ISSN 2347-5579

Unique Journal of Medical and Dental Sciences

Available online: www.ujconline.net

Review Article

COMPUTER-AIDED DESIGN AND MANUFACTURING IN DENTISTRY: A REVIEW

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Received: 03-02-2016; Revised: 01-03-2016; Accepted: 31-03-2016

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ABSTRACT

Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) was first introduced to dentistry in the mid-1980s.Both chair side and chair side—laboratory integrated procedures are available for CAD/CAM restoration fabrication. In selecting which procedure to follow, consideration should be given to esthetic demands, chair side time, and laboratory costs, number of visits and convenience and return on investment associated with CAD/CAM equipment. In the last two decades, exciting new developments in dental materials and computer technology have led to the success of dental computer aided design/computer aided manufacturing (CAD/CAM) technology. This article provides an overview of various CAD/CAM systems.

Keywords: CAD-CAM, Lucite reinforced ceramics, Zirconia, Standard tessellation language format, Surgical stents

INTRODUCTION

The technological changes taking place are truly revolutionizing the way dentistry is practiced and the manner in which laboratories are fabricating restorations. It is without doubt that high quality dental devices can routinely be fabricated through the collaboration of dentist and dental technicians. Nevertheless, dental laboratory work still remains to be labour-intensive and experience dependent[1]. The advent of CAD/CAM has enabled the dentists and laboratories to harness the power of computers to design and fabricate esthetic and durable restorations. CAD refers to computer aided designing, CAM refers to computer aided milling or machining. This process is sometimes referred to as CAD-computer-integrated manufacturing (CIM) process, where CIM refers to computer integrated machining or milling. Ever since the introduction of CAD-CAM to dentistry, there has been a constant phase of advancement to the technology[2].

Historical Background-

The CAD/CAM technology was introduced by Duret in 1971 in restorative dentistry and in 1983, the fi rst dental CAD/CAM restoration was manufactured[2,3]. Initially CAD-CAM was used for large industrial projects that has made their production easier and faster. Unlike today, dental CAD-CAM was not very popular due to a number of factors that included: The cost of the equipments and the time needed, the precision needed while recording the details of the site of preparation of the restoration, precision in the fi nal milling of the accurate restoration[4].

In 1979, Heitlinger and Rodder milled the equivalent of the stone model to make the crown, inlay or pontic. In 1980, Moermann et al. took a single picture of the tooth preparation and milled only the internal surface of the inlay[5]. The CEREC 1 system was the first to be introduced for dental purpose that marked a landmark in the mid 1980's. It was developed by Siemens Corporation. The ceramic reconstruction or CEREC system stands for "Chair side economical restoration of esthetic ceramic" and was first introduced in 1987.5Siemens Corporation later developed the second generation CEREC 2 system in 1994 and Sirona, Benheim, Germany brought the third generation CEREC 3 system in 1999.

Dr. Anderson developed Procera System He attempted to fabricate titanium copings by spark erosion and introduced CAD/CAM technology into the process of composite veneered restorations[6, 7]. This system later developed as a processing centre networked with satellite digitizers around the world for the fabrication of all ceramic frameworks[8].

CAD-CAM components and procedure

The CAD-CAM system is composed of a scanning unit that is composed of a high resolution camera that reads the finest details of the surface to be scanned. The scanned data is converted into STL format. The STL format is the format that is readable by most of the CAD-CAM software. This STL format is transferred to the milling system that is attached to

the computer. The STL data is used for milling the required prosthesis that has been designed using CAD-CAM software. The restorations are designed on a computer using CAD software based on the digitized data that acts as a virtual wax-up. The restorations are processed using a computer assisted milling machine. In the more recent times to counteract the difficulty of accurately scanning the abutments and the adjacent teeth, stone models are poured after impressions and these stone models are scanned using the scanning system and the STL image thus obtained is used for milling the prosthesis. The entire process of electronic designing and subsequent milling of a ceramic restoration requires approximately 25 to 30 min[4,9].

