (IPS e.max CAD)

The chairside cases above are courtesy of Dr. James Klim

Integrated Chairside—Laboratory CAD/CAM Technique

An integrated chairside—laboratory technique requires two visits. The clinician either can scan the preparation directly and then send the scan to the laboratory, or can take a traditional impression, after which a stone model is poured and the laboratory scans the stone model. In the first case, the patient still does not require an impression, removing a source of discomfort for the patient and a potential source of inaccuracy for the clinician.

Chairside scanning of a preparation and digital transmission to the laboratory can be achieved by several systems. CEREC Connect (Sirona) and iTero (Cadent) scans either take a series of stills and send the digital image either to a laboratory for milling of the restoration (CEREC Connect), or for milling of the coping at the manufacturer's lab (iTero). It is also possible to email digitally scanned images from the office to the laboratory. As an alternative, iTero offers to create an accurate model that can be used for traditional fixed-restoration fabrication in any laboratory. Video stream can also be used (LAVA Chairside Oral Scanner, 3M ESPE); either the digital image is sent to a LAVA milling machine for fabrication of the coping/substructure, or the video is processed to fabricate an accurate model used for traditional fabrication. Other systems are also used by laboratories to create copings, substructures, and abutments by CAM, after which hand fabrication of any required ceramics and finishing is conducted either by the same laboratory or by the laboratory that scanned and referred the case for milling of the substructure (Procera, Nobel Biocare; Medifacturing, Bego; Cercon, Dentsply; Atlantis, Astra Tech; Everest, Kavo). It is estimated that the number of scanners in the United States will increase by almost 20% per year between 2008 and 2013, indicative of their increasing appeal and application.[22]

Ceramic blocks for laboratory-milled restorations are available as zirconia (zirconium oxide) and lithium disilicate glass blocks. Zirconium oxide (IPS e.max ZirCAD, Ivoclar Vivadent; Cercon, Dentsply Ceramco) can be used to create accurate and strong copings and bridge substructures. After milling, the unit can be adjusted using an external liner (Zirliner, Ivoclar Vivadent) that enables characterization before the outer ceramic suprastructure is created. The external ceramic layer can be created either using press ceramics (in the same manner as for a traditional bridge) or layering ceramic material onto the substructure using a fine brush and powder/liquid.

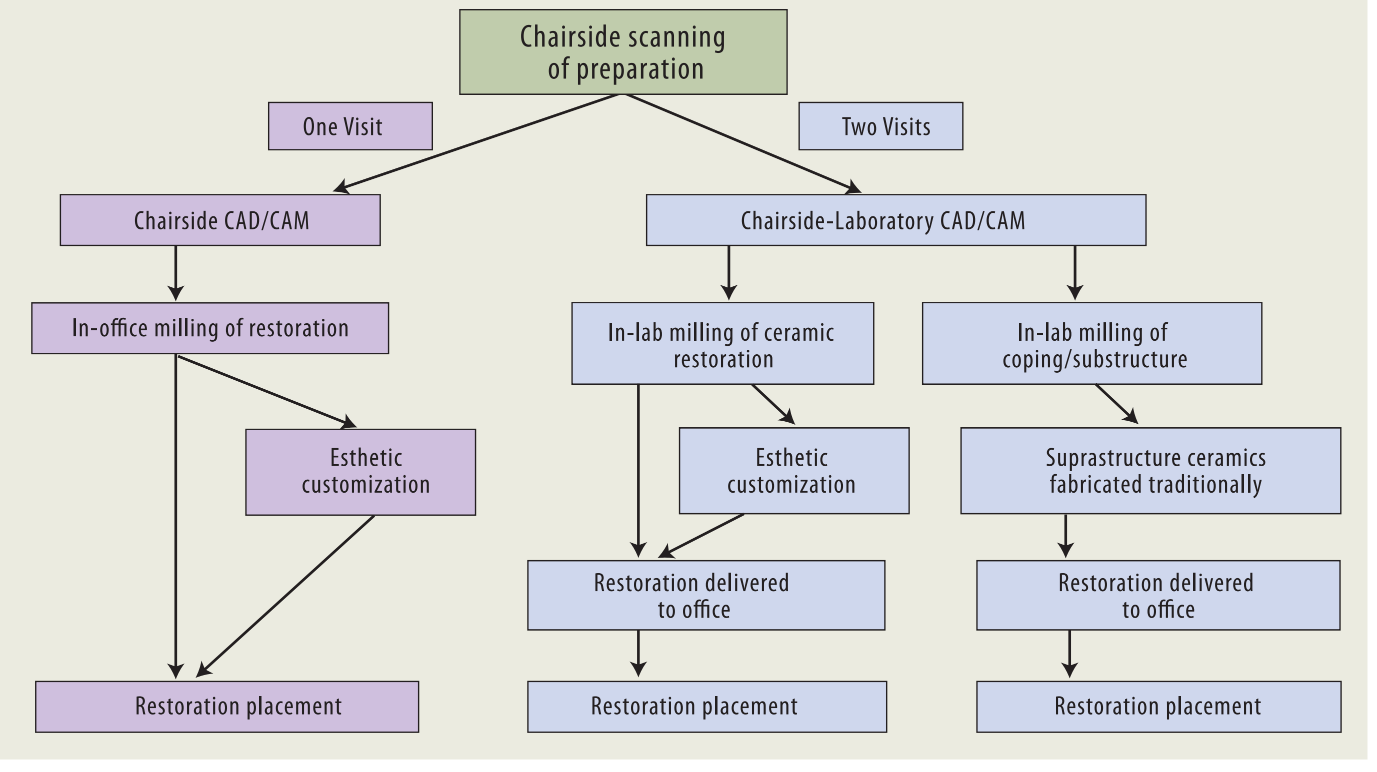
Table 3. Chairside-laboratory integrated technique

