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Review Article

Dental CAD/CAM: A Systematic Review

Babita Yeshwante [1], Nazishbaig [2], Supriya Deshpande [3], Sonali Patil [4], Sneha Makanikar[5], Swati Bhandari[6]

[1] Head Of Department, CSMSS Dental College And Hospital, Aurangabad
[2] Professor, CSMSS Dental College And Hospital, Aurangabad
[3,4,5,6] Post Graduate Student, CSMSS Dental College And Hospital, Aurangabad

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ABSTRACT

CAD CAM systems have been introduced to dental field in late 1980's and have started being used in various fields ofDentistry. *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. CAD/CAM is proving to be a valuableimageenhancer, production booster and profit generator.This is an attempt to provide an overview of various CAD/CAM systems.*

Introduction

In dentistry, we have a long history of contributing to the needs of patients by offering dental restorative and prosthetic devices such inlays, onlays, crowns,fixed partial dentures (FPDs), and removable dentures, to recover patients' oral function and maintain their health.

During the 20th century, both dental materials and dental technologies for the fabrication of dental devices progressed remarkably.[1]The technological changes taking place are truly revolutionizing the way dentistry is practiced and the manner in which laboratories are fabricatingrestorations. 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.Owing to the increased demand for safe and esthetically pleasing dental materials, new highstrength ceramic materials have been recently introduced as materials for dental devices[2,3].

CAD/CAMSystems:

Based on their production methods these systems can be divided into the following groups.

1.In office system: Most widely and commercially used in Cerec System. This system can scan the tooth preparation intraorally and by selecting appropriate materials, the dentist can fabricate the restorations and seat it within a single appointment.

2. **CAD/CAMS – Dental laboratory models**: The indirect systems scan a stone cast or die of the prepared tooth, in the dental lab (Cerec-in lab). Many of this system produce copings which require the

* Corresponding author: **Dr.Supriya Deshpande, First Year Pg Student ,Department Of Prosthodontics And Crown And Bridge, Csmss Dental College,Kanchanwadi,Aurangabad, Mob No:9921388089**

