

Changing Perspectives

CAD/CAM Ceramic Update

Markus B. Blatz, DMD, PhD

Dr. Markus Blatz will be speaking at the 30th Annual AACD Scientific Session in Orlando, Florida. The title of his course is "The CAD/CAM Ceramic Update." In this Q&A, Dr. Blatz shares his perspectives on the new developments of CAD/CAM and the clinical possibilities that surround them.

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Q: Can you offer a general overview of CAD/CAM systems and tell readers which you prefer?

MB: The pace of new developments and number of CAD/CAM systems entering the market is simply breathtaking. In fact, it has become quite overwhelming for many practitioners and laboratory technicians to keep track of these advances and to make a conscious decision when it comes to purchasing a system. And while some have gained tremendous in-depth knowledge, there are many others who are still confused about even the basic functions and workflow of CAD/CAM technology in the dental laboratory and/or office. For the latter, allow me to clarify some of the fundamental functions and applications.

The first differentiation is between laboratory-based and chairside CAD/CAM systems. These can be further categorized by open and closed systems. The scans are made from a model, impression, or directly in the oral cavity. The desired framework or restoration is designed on the computer screen and that information is sent to a manufacturing unit, milling machine/center, or production site. With a closed system, the raw data obtained by the scanner and the design made on the computer is not freely ac-

cessible to the clinician or technician. It must be forwarded to a fabrication unit or center as specified by the manufacturer. The data/design obtained with an open system can be accessed and fed to various milling units or production centers. Therefore, the advantage of the open systems is that one is not limited to one or a few milling and production options. However, if units that are not necessarily recommended by the manufacturer are used, the entire workflow and ultimate outcome becomes the responsibility of the technician. This is why many closed systems claim that they can provide a better quality product due to a standardized and more calibrated manufacturing process. It is indeed true that each component of the digital workflow has to play in concert with the other components to achieve optimal quality of the end product.

The first piece involved in the workflow is the scanner. Laboratory and chairside scanners have undergone significant improvements over the last few years and can now provide stunning accuracy with user-friendly design and handling. This is especially true for new chairside scanners. Besides tremendously increased scanning accuracy and speed, they have become significantly smaller and are now almost the size of a regular handpiece. One of the systems we are evaluating right now simply plugs into a tablet computer device, which makes it extremely versatile.

The next component, the design software, has also become much more user-friendly in the recent past and is a far cry from the often cumbersome and expert-only programs we had just a few years ago. Most steps are now fully automated and allow a material- and patient-specific restoration and framework design. These restorations can then be either fabricated directly in the office, a dental laboratory, or at an industrialized manufacturing/milling center.

Finally, even phases that may be perceived to be less important at the end of the digital chain, which is the restoration fabrication, all add up for the quality, precision, and longevity of the end product. For example, sharpness of the milling burs and temperature calibration of the sintering ovens play a fundamental role not just for the fit, but also for the physical properties and functional success of the definitive restoration.

At the present time, most of the available chairside systems are used preferably for single-unit and short-span restorations, while laboratory systems can typically handle everything up to full-mouth reconstructions.

A few years ago, I founded the Penn Dental CAD/CAM Ceramic Center at the University of Pennsylvania. There, we are using and evaluating a number of different laboratory and chairside CAD/CAM systems. Unfortunately, it is not possible to point to the "best" CAD/CAM system since all of them have advantages and disadvantages and none of them can do everything. You can expect all reputable systems to provide excellent accuracy, and manufacturers are constantly improving the various systems and their components.

If you send your impressions to a laboratory for fabrication of CAD/CAM restorations, you may not have much control over their handling and system selection. If you are in the market for an intraoral scanner or chairside system, however, it is important to get as much information on as many different systems as possible. Since, as mentioned earlier, the various CAD/CAM systems have different features and possibilities, you should make your selection based upon your specific needs and practice composition. This includes types and numbers of restorations done in your practice. You also need to decide if you wish to fabricate restorations directly in your office with a chairside or in-office laboratory milling system.