Advantages
Automates steps or all of fixed restorative fabrication
Accuracy
Less opportunity for error compared to traditional technique
Opportunity to subcontract CAD/CAM to avoid capital costs
Opportunity to focus on artistic ceramics
Scanned image transferred directly to the laboratory from the office
Reduced chairside time
Team approach to fixed restorations
Disadvantages
Requires two visits

Where esthetics is the key consideration, lithium disilicate ceramic glass blocks can be used (IPS e.max CAD or IPS e.max CAD LT, Ivoclar Vivadent) for crowns and implant crowns, selecting either a high- or low-translucency block. Lithium disilicate blocks achieve full strength only when crystallized at 850 degrees Celsius after milling; this allows rapid cutbacks for customization of shading. After milling in the machine (inLab System, Sirona; Everest System, Kavo), the restoration can be veneered with nanofluorapatite ceramic material (IPS e.max Ceram, Ivoclar Vivadent) to further customize esthetics, if desired, and then stained and glazed in the same manner as traditional restorations.

Advantages of a laboratory CAD/CAM milled restoration include reduced chairside time and increased accuracy. Since a stone model is not used, stone pouring errors are eliminated, as are errors associated with abrasion of the adjacent and opposing teeth due to manipulation of the models during fabrication that could result in over-contouring, tight contacts, and excessive occlusal height. In addition, reduced time is required for fabrication of the substructure. Depending on the laboratory, it may be more cost-effective to subcontract CAD/CAM milling to a different laboratory. The laboratory would then focus on the demanding artistic process of optimizing the ultimate contour and esthetics of the restoration. The case below courtesy of Mr. Corrales shows the results of chairside—laboratory CAD/CAM restorations for the anterior esthetic zone. The patient presented with a discolored upper right central incisor, her only complaint. After discussing the available options, the dentist and patient decided that the most esthetic option would be fabrication of a full-coverage ceramic crown and a veneer on the upper left cen-

Figure 15. Flow chart: CAD/CAM methods and options



tral incisor. A chairside—laboratory CAD/CAM technique was selected and customization of the restoration was achieved in the laboratory after milling of the restorations.

