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Cad Cam in Prosthodontics: A Review

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ABSTRACT

In the present world time is money, as of with prosthodontics also. Cad cam had made speed and accuracy to a extent that normally it is unimaginable In the last 20 years this technology has grown without bounds. Now fabrication of an inlay, onlay, or a zirconia crown and bridge has become very easy. Single sitting tooth preparation and cementation is possible with cad cam technology. This article is a review of how this all started and its evolution. It throws light on different systems developed by various companies and their merits and demerits.
Keywords: CAD CAM, Prosthodontics, Dentistry

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INTRODUCTION

The term CAD/CAM, which comes from machine-tool technology and stands for "Computer-Aided-Design / Computer-Aided-Manufacturing", designates the three-dimensional planning of a workpiece on the screen of a computer with subsequent automated production by a computer controlled machine tool, Francois Duret introduced CAD-CAM technology to the field of dentistry in 1971. His idea was to use technologies established in industry could be applied to benefit dentistry. CAD/CAM technology has been used in the manufacturing industry for many years. Today, CAD/CAM technology isalso used in dentistry to help dentists and dental lab technicians fabricate precise shapes and sizes for dental restorations, like inlays, onlays, crowns, and bridges. Dentists use CAD/CAM technology to provide their patients with durable, well-fitted single and multiple toothrestorations in a more efficient manner than conventional lab-fabricated restorations. All CAD/CAM systems permit the production of restorations at the chair side and at least in theory eliminate potential inaccuracies associated with the indirect restoration.

HISTORY

Numerically controlled machine

Earlier the development of Computer-aided design, the manufacturing world adopted tools controlled by numbers and letters to fill the need for manufacturing complex shapes in an accurate and repeatable manner. During 1950's these Numerically-Controlled machines (NC Machines) used the existing technology of paper tapes with regularly spaced holes punched in them (think of the paper roll that makes an old-fashioned player piano work, but only one inch wide) to feed numbers into controller machines that were wired to the motors positioning the work on machine tools. The electro-mechanical nature of the controllers allowed digital technologies to be easily incorporated as they were developed.

By late 1960's Numerically-Controlled machining centers were commercially available, incorporating a variety of machining processes and automatic tool changing. Such tools were capable of doing work on multiple surfaces of a workpiece, moving the workpiece to positions programmed in advance and using a variety of tools - all automatically. What is more, the same work could be done over and over again with extraordinary precision and very little additional human input. NC tools immediately raised automation of manufacturing to a new level once feedback loops were incorporated (The tool tells the computer where it is, while the computer tells it where it should be).

What finally made NC technology enormously successful was the development of the universal NC programming language called APT (Automatically Programmed Tools). Announced at MIT (Massachusetts institute of technology) in 1962, APT allowed programmers to develop postprocessors specific to each type of NC tool so that the output from the APT program could be shared among different parties with different manufacturing capabilities.

DENTAL CAD/CAM

Computer-aided design (CAD) and computer-aided manufacturing (CAM) technology systems use computers to collect information, design, and manufacture a wide range of products. These systems have been in general use in industry for many years, but dental CAD/CAM applications were not available until the 1980s. The earliest attempt to apply CAD/CAM technology to dentistry began in the 1970s with Bruce Altschuler, DDS, in the United States, Francois Duret, DDS, MD, in France, and Werner Mormann, BMD, DDS, and Marco Brandestini, PhD, in Switzerland. Young and Altschuler first introduced the idea of using optical instrumentation to develop an intraoral grid surface mapping system in 1977.

1. In 1984, Duret developed the Duret system, which was later marketed as the SophaBioconcept systems, demonstrating the ability of CAD/CAM to generate single- unit, full-coverage restorations. However, this system was not successful in the dental market because of its complexity and cost. The first commercially available dental CAD/CAM system was CERECb, developed by Mormann and Brandestini. The American Dental Association specifies that a dental restoration must fit its abutment within a 50 μm range. So this requirement calls any system to have a very accurate data collection technique, sufficient computing power to process and design complex restorations, and a very precise milling system.