Q: What can we expect in terms of differing contemporary CAD/CAM materials, as well as their pros and cons?

MB: For me, one of the most exciting aspects of CAD/CAM technology is the wide range of materials available. Today, we can mill or fabricate virtually any dental material. This includes all the different ceramic materials, from silica-based glass-ceramics to high-strength ceramics such as zirconia. Due to their optical, chemical, and mechanical properties, ceramics are preferred by many clinicians for a variety of indications from laminate veneers to multiple-unit full-coverage restorations. Composite resin materials have gained popularity specifically for inlays and onlays, where they seem to be more user-friendly than the more brittle ceramic materials. There is much excitement about the relatively new material group of so-called "hybrid ceramics," which typically contain great amounts of silica as well as polymers and may combine some of the advantages of ceramics and composites. Other materials that are used in combination with CAD/CAM technology are metal alloys, resins, and even waxes.

We increasingly use CAD/CAM-fabricated provisional restorations, which serve as great tools not only to maintain the space, but also to provide valuable information for the final restoration from an esthetic and functional standpoint. The acrylic materials that are typically used for those provisionals are much more homogeneous and stronger than the typical cold- or heat-cure provisional materials.

They can also be polished far more easily and provide a much smoother and less plaque-adhering surface, as we have shown in some of our studies (these very recent studies have not been published yet; I will be presenting the exciting new data in Orlando). Another great feature with CAD/CAM provisionals is the fact that the design information is already in the computer and can be used for the design of the definitive restoration or framework. It is also very simple to remake such a restoration in the exact same manner and as many times as needed in case of fracture, failure, or change in design. CAD/CAM provisionals are advantageous for implant-supported full-mouth rehabilitations. **Figures 1 through 5** illustrate the application of CAD/CAM provisionals for two central incisor full-coverage crowns.

Q: What materials do you recommend for these different situations?

a. Inlays/Onlays

MB: I was trained and have practiced as a faculty member for several years in Germany, where inlay and onlay restorations are quite popular. My personal preference for tooth-colored inlay/onlay restorations is silica-based ceramics, such as porcelain or lithium disilicate, which can easily be resin-bonded. Many colleagues, however, are not comfortable with the brittleness of ceramic inlay/onlay materials and prefer indirect composites, which have also shown excellent long-term success. This is actually one of the indications where the new hybrid ceramics may show some real advantages over the more traditional materials.

b. Crowns

As with all my material and technique selections, I make that decision based upon the patient's needs. Unfortunately, similar to what I mentioned about CAD/CAM systems, there is no one material that can do everything. One has to look at the physical properties and the esthetic features of the material and make a selection based upon the patient's situation, esthetic expectations, and functional prerequisites. Silica-based glass-ceramics, for example, provide excellent optical and esthetic features but only low

fracture strength. For crown restorations, they need support from a metal alloy or high-strength ceramic coping. High-strength ceramics, such as zirconia, provide significantly better physical properties but lower translucency. Lithium disilicate ranks in between and has, therefore, become extremely popular for single crowns. I am very curious to see how full-contour zirconia and the new hybrid ceramics will clinically perform in the long term.

The clinical situation shown in **Figures 6 through 9** demonstrates what I mean by patient-based material selection. Any of the materials mentioned above would probably be feasible in the hands of the skilled dental technician. The determining factor in this situation, however, is the existing cast-gold post and core (**Fig 6**). A highly translucent material may not adequately mask that core. It was, therefore, decided to fabricate a CAD/CAM zirconia coping and take advantage of its limited translucency and whitish appearance to mask the core and mimic the value of the adjacent teeth after whitening. A feldspathic veneering ceramic was fired onto the coping for optimal esthetics. We actually tried two options: with and without a porcelain shoulder (**Fig 8**). Ultimately, we cemented the one with the zirconia shoulder, which, through its higher value, provided a better soft-tissue color.