Case Presentation: Integrated Chairside—Laboratory Technique

Figure 16. Preoperative view showing discolored right central incisor

Figure 17. Crown and veneer preparations with severe disparity in color

Figure 18. Scanned image from dental office

Figure 19. Virtual design image of a framework (custom impression tray)

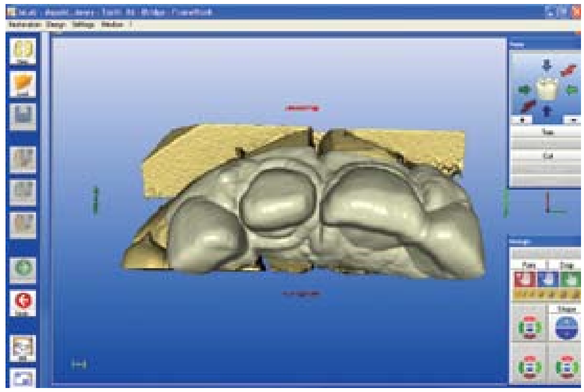


Figure 20. Impression milled using CAD wax

Figure 21. InLab image of crown design

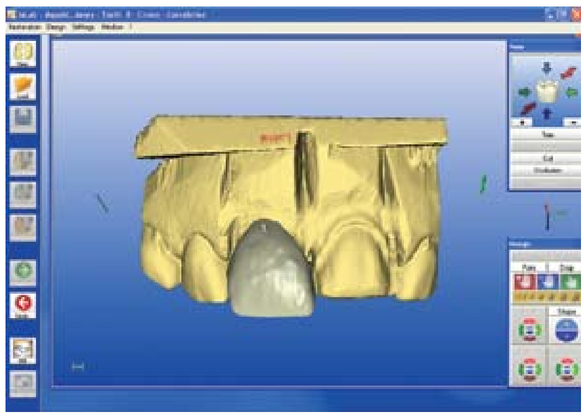


Figure 22. InLab image of veneer design

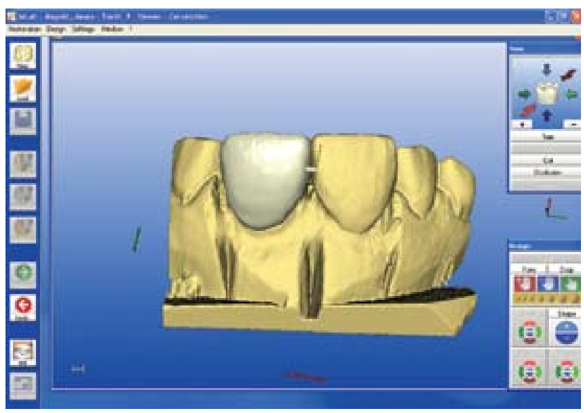
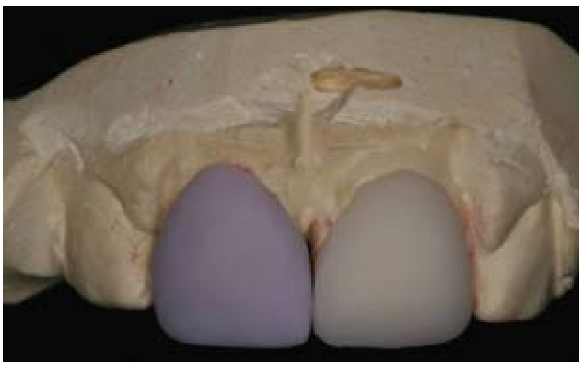


Figure 23. Poured model and CAD milled wax

Figure 24. CAD ceramic blocks used for the restorations

Figure 25. Milled restorations



Note the bluish shade of the upper right central incisor crown compared to the upper left central incisor veneer. This temporary blue shading is a feature of e.max CAD while the ceramic is in a crystalline intermediate phase After final firing, the ceramic will be stronger and with the esthetic shade selected for the crown.