The exciting new developments have led to the success of contemporary dental CAD/CAM technology During the last 2 decades. Several methods have been used to collect 3-dimensional data of the prepared tooth using optical cameras, contact digitization, and laser scanning. Replacement of conventional milling discs with a variety of diamond burs has resulted in major improvements in milling technology. Another vital factor has been the development of alumina (aluminum oxide) and zirconia (zirconium oxide) ceramic materials, which possess excellent machinability and physical strength. Integration of these technologies has resulted in the introduction of several highly sophisticated CAD/CAM systems.

Integration of CAD & CAM Together at Last

The development of Computer-aided design had little effect on CNC initially due to the different capabilities and file formats used by drawing and machining programs. However, as CAD applications such as SolidWorks and AutoCad incorporate CAM intelligence, and as CAM applications such as MasterCam adopt sophisticated CAD tools, both designers and manufacturers are now enjoying an increasing variety of capable CAD/CAM software. Most CAD/CAM software were developed for product development, design and manufacturing of components and molds.

Today, over three-quarters of new machine tools incorporate CNC technologies. These tools are used in every conceivable manufacturing sector. Today CNC technology is related to Computer Integrated Manufacturing (CIM), Computer Aided Process Planning (CAPP) and other technologies such as Group Technology (GT) and Cellular Manufacturing.

CAD CAM

The contemporary CAD/CAM systems consist of three components: The scanner, which scans the dental preparation provided by the dentist either intraorally or extraorally by reference to tooth models. For inlays and single crown frameworks, just the surface data of the prepared teeth need to be digitized. For FPD frameworks or additional occlusal characterization, further data from the neighboring teeth and antagonists, as well as from the spatial relation of the prepared teeth to one another, are required [22].

The software CAD consists of a computer unit used for the three-dimensional planning and design of restorations on the computer screen. The software programs available today offer a high level of intervention and permit the design and production of an individually adapted restoration. Systems not offering a full CAD component are not considered as CAD/CAM systems but just as CAM systems.

The hardware CAM covers different production technologies for converting the virtual restoration into a dental material. At present, computer-controlled milling or grinding machines are mainly used. They machine the restoration from the full material block consisting of prefabricated metal or ceramic. As a rule, after the CAM production, some manual corrections and final polishing or individualization of the restoration with staining colors or veneering materials are required to be carried out by the dental technician.

Uses of CAD/CAM in prosthodontics are as follows

- Inlays and onlays [21,23]
- Crowns and bridges
- Fabrication of post and cores
- Complete denture fabrication [10,36]
- Removable Partial Denture Prosthesis Fabrication [36]
- Designing the placement of the Implant [41,47]
- Designing the maxillo facial prosthesis [25,26,30]

Steps for fabrication [5,7]

- TOOTH PREPARATION
- POWDERING
- SCANNING-IMPRESSION
- DESIGNING- CREATING VIRTUAL MODELS [8]
- MACHINING- copy milling/erosion [8]
- VENEERING
- CEMENTATION

Indications

- The crown and bridge in the esthetic region,

- Patients who are allergic to the metal restoration,
- Patients with quick need of restorative treatment,
- High esthetic desires

Contraindications

- Erupting tooth
- Malpositioned tooth
- For patients who are advised for temporary luting
- Periodontally weak tooth.
- Posterior quadrants

Advantages

The main advantage of this system is that it eliminates the impression procedure. If the dentist owns the system, the details of the treatment done can be directly transferred from the patient. Secondly, there may be no need for a temporary restoration or a return visit to the office for a permanent restoration. If the technology is located at a dental lab rather than the dental office, then a two-visit restoration is necessary.