Q: When seating/cementing restorations, what is your method of choice?

MB: This again depends on material properties and patients' needs. Silica-based ceramic materials require resin bonding and must therefore be adhesively bonded with composite resin luting agents and the appropriate tooth and restoration bonding steps. Conventional cementation protocols with glass-ionomer, resin-modified glass-ionomer, or self-adhesive resin cements are my preference for full-coverage, high-strength ceramic crowns with adequate retention. Whenever resin bonding is needed (e.g., compromised retention or a resin-bonded restoration type), composite resin luting agents and adequate bonding agents/pre-treatment steps are necessary. High-strength ceramics do not contain silica and therefore are not etchable with hydrofluoric acid. Also, silane coupling agents are not useful. However, special adhesive primers are available and crucial to provide strong, durable chemical and mechanical bonds between composite resin cements and high-strength ceramics.

Q: How do you see CAD/CAM advances affecting the precision of the design and fabrications when it comes to implants?

MB: Accuracy and passive fit is crucial for implant survival and success. This is where CAD/CAM technology has a significant advantage over traditional fabrication methods. As shown by many other groups, we have also published a number of research studies that clearly show the high accuracy of CAD/CAM-fabricated implant components. This is especially true for multi-unit and full-mouth reconstructions, where traditional fabrication methods such as casting are significantly less accurate.



Figure 1: Preoperative situation of two endodontically treated central incisors that require full-coverage crowns.

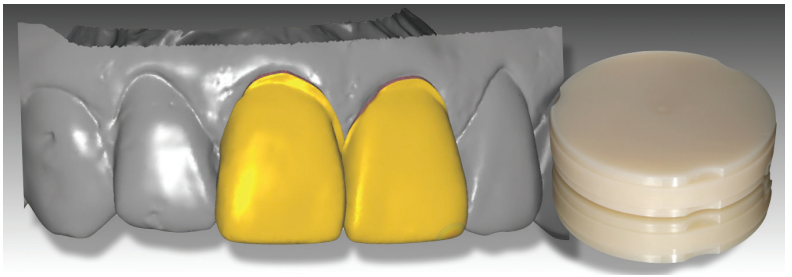


Figure 2: Before preparation, CAD/CAM shell-type provisional restorations are designed and milled out of one block of CAD/CAM acrylic material. The homogeneous material provides increased strength and improved polishability.



Figure 3: CAD/CAM provisional restorations on the model.



Figure 4: Crown preparations of the two central incisors.



Figure 5: The CAD/CAM provisional restorations relined and inserted with a provisional cement. They serve as an excellent tool to assess esthetic and functional parameters before fabrication of the final restorations. The information on the computer is helpful in designing and selecting the most appropriate material for the definitive restorations.



Figure 6: An example of patient-based material selection. A material that can mask the existing cast-gold post and core but also mimic the optical properties (i.e., value) of the adjacent teeth after tooth whitening is required.

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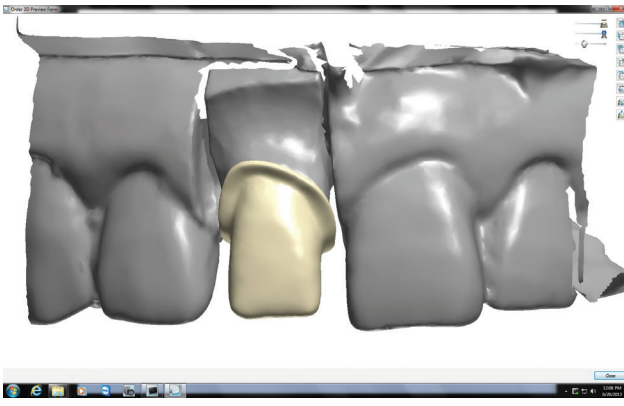


Figure 7: CAD/CAM coping design on the computer screen.