Figure 26. Restorations after cutbacks have been created incisally to enable ceramic layering for customization

Figure 27. Ceramic layering in progress

Figure 28. Final seated crown and veneer

The case above is courtesy of Mr. Edward B. Corrales

Luting Lithium Disilicate and Zirconium Oxide CAD/CAM Restorations with Resin Adhesive Cements

The choice of luting cement for a CAD/CAM restoration is based on the same criteria as for any other prefabricated restoration – the restorative material and the type/design of the preparation. CAD/CAM restorations are typically fabricated from lithium disilicate or zirconia, providing both strength and esthetics. Depending on the preparation design, either an adhesive or non-adhesive luting cement can be used with these materials. Retentive full-coverage crowns with an underlying taper of between 4 and 8 degrees can be luted with either type of cement from the perspective of retention. Non-retentive restorations rely on the bonding strength of an adhesive luting cement to retain the final restoration. Luting cements can be divided into two basic categories – resin adhesive cements and conventional cements. Conventional cements such as zinc phosphate and zinc polycarboxylate have a long history of use; there are some drawbacks with these cements however. Zinc phosphate cement sets through an acidic chemical reaction that may cause pulpal irritation, taking 48 hours to reach a neutral pH, it is soluble intraorally and it does not bond to the tooth. Zinc polycarboxylate cement does offer some bonding through the interaction of calcium in the tooth and polycarboxylate. Both zinc phosphate cements and zinc polycarboxylate cement possess a film thickness that may preclude full seating of the restoration under some circumstances. Neither is suitable for esthetic restorations. The third group of conventional cements are the glass ionomers. In comparison to zinc phosphate and polycarboxylate, they offer a thinner film thickness and higher strength. The low initial pH and setting reaction can result in sensitivity, although the low pH is of short duration. The solubility of glass ionomer cements is considerably lower than for zinc phosphate and zinc polycarboxylate.

Resin Adhesive Cements

Resin adhesive cements offer superior esthetics and low viscosity. They chemically bond to the restoration surface and the tooth surface, either providing all of the retention or, for retentive preparations, improved retentive strength. They also have greater compressive strength. Use of a resin adhesive luting cement is essential for restorations with a non-retentive form or short preparations such as posterior crowns in patients with low inter-occlusal heights.[23] As a group, resin adhesive luting cements are used for veneers, inlays, onlays, full coverage crowns and fixed partial dentures. They use either a self-etch or etch-and-rinse (also known as total etch) technique, differentiated by the manner in which etching and bonding is achieved. The etch technique was first suggested in dentistry by Buonocore.[24] Since these two techniques have different characteristics with respect to bonding to enamel and dentin, the type of preparation and whether bonding will be substantially to enamel or substantially to dentin should be considered. However, both techniques are proven to provide adequate bonding for enamel and dentin provided an appropriate technique is used, with the etching process creating microscopic recesses into which the adhesive can flow prior to curing. Before etching the surface of interest, it must be clean and free of debris. This is especially important when using a self-etch technique since there is no rinsing step involved that could remove any residual debris. Etching and rinsing removes the smear layer from the enamel and dentin that was created during instrumentation[25], enabling the adhesive to reach the microscopic recesses in the surface. Self-etching leaves the smear layer in place but increases its permeability such that the adhesive can still reach the tooth surface as well as mix with the smear layer, forming a hybrid layer. This hybrid layer becomes part of the adhesive interface.

Etching and bonding resin adhesives to enamel

Enamel is largely inorganic, consisting of approximately 96% hydroxyapatite crystals and contains little organic material or water. Either a self-etch or etch-and-rinse technique can be used for enamel, with the etched enamel layer being up to 50 µm after treatment.[26] It has been found that an etch-and-rinse technique produces a stronger bond to enamel than the self-etch technique.[27] Bond strengths to enamel are greater if the enamel was first instrumented if using a self-etch technique. For the surfaces of preparations with both enamel and dentin, dentin – which is more porous and less resistant to etching – should be etched for less time than enamel.

Etching and bonding resin adhesives to dentin

Dentin comprises more organic material and is more porous than enamel, and contains dense collagen fibrils. Self-etch adhesives have been found to provide greater bond strength to dentin than etch-and-rinse adhesives and tolerate moisture better. Using the self-etch technique, the residual smear layer becomes part of the adhesive layer. Since the adhesive contains water, it is not necessary to ensure that the dentin is slightly moist (without being too moist) prior to application of the adhesive (as is required with the etch-and-rinse technique). If an etch-and-rinse technique is used for dentin, the dentin must be slightly moist to avoid reduced bond strength.[28,29]

