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REVIEW ARTICLE

Advances in Technicians on CAD/CAM Restorations: A review

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ABSTRACT
The introduction of chair side and laboratory-based computer-aided design/computer raided manufacturing (CAD/CAM) technology in dentistry has radically changed the way in which dentists approach the restorative workflow. As the CAD/CAM industry is evolving, new scanners, design software, and mills or printers are being introduced regularly. New materials are under development and existing software continues to be updated. Now more than ever, it is important to understand what each system has to offer and which can best meet the needs of an individual practice. The CAD/CAM systems have developed considerably, offering accuracy and more options than previously. It can be envisioned that CAD/CAM technology developments will continue to offer dentistry more options for its use, including further CAD/CAM integration of procedures and imaging enhancements. In this review, we used the PubMed and Medline database for recent history of the development of dental CAD/CAM systems for the fabrication of crowns and fixed partial dentures. The aim of this literature review was to provide useful information prosthodontics.
Keywords: *CAD/CAM, Crowns and fixed partial dentures, Dentistry.*

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INTRODUCTION

What is the dental CAD/CAM?

Computer-aided design/computer aided manufacturing (CAD/CAM) systems have evolved over the last two decades and have been used by dental health professionals for over twenty years [1]. Francois Duret introduced CAD/CAM in restorative dentistry [1, 2]. One of the main lines of implementation was the intraoperative use for dental restoration using prefabricated ceramic monoblocks [3]. The CAD/CAM systems have been used mostly for the manufacturing of prosthetic fixed restorations, such as inlays, onlays, veneers and crowns. During the last decade technological developments in these systems have provided alternative restorations using different materials such as porcelain, composite resin and metallic blocks, which could not be prosecuted previously because of technical limitations [4].

OVERVIEW OF THE CAD/CAM

Many dental laboratories have recognized the benefits of utilizing the CAD/CAM process for years as a means to increase production while controlling costs. Often times the systems can be used to extend the working hours of the dental laboratory by programing equipment to mill designed restorations after typical working hours [5]. The challenge for many dentists as newer techniques and systems are introduced is to understand which of the three processes; imaging, designing and fabrication, of the CAD/CAM workflow are desirable and useful for a dental practice [6].

The CAD-CAM system includes three parts, which correspond to the three basic steps of the process: (I) First, a device is used to input the existing dental shapes into the system. This device includes a laser source (diode) which, through the first endoscope, projects light on the desired picture area. A second endoscope, adjacent to the first, allows a camera to take pictures in the mouth. This camera is connected to a system that digitizes the information and correlates the different views [7]. (II) The CAD system, including all necessary hardware and software, allows the operator to create an electronic model of the impression, display it on the screen, an d use it to design the prosthesis. The CAD system is linked to a proprietary articulator, called the Access Articulator, which provides the data relating to the dynamic movements of the jaw. (III) The CAM system, which includes a numerically controlled machine tool with four-axis capability. This machine will automatically mill the prosthesis from conventional or special materials [8].

In reality, dental CAD/CAM is neither simple nor easy for the following reasons. At first, total cost, operation time, and manipulation of the systems for processing dental devices using CAD/CAM technology should be at the levels found in conventional systems, or be superior, to replace the conventional individual tailormade restorations and ensure that new systems are practical in daily laboratory work and clinical practice [12]. Also, morphology of the abutment teeth, related adjacent teeth, opponent teeth designing the restoration to adjust crowns, fixed partial dentures (FPD) to abutment teeth and dentitions. However, it was difficult to recognize the delicate margin prepared by dentists using the compact digitizers available at that time. Therefore, the development of an accurate and compact digitizer and related sophisticated software was necessary for high-precision digitizing of complex and delicate targets. Numerical representation of the shape of crowns and FPDs is complex in comparison with the typical industrial products that are expressed using functional equations [13]. In addition, because the restorations not only have to be adjusted for abutment teeth but must also harmonize with adjacent and opposing teeth, once again, the development of sophisticated CAD software of restorations was necessary. Accurate processing, including mechanical milling of sharp corners and delicate margins of crowns and FPDs, was difficult with brittle ceramic materials. Therefore, the development of a stiff processing machine and sophisticated software to control the tool path were necessary. In addition, the size of the machine needed to be limited for installation in a normal dental laboratory office [14].

CAD CAM Systems

To date several CAD CAM Systems produced such as Cerec 3. Vita CEREC Mark II (Vita Zahnfabrik) Dicor MGC (Dentsply, L. D. Caulk Division) Procera AllCeram. (Nobel Biocare, Goteborg, Sweden), Celay (Mikrona,Spreitenbach, Switzerland). The ones mostly used at present are: CEREC system 3 (Sirona), Lava system (3 M), Procera system (Nobel Biocare), Everest system (KAVO). Cercon system (Degudent, Densply International Company), hereafter described, was used for the resolution of the clinical cases here exposed [9-11].