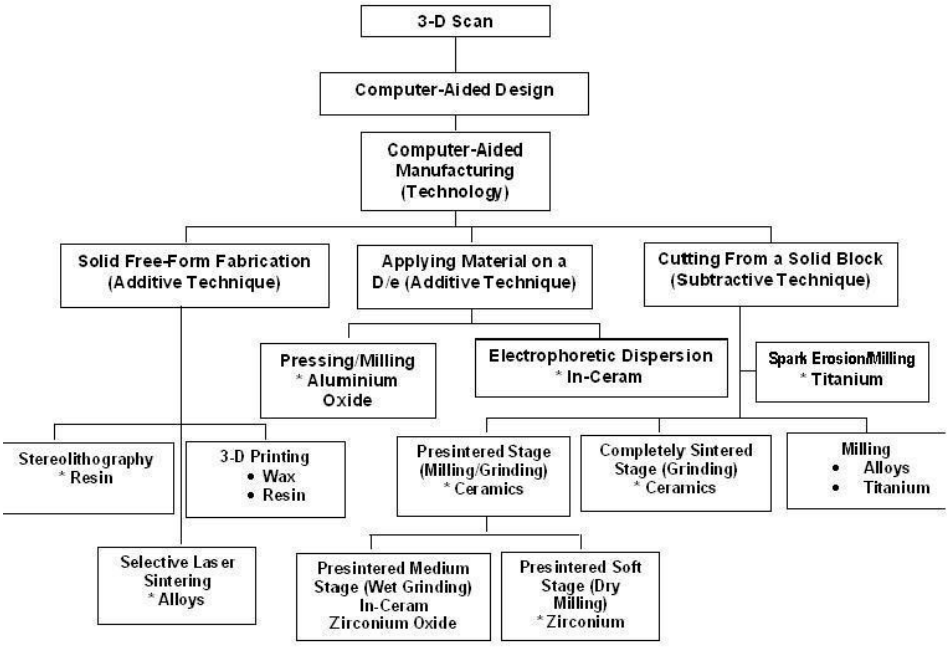

fig-1. An Overview Of CAD-CAM Systems Available Today In India

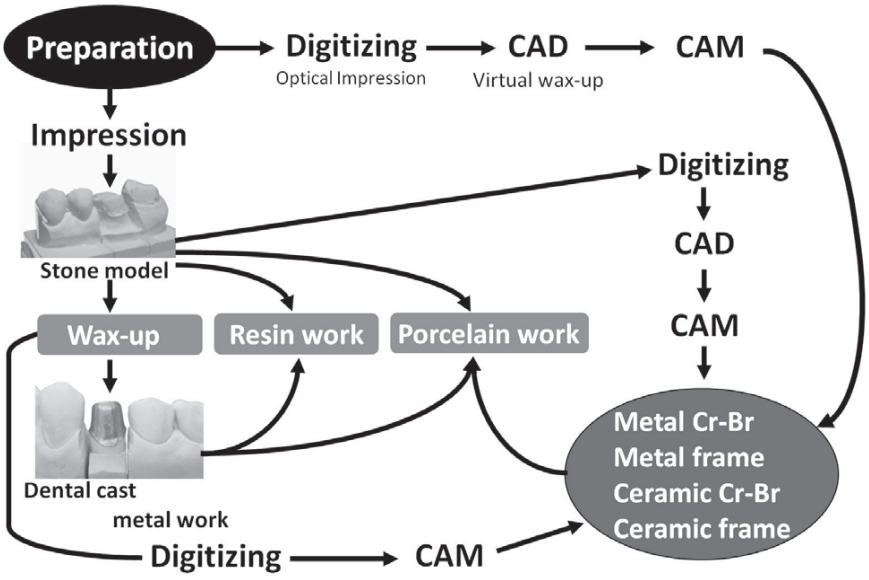

Fig-2. An overview of current dental CAD/CAM Fig. systems using for the fabrication of crown-bridge restorations

dental technician to add esthetic porcelain for individualization and characterization of the restoration.

3.CAD/CAM for outsourcing dental lab work using networks:

since the design and fabrication of the framework for high strength ceramics is technique sensitive, new technologies using CAD/CAM combined with network machining center that is outsourcing the framework fabrication using an internet have been introduced[4]

Objectives and potentials of the CAD/CAM technology

It aims towards eliminating the traditional impression methods by designing and machining the restoration with the aid of computer; to produce chair-side restorations and finally to improve the qualities of restoration.

Stages in prostheses fabrication with CAD/CAM Technology

There are various stages in fabrication of the prostheses with CAD/CAM technology.

A. Computer surface digitization

B. Computer-aided designing

C. Computer assisted manufacturing

A) Computer surface digitization.

This technique can be broadly divided into two categories:

1. Mechanical scanning devices.
2. Optical scanning devices.

Technologies used for computer surface digitization:

1. Optical camera.
2. LASER surface scanning device
3. 3-D scanning device (digitizer)
4. Photogrammetry
5. Moiré fringe displacement
6. computedtomography (CT-Scan).
7. magnetic resonance imaging (MRI)
8. 3-D ultrasonography etc.

B)Computer-aided designing (CAD).

Once the 3-D image is captured through any of the computer surface digitization techniques, 3-D image processing is done and the digitized data is entered in the computer.

Finally,curve smoothening, data reduction and blocking of undercuts can be done at this stage. Designing of the restoration is done using CAD software, which in turn send commands to the CAM unit, for fabricating the restoration.

C) Computer-aided manufacturing (CAM).

In this stage the milling is done with computerized electrically driven diamond disks or burs which cut the restoration from ingots. This process is commonly known as "substractive method".

D) Other CAM methods :

A) Additive: eg i) rapid prototyping
ii)selective laser sintering.

- Prevent material wastage since there is no remaining excess material. Some CAD/CAM systems have been developed which utilize a combination of these two methods (additive and subtractive methods).

Another different rapid prototyping method is 3-D printing, in which after computer-aided designing, the machine is used to build (print) a wax pattern of the restoration. Then this wax pattern is cast similar

to normal lost-wax technique. Advancement has taken place in such a way that instead of wax, resin-type material is being used to fabricate patterns. Rapid prototyping can also be used to fabricate auricular prostheses.