Resin adhesives and CAD/CAM restoration surfaces

Restoration surfaces can be treated to increase the surface area available for bonding of resin adhesives. This results in increased retention of the adhesive to the restoration. An etching technique using hydrofluoric acid followed by silanation can be utilized for CAD/CAM restorations fabricated from lithium disilicate- and leucite-containing ceramics (as well as restorations fabricated from feldspathic porcelain) to increase the available surface area of the intaglio (inner surface of the ceramic restoration) for adhesion. For CAD/CAM and traditional restorations fabricated from zirconia, sandblasting is an important step for retention to increase the surface area as etching is ineffective on these surfaces.[30]

Figure 29 a-c. Etch-and-rinse technique

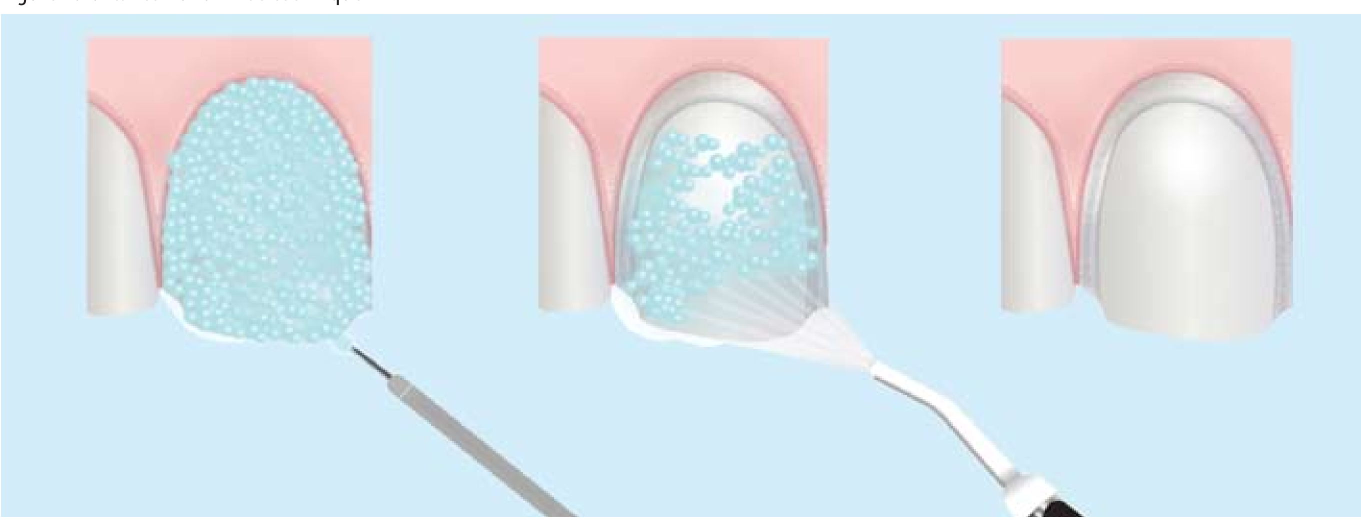
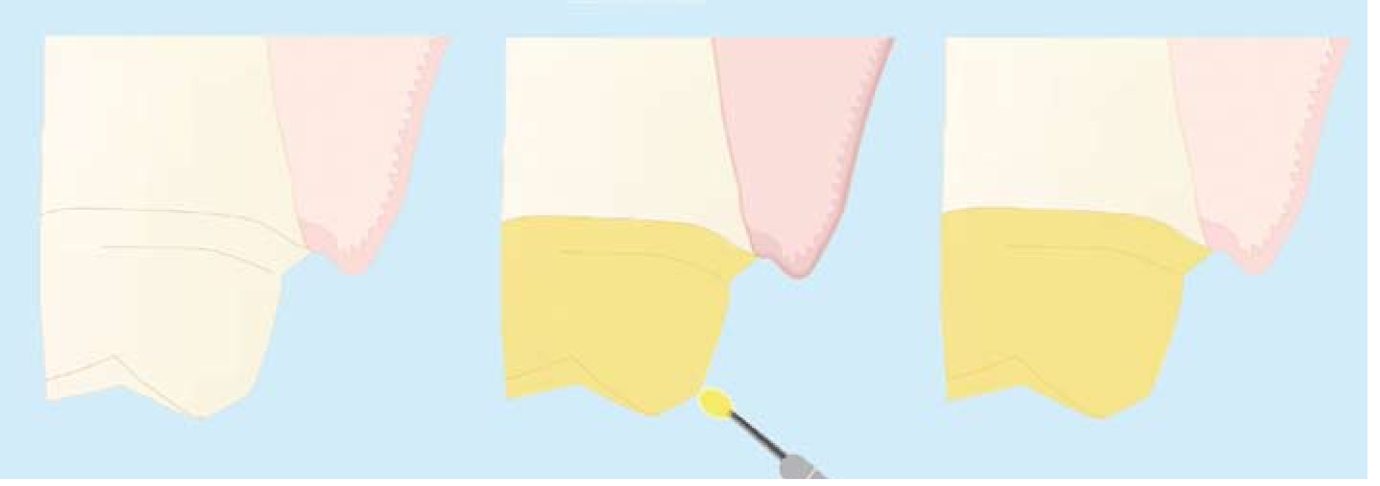