CEREC

With CEREC 1 and CEREC 2, an opticalscan of the prepared tooth is made with a couple charged device (CCD) camera, and a 3-dimensional digital image is generated on the monitor. The restoration is then designed and milled. With the newer CEREC 3D, the operator records multiple images within seconds, enabling clinicians to prepare multiple teeth in the same quadrant and create a virtual cast for the entire quadrant. The restoration is then designed and transmitted to a remote milling unit for fabrication. While the system is milling the first restoration, the software can virtually seat the restoration back into the virtual cast to provide the adjacent contact while designing the next restoration [19].

DCS Precident

The DCS Precident system is comprised of a Preciscan laser scanner and Precimill CAM multitool milling center. The DCS Dentform software automatically suggests connector sizes and pontic forms for bridges. It can scan 14 dies simultaneously and mill up to 30 framework units in 1 fully automated operation. Materials used with DCS include porcelain, glass ceramic, In- Ceram, dense zirconia, metals, and fiber-reinforced composites. This system is one of the few CAD/CAM systems that can mill titanium and fully dense sintered zirconia [20].

Procera

Procera/AllCeram was introduced in 1994 and according to company data, has produced 3 million units as of May 2004. Procera uses an innovative concept for generating its alumina and zirconia copings. First, a scanning stylus acquires 3D images of the master dies that are sent to the processing center via modem. The processing center then generates enlarged dies designed to compensate for the shrinkage of the ceramic material. Copings are manufactured by dry pressing high-purity alumina powder (>99.9%) against the enlarged dies. These densely packed copings are then milled to the desired thickness. Subsequent sintering at 2,000°C imparts maximum density and strength to the milled copings. The complete procedure for Procera coping fabrication is very technique-sensitive because the degree of die enlargement must precisely match the shrinkage produced by sintering the alumina or zirconia [21].

Lava

Lava introduced in 2002, Lava uses a laser optical system to digitize information from multiple abutment margins and the edentulous ridge. The Lava CAD software automatically finds the margin and suggests a pontic. The framework is designed to be 20% larger to compensate for sintering shrinkage. After the design is complete, a properly sized semisintered zirconia block is selected for milling. The block is bar coded to register the special design of the block. The computer- controlled precision milling unit can mill out 21 copings or bridge frameworks without supervision or manual intervention. Milled frameworks then undergo sintering to attain their final dimensions, density, and strength. The system also has 8 different shades to color the framework for maximum esthetics [22].

Everest

Marketed in 2002, the Everest system consists of scan, engine, and therm components. In the scanning unit, a reflection-free gypsum cast is fixed to the turntable and scanned by a CCD camera in a 1:1 ratio with an accuracy of measurement of 20 μm. A digital 3D model is generated by computing 15 point photographs. The restoration is then designed on the virtual 3D model with Windows-based software. Its machining unit has 5-axis movement that is capable of producing detailed morphology and precise margins from a variety of materials including leucite-reinforced glass ceramics, partially and fully sintered zirconia, and titanium. Partially sintered zirconia frameworks require additional heat processing in its furnace [23].

Cercon

The Cercon System is commonly referred to as a CAM system because it does not have a CAD component. In this system, a wax pattern (coping and pontic) with a minimum thickness of 0.4 mm is made. The system scans the wax pattern and mills a zirconia bridge coping from presintered zirconia blanks. The coping is then sintered in the Cercon heat furnace (1,350°C) for 6 to 8 hours. A low-fusing, leucite-free Cercon Ceram S veneering porcelain is used to provide the esthetic contour. In an in vitro study the marginal adaptation for Cercon all-ceramic crowns and fixed partial dentures was reported as 31.3 μm and 29.3 μm, respectively [24].

Chairside CAD/CAM

Chairside CAD/CAM systems include both a scanner and a mill for fabricating a restoration. With these systems, clinicians can scan, design, and mill a full-contour restoration in-office. As seen with designated digital impressioning systems, a digital scan is taken of the preparation. Instead of electronically sending the data file to a dental laboratory for fabrication, the clinician is able to design the restoration chairside using software included in the CAD/CAM system. When fabricating a chairside restoration, the clinician can choose a crown, inlay, onlay, or veneer [25]. Most of these software systems offer design options ranging from copying pre-existing tooth conditions to choosing from a library of proposals based on morphological details of adjacent teeth. These software programs offer a multitude of tools to modify the proposed restoration, including tools to adjust interproximal contacts, height of contour, occlusion, and other characteristics [26]. Depending on the material, restorations may be customized using stain and glaze and then fired in a porcelain oven, giving the dentist more creative freedom and control. The finished restoration can be cemented during the same appointment. Patient responses to these types of systems are generally positive due to the quick turnaround of their indirect restoration; in most cases, no temporary is required [27].