Review of common CAD/CAM systems-

(a) Cerec –

An acronym for chair side economic introduced in*reconstruction of esthetic ceramic Cerec 1980s, improved cerec 2 introduced in 1996 and the advanced 3-D Cerec 3 in 2000. With Cerec 1 and Cerec 2, an optical scanner is used to scan the prepared tooth or impression and a 3-D image is generated on monitor. A milling unit is used to prepare the restoration. With newer Cerec 3-D, the operator records multiple images within seconds, enabling clinician to prepare multiple teeth in same quadrant and create a virtual cast for the entire quadrant. Designed restoration is transmitted to a remote milling unit for fabrication.

(b) DCS Precident-

Comprises of a Preciscan laser Scanner and Precimill CAM multitool milling center. The DCS software automatically suggests, connector sizes and pontic forms for bridges. It can scan 14 dies simultaneously and mill up to 30 frameworks unit in one fully automated operation. It is one of the few systems that can mill titanium and fully dense sintered zirconia. An in vitro study showed that marginal discrepancies of alumina and ziroconia based posterior fixed partial denture machined by the DCS system was between 60 µm to 70µm[10].

(c) Cercon –

Commonly referred to as a CAM system, it does not have a CAD component. The system scans the wax pattern and mills a zirconia bridge coping from presintered zirconia blanks, which is sintered at 1,3500C for 6-8 hrs. Veneering is done with a low fusing, leucite free cercon Ceram to provide esthetic contour. Marginal adaptation for cercon all ceramic crowns and fixed partial dentures was reported 31.3 µm and 29.3 µm respectively[11].

(d) Procera –

All Ceram System Introduced in 1994, it is the first system which provided outsourced fabrication using a network connection. Once the master die is scanned the 3-D images is transferred through an internet link to processing center where an enlarged die is milled by a computer controlled milling machines. This enlargement compensates for sintering shrinkage. Aluminum oxide powder is compacted on the die and coping is milled by a computer controlled milling machines. This enlargement compensates for sintering shrinkage. Aluminum oxide powder is compacted on the die and coping is milled before sintering at a very high temp (>1550°C). The coping is sent back to the lab for porcelain veneering. According to research data average marginal gap for Procera all Ceram restoration ranges from 54 µm to 64 µm. [12]

(e) Lava CAD/CAM System-

Introduced in 2002, used for fabrication of zirconia framework for all ceramic restorations. This system uses yttria stabilized tetragonal zirconia poly crystals (Y-TZP) which have greater fracture resistance than conventional ceramics. Lava system uses a laser optical system to digitize information. The Lava CAD software automatically finds the margin and suggests a pontic. CAM produces an enlarged framework to compensate shrinkage[5].

Advantages of Cad-Cam Systems-

1. Application of new materials-

Advancement and development in the material science has constantly motivated to develop newer manipulation techniques also. Introduction of high-strength ceramics brought into consideration of processing FPD frameworks but it was difficult to process them using conventional dental laboratory technologies. Such high strength dental ceramics could be used with the CAD/CAM technology for processing fixed prosthesis[13].

2. Reduced labor-

The application of CAD/CAM technology reduces the labour cost and the chair side time. The total processing time is much shorter than that of conventional powder build-up and baking of porcelain. With regard to particular esthetic requirements, milled crowns could be completed merely by staining, using a conventional and simple method. The esthetic requirements can be more accurately met when compared to the conventional techniques[13].

3. Cost effectiveness

Production of all-ceramic FPDs using a zirconia framework fabricated by a CAD/CAM process could provide even more financial benefits to owners of dental laboratories because they can invest in small measuring machines and not in large expensive facilities; thus they could concentrate on conventional porcelain processing.

4. Quality control

Clinical and in vitro studies using finite element and graphic analyses show that the primary causes of failure reported for all-ceramic FPDs differed from those reported for the metal-ceramic FPDs. Fractures of ceramic FPDs tended to occur in the connector areas because of the concentrated stress. 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[14].

CONCLUSION

CAD/CAM systems offer automation of fabrication procedures with standardized quality in a shorter period of time. The application of dental CAD/CAM systems is promising, not only in the field of crowns and FPDs, but also in other fields of dentistry. There is no doubt that the application of CAD/CAM technology in dentistry provides innovative, state-of-art dental service, and contributes to the health and Quality of Living of people in aging societies. As

Duret concluded "The systems will continue to improve in versatility, accuracy, and cost effectiveness, and will be a part of routine dental practice in coming time.

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Source of support: Nil, Conflict of interest: None Declared