Figure 30 a-c. Self-etch technique



Resin adhesive cement options

Resin adhesive cements can be light-cured, autopolymerized (self-cured) or dual-cured. This increases their versatility compared to other cements. For translucent restorations such as veneers, a light-cured resin cement is used (Variolink Veneer, Ivoclar Vivadent; RelyX Veneer Cement, 3M ESPE; Calibra, Dentsply). This also gives more time for accurate placement and removal of excess cement. For opaque restorations, a self-cured or dual-cured resin adhesive cement is required. A dual-cured cement is preferred for opaque restorations to enable self-curing within the bulk of the cement and additive light-curing at the margins (Multilink Automix and Variolink II, Ivoclar Vivadent; Linkmax, GC America).

CAD/CAM Veneer Cementation

The esthetic results obtained with a resin adhesive cement are critical in the case of thin anterior veneers. Esthetic resin adhesive cements (Variolink Veneer, Ivoclar Vivadent; RelyX Veneer Cement, 3M ESPE; Calibra, Dentsply) enable the clinician to select a veneer cement shade that will complete the shade characterization of the fabricated veneer to optimize esthetics of the final restoration. For thin veneers, the cement can be used for final customization of the shading. The shade is first tested using try-in paste that matches the shade of the proposed cement prior to cementing the veneer in place.

Self-Adhesive Resin Cements

The latest type of resin cements are self-adhesive, and are dual-cured. They require only one step, and do not require separate application of etchant, or etchant and bonding agents, prior to application of the cement. These cements are effective for CAD/CAM zirconia restorations.[31]

Summary

CAD/CAM restorative procedures have developed considerably since their introduction. Currently available CAD/CAM materials offer excellent strength and esthetics with a wide range of available shades; practitioners have the opportunity to customize shading after milling and can use blocks with multiple chroma shades built into the ceramic. CAD/CAM is increasingly used, and it can be anticipated that its use will continue to increase, especially with the availability of direct image transfer scanners from the chair to the dental laboratory and between laboratories. These offer the ability for the office or laboratory with moderate fixed-restoration production to adopt CAD/CAM dentistry without a large capital investment. CAD/CAM now offers automated production, accuracy, esthetically pleasing and strong restorations, and flexibility to both the dentist and the laboratory technician.

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Author Profile

Dr. James Klim graduated Summa cum Laude, Valedictorian, from Loma Linda University in 1984. He has been awarded high academic recognition by the Alpha Omega Fraternity and the Omicron Kappa Upsilon Society and has received the Prince Award from Loma Linda University School of Dentistry. He has been awarded fellowships from the Academy of General Dentistry and Academy of Dental-Facial Esthetics. He is an Accredited member in the American Academy of Cosmetic Dentistry. He is an international speaker, author, and instructor of current dental technology, practice development and aesthetic dentistry. In addition, he has taught at several advanced post graduate institutes in practice development and aesthetic dentistry around the country. Currently, Dr. Klim has a full time restorative practice in Santa Rosa, California and is founder and director of CADStar™, the training center for advanced dental CAD/CAM (CEREC) education.