Application and Benefits of the CAD/CAM

The advantages of using CAD/CAM technology for the fabrication of crowns and FPDs can be summarized as: 1) application of new materials, 2) reduced labor, 3) cost effectiveness and 4) quality control. Materials and their processing technology have been intimately related to the fabrication of dental restorative and prosthetic devices throughout the history of dentistry. When new materials are introduced as candidates for the material of dental devices, the application of conventional technology is first tested. We sometimes overcome difficulties of processing new materials and succeed in routinely introduce new materials. However, high-strength ceramics that were expected to be the new materials for FPDs frameworks have been difficult to process using conventional dental laboratory technologies [15].

Therefore, this challenged us to apply CAD/CAM processing, particularly at a processing center with large facilities. Overall, CAD/CAM technology was useful and effective in compensating for changes in dimensions that come with processing chalky material and post-treatment to obtain fit of crowns and FPDs to abutment teeth. In addition, the operator attended the machine for only 5-6 min and most of the process was performed automatically by the CAD/CAM machine. Therefore, labor was vastly reduced using CAD/CAM machine. Furthermore, systems of outsourcing of some specialized procedures to a processing center using network connections allows for further reduction of labor time [16]. The use of CAD/CAM technology can not only shape restorations by milling, but also allows for quality control of the dental devices by designing optimal shapes based on material characteristics by CAD; thus preventing degradations such as residual strain due to the effects of processing, and ultimately providing reproducible processing. When milling a prefabricated ceramic block, the quality of which has been confirmed beforehand by the manufacturer, there are almost no internal defects in the milled products, whereas conventional powder build-up and baked porcelain products usually contain internal porosity [17, 18].

Clinical production of crown

The design of a crown with a CAD system is an interesting operation in that it clearly shows the superiority of the CADCAM approach over medical imaging techniques such as magnetic resonance imaging or scanners. Three-dimensional medical imaging does not go beyond the development in space of an observed image [40]. Early researchers explaining that such a rep re sensation was of limited interest, and that the power of a medical application for CAD-CAM would be in its ability to design a piece that would replace what was being observed. In dental CAD-CAM, there is a big difference between the initial object (the preparation) and the final object (the prosthesis). It is possible to go beyond the stage of a mere reproduction because prosthetic rules can be integrated in the software [41].

Special software is provided by the manufacturers for the design of various kinds of dental restorations. With such software, crown and fixed partial dentures (FPD) frameworks can be constructed on the one hand; on the other hand, some systems also offer the opportunity to design full anatomical crowns, partial crowns, inlays, inlay retained FPDs, as well as adhesive FPDs and telescopic primary crowns [31]. The software of CAD/CAM systems presently available on the market is being continuously improved. The latest construction possibilities are continuously available to the user by means of updates. The data of the construction can be stored in various data formats [32]. The systems available on the market are differentiated mostly in their construction software. While many systems emphasise an indication spectrum that is as broad as possible, other manufacturers place emphasis on intuitive use and user-friendliness [33, 34].

Design of the crown

The use of CAD/CAM technology can not only shape restorations by milling, but also allows for quality control of the dental devices by designing optimal shapes based on material characteristics by CAD; thus preventing degradations such as residual strain due to the effects of processing, and ultimately providing reproducible processing. When milling a prefabricated ceramic block, the quality of which has been confirmed beforehand by the manufacturer, there are almost no internal defects in the milled products, whereas conventional powder build-up and baked porcelain products usually contain internal porosity [35]. According to clinical and in vitro studies using finite element and fractographic analyses, the primary causes of failure reported for all-ceramic FPDs differed from those reported for the metalceramic FPDs. Fractures of ceramic FPDs tended to occur in the connector areas because of the concentrated stress [36]. Therefore, the design of the connector, particularly the dimensions, must be made independently depending on the type of ceramic material used for the framework. CAD better guarantees the durability and reduces the risk of fracture [37].

Processing data can be saved and followed up during the functional period for the device. Even if evidence is required to predict the prognosis of restorations during the functional period, these features detailed here have not been available with the conventional production systems in general use [38]. Therefore, quality control of dental restorative and prosthetic devices using CAD/CAM technology will be a factor with increasing importance in the future with an aging society because such restorative and prosthetic devices will need to function for longer periods as part of the body [39].

CONCLUSION

CAD/CAM systems have dramatically enhanced dentistry by providing high-quality restorations. The evolution of current systems and the introduction of new systems demonstrate increasing user friendliness, expanded capabilities, and improved quality, and range in complexity and application [28]. New materials also are more esthetic, wear more nearly like enamel, and are strong enough for full crowns and bridges. Dental CAD/CAM technology is successful today because of the vision of many great pioneers [29]. As Duret concluded in his article in 1991, "The systems will continue to improve in versatility, accuracy, and cost effectiveness, and will be a part of routine dental practice by the beginning of the 21st century [30].

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