Figure 8: Two porcelain-fused-to-zirconia crowns were prefabricated and tried in to select the most appropriate design: zirconia shoulder or porcelain shoulder.



Figure 9: Postoperative view. The crown with the zirconia shoulder provided better esthetics of the surrounding gingiva.

Several systems allow the integration of CAD/CAM technology already in the treatment-planning stage to select and precisely place the implants through guided surgery. These steps are followed by the precise fabrication of a CAD/CAM provisional or definitive implant restoration or overdenture bar.

For whatever reason, some people believe that the high accuracy achievable with CAD/CAM technology in the laboratory allows them to be somewhat less accurate with their clinical techniques. The contrary is actually true: greater accuracy in the laboratory requires greater accuracy in the dental office. Especially for implant-supported restorations, accurate impression-taking techniques and implant-transfer protocols are fundamental for success, especially in combination with CAD/CAM technology.

Q: What does current scientific evidence show when it comes to the essential integration and long-term outcome of this new technology?

MB: While CAD/CAM technology has become increasingly popular over the last few years, possibly spurred by the overall increased use of computer technology in our professional and personal lives, it is actually not that new. Some of the systems have been on the market for more than two decades and have evolved over this time into the excellent products that are available today. CAD/CAM is a fabrication method that provides proven accuracy and great versatility when it comes to material selection. The scientific evidence clearly supports that. Some of the materials used in combination with CAD/CAM technology, however, have come to the market only very recently, with great marketing but little science. Some of them, unfortunately, have very limited or no scientific confirmation and we are learning our lessons "on the go."

With veneered zirconia crowns, for example, we learned that, contrary to initial claims, veneering porcelains and firing protocols must be very different from the ones used for porcelain-fused-to-metal (PFM) restorations to avoid chipping and fractures. Now, with proper veneering porcelains and firing parameters, success rates have greatly improved. In two of our own studies,^{1,2} we have looked at more than 2000 posterior crowns made in private practices and found no difference in long-term success rates between porcelain-fused-to-zirconia and PFM crowns after seven years. Other materials, such as lithium disilicate, already have a long clinical track record, even though not necessarily in combination with CAD/CAM.

I genuinely believe that CAD/CAM technology will change our perspective and discussion about restoration longevity, at least in some areas. One of the main reasons for our frustration with failures is the difficulty in exactly recreating restorations or teeth. If we can, for example, mill a CAD/CAM complete