Edward B. Corrales is the owner of Downtown Dental Design, San Diego, CA. Mr. Corrales trained at the Dental Technology Institute in Orange County, California and holds a Master LVI Ceramic certificate. His laboratory specializes in esthetic and full mouth reconstruction cases and implantology, utilizing advanced digital technologies for dental photography, dental imaging and digital lab communication and production. He has written articles and lectured nationally and internationally to dentists and dental technicians on materials, techniques and digital technology. He is currently teaching courses in the San Diego area on subjects including basic porcelain layering, digital dental photography, and software implementiation with CAD/CAM technology. He is the founder of the San Diego Dental Institute. Mr. Corrales is currently pursuing AACD accreditation, and is an instructor at the Scottsdale Center for Dentistry.

Acknowledgment

The chairside cases in this course were provided by Dr. Klim and the integrated chairside-laboratory case was provided by Mr. Corrales.

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Questions

1. The introduction of CAD/CAM to dentistry took place during the 1960s.
   a. True
   b. False
2. Only inlays, onlays, and veneers can be fabricated using CAD/CAM techniques.
   a. True
   b. False
3. Using a traditional technique (non-CAD/CAM) ________.
   a. requires careful retraction or removal of soft tissue around the preparation margins
   b. requires selection of an appropriate impression material for the technique used
   c. is one of the more difficult procedures in dentistry
   d. All of the above
4. An advantage of the traditional technique is ________.
   a. the lack of a learning curve beyond staying current with the use and handling of materials
   b. that no procedure-specific capital equipment is required
   c. that it consistently provides superior results, compared to other techniques
   d. a and b
5. Using a traditional technique, it is usually possible to provide a custom-fabricated, single-visit fixed restoration.
   a. True
   b. False
6. Using a CAD/CAM restorative technique, traditional impressions can be replaced by use of ________.
   a. a handheld scanning device that mechanically records the form and margins of the preparation
   b. a handheld scanning device that digitally records the form and margins of the preparation
   c. a static scanning device that digitally records the form and margins of the preparation
   d. none of the above
7. According to the article, it has been suggested that a ________ be used to expose subgingival margins.
   a. soft tissue electrosurgical unit
   b. soft tissue diode laser
   c. hard tissue diode laser
   d. all of the above
8. The basic techniques that can be utilized for CAD/CAM restorations ________.
   a. involve a chairside and chairside-processing area
   b. are chairside and integrated chairside –laboratory techniques
   c. are an integrated chairside laboratory and laboratory –store technique
   d. a and b
9. The clinician should consider whether monthly production would support investing in a chairside CAD/CAM unit.
   a. True
   b. False
10. During scanning for a CAD/CAM restoration, the clinician must ensure that all margins of the cavity are captured by the scan and then visualized.
    a. True
    b. False
11. From the patient's perspective, a potential advantage of chairside CAD/CAM fabrication of fixed restorations is that ________.
    a. the restoration is ready in one visit
    b. no impression is required
    c. there is reduced potential for tooth sensitization
    d. all of the above
12. Estefan et al. found that both milled inlay and onlay restorations met the American Dental Association's standard of fit within 50 micrometers.
    a. True
    b. False
13. Otto and Muhlemann found an 88.7% success rate up to 17 years after placement for 187 inlays and onlays placed using an early-generation chairside CEREC between 1989 and 1991.
    a. True
    b. False
14. ________ found that the success rate depended on the etching and luting cement used.
    a. Black et al.
    b. Pearlmutter et al.
    c. Sjogren et al.
    d. none of the above
15. Of 617 veneers placed over an eight-year period (1989-1997) that were then reevaluated by Wiedhahn et al., the survival rate was _____ after up to nine years.
    a. 78%
    b. 84%
    c. 88%
    d. 94%
16. CAD/CAM materials have included leucite-reinforced ceramic, feldspathic ceramic, and composite resin.
    a. True
    b. False
17. For chairside CAD/CAM restorations, the objective is an esthetic, strong material requiring maximal post-milling esthetic adjustment to tailor the restoration chairside.
    a. True
    b. False
18. Leucite-reinforced material is designed to ________.
    a. match the dentition for strength
    b. match the dentition for surface smoothness
    c. scatter light similarly to enamel
    d. all of the above
19. Low translucency material is indicated for crowns and veneers, giving a brighter appearance.
    a. True
    b. False
20. Leucite-reinforced blocks with multiple shading created within the block offer a ___________.
    a. natural-shaded and opaque appearance
    b. natural-shaded and translucent appearance
    c. striped and translucent appearance
    d. none of the above
21. For specific cases, milled restorations can be characterized by layering ceramic material on top.
    a. True
    b. False
22. An integrated chairside-laboratory technique requires one or two visits.
    a. True
    b. False
23. Ceramic blocks for laboratory-milled restorations are available as ________.
    a. zirconium chloride
    b. zirconium oxalate
    c. zirconium oxide
    d. all of the above
24. Where esthetics is the key consideration, lithium disilicate ceramic glass blocks are preferable to zirconia.
    a. True
    b. False
25. An advantage of a laboratory CAD/CAM milled restoration is the ________.
    a. reduced chairside time
    b. elimination of stone model errors
    c. increased accuracy
    d. all of the above
26. Retentive full-coverage crowns with an underlying taper of between 8 and 23 degrees can be luted with adhesive or nonadhesive cement from the perspective of retention.
    a. True
    b. False
27. Use of a resin adhesive luting cement is essential for restorations with a nonretentive form or for short preparations such as posterior crowns in patients with low interocclusal heights.
    a. True
    b. False
28. ________ have been found to provide greater bond strength to dentin than ________ and tolerate moisture better.
    a. Etch-and-rinse adhesives; self-etch adhesives
    b. Self-etch adhesives; etch-and-paste adhesives
    c. Etch-and-rinse adhesives; dry-etch adhesives
    d. Self-etch adhesives; etch-and-rinse adhesives
29. Self-adhesive resin cements are effective for CAD/CAM zirconia restorations.
    a. True
    b. False
30. Currently available CAD/CAM materials offer excellent strength and esthetics.
    a. True
    b. False