CAD/CAM technology cannot replace the dentist or dental lab technician who must be accurate in creating the initial tooth preparation and impression. For example, a high level of skill is crucial in fabricating and fitting crowns. An ill-fitted crown can leave space between the teeth or between the tooth preparation and the crown, which may be problematic in two ways:

Increased risk of infection or disease because debris may lodge in the open space. Increased risk of teeth shifting because of the open space. Previously, it has been difficult to offer high levels of tooth restoration strength without using metals, such as in an amalgam dental filling or gold restoration. However, today's ceramics work very well in the milling chamber, providing strength, durability, and a high esthetic value. Furthermore, today's materials such as zirconia may be more "fracture resistant" than those of the past. Although CAD/CAM is an exciting technology, it is not necessarily applicable to all procedures requiring porcelain [4-7].

Advantages of CAD/CAM in a private dental office

The concept that a dentist can, in a single appointment, administer anesthetic in preparation for, prepare the tooth for, make an impression for, design, mill, customize and place a restoration is desirable for many clinicians and patients. The command of “one-appointment” dentistry is powerful not only for the patient, but also for the entire dental team and the office’s productivity. Single-appointment dentistry has a variety of benefits: the need for only one administration of anesthetic, the absence of need for temporary or provisional restorations (therefore, no lost temporaries or re-cementations), the absence of laboratory fees and a reduction in second-chair set-up costs. These factors ultimately equate to fewer instruments needing to be sterilized, less need for chair time set-up/breakdown and improved office efficiency.

Another, often overlooked advantage is the disposable supplies that can be eliminated (from impression material, wax, stone, temporary bridge resin and cement to cotton and paper disposables) by institution of a CAD/CAM system. Clinicians can gain other intangible advantages in the long term by introducing CAD/CAM technology into their already-busy dental practices. With CAD/CAM technology, clinicians maintain total product and artistic control of the restorations to be fabricated and seated. It allows clinicians to spend the majority of their time on tooth preparation and on seating of the final restoration; the software programs' options deliver a product that may need only endpoint characterization, staining or glazing. The computer and milling processes diminish potential inaccuracies resulting from the hand/laboratory fabrication process and are able to provide a restoration that fits within the 50-micrometer range established by the American Dental Association.

When the dentist implements CAD/CAM technology, he or she must create a schedule that supports single-appointment treatment. This schedule arrangement can both save time and increase efficiency. Dentists can complete most CEREC single-unit crowns within one and one-half hours. Dentists can treat quadrants within two or two and one-half hours. With this type of dentistry, the second "seating" appointment now is freed up and can be redesignated for an additional productive appointment. Given a traditional two-appointment procedure and time allotment, this single-appointment treatment approach becomes practical. Moreover, a practitioner seasoned in using CEREC can perform additional procedures while the restoration is being milled, again enhancing the practice's efficiency and productivity.

Patients often experience irritation in, sensitivity in and/or difficulty in cleaning temporized teeth. Single-appointment dentistry avoids these complaints. Also, clinicians must consider the diminished chance of bacterial invasion during this phase; decreased pulpal stress resulting from excessive cleaning, drying or trauma; and decreased need for the additional tooth manipulation that often is experienced at a second appointment. Given the fact that veneers represent a significant portion of laboratory-fabricated restorations today and that veneer temporaries easily can be displaced and are time-consuming to fabricate, dentists should find the convenience of single-appointment dentistry significant.

Furthermore, the CEREC veneer software program is easy to use and will enhance the implementation of single-appointment dentistry. Dentists have the ability to include their team members by delegating some of the tasks in the CEREC process. In such a scenario, assistants may be included in introductory CEREC training and can better their skills by taking additional training courses specifically designed for assistants. In practice, the team approach flows thus: the dentist prepares the tooth, powders it and makes the optical impression. Then the assistant designs the restoration, mills it, polishes it and prepares it for bonding. Finally, the dentist completes the procedure by bonding the restoration.

Disadvantages of using CAD/CAM in a private office

In the implementation of any new technology, discussions arise that require critical thinking. The primary consideration in a CAD/CAM purchase is the length of the learning curve, which may range from a few days to several months and may result in the loss of office production, the loss of patient treatment time and an increase in the clinician's frustration. Other obstacles to incorporating this system into practice are the cost of the equipment, the potential for the dental team to resist the system's use, the clinician's lack of confidence in using a computerized system, and perhaps the clinician's lack of willingness to learn a new concept that will require training and practice. Dentists who have difficulty integrating this technology into their practices usually are dentists who do not want to change the way they are practicing. However, the advantages of this system outweigh these disadvantages listed and so it is emerging as a successful treatment option.