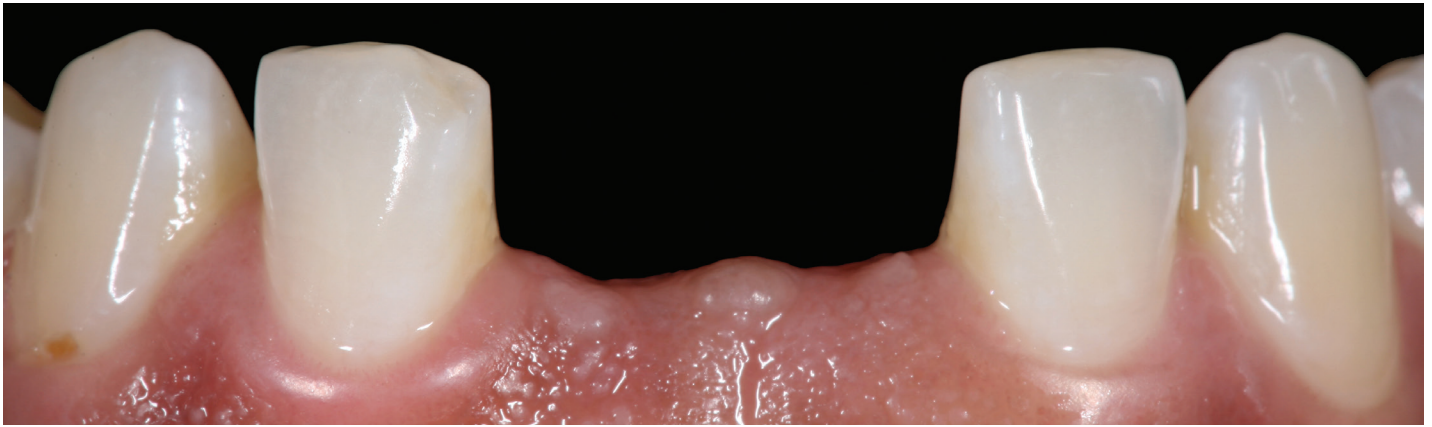


Figure 10: Preoperative situation with two missing central incisors. The patient did not want dental implants but still requested the least invasive approach.



Figure 11: Two single-retainer resin-bonded fixed partial dentures were fabricated from zirconia with CAD/CAM technology.



Figure 12: Postoperative labial view of the ceramic resin-bonded fixed partial dentures after adhesive bonding with composite resin and special zirconia primer.



Figure 13: Postoperative image, right lateral view.



Figure 14: Postoperative image, left lateral view.

denture out of an acrylic material in one piece, it is very simple to duplicate and fabricate the exact same denture as many times as one wishes in the event of a failure.

Q: What do you feel is the biggest fear dentists and lab technicians have regarding the use of CAD/CAM? What do they need to realize to overcome it?

MB: Some faculty members in my department are quite excited about and already involved in CAD/CAM technology, while the majority is still hesitant. For some, it is fear of new technologies in general. Most of them, however, just don't see any advantage or reason for changing the techniques they have become accustomed to over many years. I believe their biggest fear is of the steep learning curve involved in using this technology. While most procedures are faster with CAD/CAM technology, it does take time and effort to learn a new technique and to become experienced and efficient with it. Once they understand the actual benefits in terms of speed, accuracy, and versatility, they usually make the move.

Many, however, are simply waiting for further improvements, especially in intraoral scanners, and want to see how the market evolves before they are willing to make a decision to purchase a specific system. To those I say that it is wise to thoroughly assess the options. However, there never is a "good time" and one should get involved as early as possible in what is, without a doubt, the future of dentistry.

It is interesting to see how easily our students, being brought up in the digital age, embrace these technologies. Therefore, we started teaching about CAD/CAM technology and intraoral scanners in our preclinical courses.

Q: What are you planning to discuss at your AACD 2014 Orlando presentation that attendees won't want to miss?

MB: During my presentation, I will focus on the exciting clinical possibilities of CAD/CAM technology and associated dental materials, from porcelain laminate veneers to implant-supported full-mouth rehabilitations made from zirconia. An understanding of the evolution and composition as well as physical and optical properties

of CAD/CAM materials, especially ceramics, is key to adequate material selection and to achieve ultimate esthetic and functional success. Laboratory and clinical handling of these materials, including cementation and adhesive resin bonding, will be the main topics of my discussion. Combining material properties, esthetic features, and adhesive concepts allows for innovative treatment options, such as CAD/CAM all-ceramic resin-bonded fixed partial dentures (Figs 10-14). They can be applied as an excellent alternative to traditional protocols and I will explain when and how to do them.

All these topics will be supported by scientific evidence and the numerous research studies we have conducted in our own laboratories and clinics.

I am very excited to being part of this meeting and look forward to seeing you in Orlando!

Acknowledgments

The dental laboratory technology shown in Figures 2, 3, 5, 11, 12, and 15 was performed by Michael Bergler, MDT (Philadelphia, PA). The dental laboratory work shown in Figure 9 was done by Cusp Dental Laboratory (Malden, MA).

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Dr. Blatz is the chair and professor of restorative dentistry, Department of Preventive and Restorative Sciences, School of Dental Medicine, University of Pennsylvania, Philadelphia.



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