ANSWER SHEET

Innovation in Dentistry: CAD/CAM Restorative Procedures

Name: ______________________ Title: __________ Specialty: ______________________

Address: ______________________ E-mail: ______________________

City: ______________________ State: __________ ZIP: __________ Country: __________

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Requirements for successful completion of the course and to obtain dental continuing education credits: 1) Read the entire course. 2) Complete all information above. 3) Complete answer sheets in either pen or pencil. 4) Mark only one answer for each question. 5) A score of 70% on this test will earn you 4 CE credits. 6) Complete the Course Evaluation below. 7) Make check payable to PennWell Corp.

Educational Objectives

1. Know the origins of CAD/CAM and its introduction into dentistry.
2. Understand the CAD/CAM technique used for chairside and integrated chairside/laboratory CAD/CAM procedures.
3. Describe the advantages and disadvantages of both traditional and CAD/CAM restorative procedures.
4. Know the types and properties of ceramic CAD/CAM blocks, and the considerations in selecting ceramic blocks for CAD/CAM restorations.

Course Evaluation

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met? Objective #1: Yes No Objective #3: Yes No
   Objective #2: Yes No Objective #4: Yes No

2. To what extent were the course objectives accomplished overall?	5	4	3	2	1	0
3. Please rate your personal mastery of the course objectives.	5	4	3	2	1	0
4. How would you rate the objectives and educational methods?	5	4	3	2	1	0
5. How do you rate the author's grasp of the topic?	5	4	3	2	1	0
6. Please rate the instructor's effectiveness.	5	4	3	2	1	0
7. Was the overall administration of the course effective?	5	4	3	2	1	0

8. Do you feel that the references were adequate? Yes No

9. Would you participate in a similar program on a different topic? Yes No

10. If any of the continuing education questions were unclear or ambiguous, please list them.

____

11. Was there any subject matter you found confusing? Please describe.

____

____

12. What additional continuing dental education topics would you like to see?

____

____

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3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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