INLAYS AND ONLAYS

Clinical performance of Cerec inlays and onlays over a functional period of 10 years were evaluated by otto. The success rate of Cerec inlays and onlays dropped to 90.4%. A total of 15 (200) 8% failures were found in 11 patients. Of these, 73% were caused by either ceramic fractures or tooth fractures. The reasons for the remaining failures were caries (20%) and endodontic problems (7%)

FIT OF INLAYS AND ONLAYS was done by ADDI and the results showed that there were only slight difference in the fit between the restorations fabricated using the three different manufacturing techniques and ceramics. Therefore long-term studies are needed to assess the clinical significance of the slight differences between the three systems.

CLASS II CEREC INLAYS Sjögren G evaluated the performance of Class II Cerec inlays. They made Sixty-six Class II CAD/CAM ceramic inlays were placed in 27 patients. Each patient received at least one inlay luted with a dual-cured resin composite and one inlay luted with a chemically cured resin composite. At the 10-year recall survival rate was 89%, 77% for the dual-cured resin composite–luted inlays and 100% for the chemically cured resin composite–luted ones. The difference was statistically significant. The properties of the luting agents seem to affect the longevity of the type of ceramic inlays Fasbinder DJ reviewed clinical studies from 1985 through 2006 that included CEREC-generated inlays, onlays or crowns. The survival probability of CEREC-generated restorations was reported to be approximately 97 percent for five years and 90 percent for 10 years.

Similar results (90%) were obtained from the above studies. The low rate of restoration fracture and longterm clinical survivability document the effectiveness of the Cad cam system as a dependable option for inlays and onlays.

Crowns and Bridges

Reich SM showed that tooth-colored, all-ceramic CAD/CAM-generated restorations are an alternative to conventional restorations if large coronal defects need to be treated. , out of 58 large, single-tooth, all-ceramic Restorations placed in 26 patients using a cad/cam. 3 years, revive rated 56 (97%) of the 58 restorations as Bravo or better. One as Charlie because of poor marginal integrity, and one restoration had to be replaced owing to a bulk fracture Witkowski S evaluated and compared the marginal accuracy and refinement time of titanium copings fabricated by 3 different CAD/CAM systems relative to standard casting techniques The marginal discrepancies (μm) ranged from 32.9 to 127.8 before and from 3.4

to 58.4 after the manual refinement of copings. The median duration of manual refinement time in minutes was 6.0 for PRO, 9.5 for DCS, 4.0 for EVE. And 4.0 for BIO (Kruskal-Wallis – test:p<.0001), Manual adjustment significantly improved the marginal accuracy of CAD/CAM system- fabricated titanium coping Hikita K conducted a study to evaluate the clinical outcome of all-ceramic crowns fabricated by dental CAD/CAM GN-I (GC, Japan). A total of 125 patients were treated in 306 teeth with failure in 5 teeth (1.6%) during 1-3 years follow up period Julia Gabriela revived single unit cad cam restorations and concluded that survival rate after 5 years is 91.6% (approx 1.75 %per year failure rate) using cerec As rightly said by Takashi M and others the development of dental cad cam systems for the fabrication of crowns and fixed partial denture in particular is clinically acceptable because failure rate of 1.6% per year he added that in future restoration are expected to be designed and fabricated with improved function related to jaw movement involving multiple–axis mandibular movements

Removable partial denture

Williams RJ had elaborated a procedure for chromium cobalt removable partial denture framework produced by cad/cam. the framework was assessed by a clinician in a conventional manner, fitted to the patient, and judged to be satisfactory by both the patients and clinician.

Complete denture

Mamaly reshad, Neo tee khin described mandibular and maxillary respcetively screw retained implant supported fixed all ceramic restoration using cad cam technology rather than using traditional approaches for they resulted in minimally invasive flapless procedure less post treatment discomfort reduced laboratory time and complexity.

Implants

Cho H compared 5 different abutments and said that All-ceramic crowns on the milled ceramic abutments were weaker than the metal-ceramic crowns on the titanium abutments Drago CJ had given an overview of the use of CAD/CAM technology for dental implants and illustrate two clinical protocols for that use. The CAD/CAM technology can reduce restorative dentists' chairside time associated with implant treatment in both edentulous and partially edentulous patients, can decrease costs without sacrificing accuracy or biocompatibility for both clinicians and dental laboratory technicians, and is available to dental laboratories without the capital expenses associated with purchasing new technology.

Tselios N presented a clinical report describing how CAD/CAM technology can facilitate the definitive restoration of immediately placed and loaded implants by allowing the fabrication of the definitive abutment as an exact duplicate of the provisional abutment. Angeles fuster Torres revived the use of cad cam in implant dentistry emphasizing on custom implant abutment and surgical template manufacturing and have concluded that cad cam technology applied to implant surgery allows production of high resistance and high density crowns. A custom design, perfect fit and higher resistance implant abutment. Surgical templates that allow transfer of software planning to surgical field

Maxillofacial prosthodontics

Jiao T described a new technique for fabricating auricular prosthesis by CAD/CAM system. The dimension shape, and anatomic contour of the auricular prosthesis were quite similar to those of the normal ear and precisely matched the deformed are. The CAD/CAM system for creating auricular prosthesis appears to be practical technique.

Cheah C presented a novel manufacturing approach that integrates laser surface digitizing/scanning and computer-aided design (CAD) and manufacturing (CAM) to achieve automated fabrication of spatially and anatomically accurate extraoral facial prostheses. The new manufacturing approach, reduced patient discomfort, minimal dependence on the artistic skills of the prosthetist, and short turnaround times for prosthesis production can be expected.

Strub J and others reviewed existing computer-aided design (CAD)/computer-aided manufacturing (CAM) systems, described the components of CAD/CAM technologies and addressed the limitations of current systems, and suggested possibilities for future systems. They concluded that Emerging technologies might expand dramatically the capabilities of future systems, but they also might require a different type of training to use them to their full effectiveness.

CONCLUSION

While much remains to be learned and many innovations still are possible, there already has been much success with CAD/CAM systems' producing ceramic restorations. Innovations will continue to affect and challenge dentistry. Existing CAD/CAM systems vary dramatically in their capabilities, each bringing distinct advantages as well as limitations. None can yet acquire data directly in the mouth and produce the full spectrum of restoration types (with the breadth of material choices) that can be created with traditional techniques. Emerging technologies may expand dramatically the capabilities of future systems, but they also may require a different type of training to use them to their full capacity. Dentists and dental students have reported that learning to operate the software and fabricating reproducible and predictable results has increased their enjoyment and level of personal fulfillment. With minimal experience, they are able to provide high-quality all-ceramic final restorations in one appointment (often only an hour in duration). As with fishing, where the number of fish one catches is directly proportional to the time spent with the hook in the water, the quality of the restorations one can provide for patients desiring all-ceramic, single-visit crowns, veneers, inlays and onlays, depends upon the time investment clinicians are willing to make in enhancing their own skills .Tackling the moderate learning curve, mastering the software, and applying the basic principles that are already part of the general practitioner's daily routine are well worth the effort. the fact that chairside CAD/CAM dentistry affords both experienced dentists and dental students the opportunity to enjoy enhanced control over the restorative process. The integration of chairside CAD/CAM software and CBCT provides dentists with a combined data set they can use for implant planning. The digital work flow for implant dentistry and chairside CAD/CAM offers new approaches to the way dentists can practice implant dentistry. There is no doubt that the application of CAD/CAM technology in dentistry provides innovative, state-of-the-art dental service, and contributes to the health and QOL of people in aging societies Therefore, we in the field of dentistry must not procrastinate in implementing new technology for the benefit of our patients.

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