CEREC in Lab system - The tooth preparation die is secured in the scanning platform and data is captured with a non-contact laser. A Ceramic block (ingot) is placed in the milling chamber. Two milling diamonds create the precise restoration. Porcelain build-up is done which results in an aesthetically pleasing restoration. Then the fit is confirmed in the patient's mouth and required adjustment
s are done[5,6].

A BRIEF HISTORY OF DENTAL CAD/CAM

In dentistry, the major developments of dental CAD/CAM systems occurred in the 1980s. There were three pioneers in particular who contributed to the development of the current dental CAD/CAM systems.

1)**Dr. Duret**: He was the first in the field of dentalCAD/CAM development[7.]

From 1971 he began to fabricate crowns with the functional shape of the occlusal surface using a series of systems using a numerically controlled milling machine. Later he developed the Sopha® System ,which had an impact on the later development of dental CAD/CAM systems in the world.

2) Dr. Moermann: The developer of the CEREC® system. He attempted to use new technology in a dental office clinically at the chairside of patients. The emergence of this system was really innovative because it allowed same-day ceramic restorations.

3) Dr. Andersson: Attempted to fabricate titanium copings by spark erosion and introduced CAD/CAM technology into the process of composite veneered restorations[7]The developer of the technically difficult because of the restricted measuring conditions in the mouth, including the presence of adjacent teeth, gingiva, and saliva, which made accurate recognition of the margin of an abutment difficult which is a critical limitation of the system to fabricate final precision restorations[9,10]

DENTAL CAD/CAM ATGLANC(FIG NO 1)

Fig-1.An Overview Of CAD-CAM Systems Available Today In India

Fig 2-An overview of the current dental CAD/CAM systems used for the fabrication of crowns and FPDs [17].

Digitization

while precision is the degree of reproducibility, e.g. the repeatability of the measurement system. Ideally a measurement device is both accurate and precise, with measurements all close to and tightly clustered around the true value[18.]The digitizing accuracy is a major factor, which has an influence on the fit of fixed restoration. Currently the data acquisition is either performed directly in the patien's mouth (intraoral) or indirectly after taking an impression and fabricating a master cast (extraoral). Regardless of the digitizing mode applied, clinical parameters, e.g. saliva, blood, movements of the patient, might affect the reproduction of teeth.

Intraoral digitization allows the dental care provider to directly obtain the data from the prepared teeth. Thus, taking an impression and fabricating a cast model are no longer necessary. Titanium dioxide or magnesium oxide powder has to be applied to the glossy, lucent tooth surfaces in order to avoid reflections and to create a measurable surface. The powder layer applied to the tooth surface results in an

additional thickness of 13-85 µm. An in vitro study showed a higher accuracy of the extraoral digitization than in case of intraoral one[15]. There are two methods available for **extraoral digitization**.

1. 1. Contact digitization
2. 2. Optical digitization
3. Accuracy is the degree of veracity, e.g. how well the measured value represents the „truth", while precision is the degree of reproducibility, e.g. the repeatability of the measurement system. Ideally a measurement device is both accurate and precise, with measurements all close to and tightly clustered around the true value[19.]

Various CAD-CAM Systems:

4. Lava System (3m Espe, Seefeld, Germany) [20]
5. Procera System Katana System[1]
6. Celay System [21]
7. Everest System[20]
8. Cercon System[20]
9. Dcs Precident[20]
10. Other Dental Cad/Cam Systems[22]
11. ZENOTec (Wieland Dental &Technik GmbH & Co KG)
12. Hint-ELs DentaCAD system (Hint-ELs, Griesheim, Germany)
13. Cerasys (Cerasystems, Buena Park, CA)
14. Wol-Ceram (XPdentcorporation, Miami, FL)
15. BEGO Medifacturing (BEGO Medical GmbH, Bremen, Germany)
16. Turbodent System (U-Best Technology Inc, Anaheim, CA)
17. Etkon system (etkon USA, Arlington, TX)
18. iTero (Cadent, Carlstadt NJ, US)

ADVANTAGES:

1.Traditional impressions are not required.

2.Natural esthetics; excellent color matching because of its similar color and translucency to enamel. Lasting esthetics because ceramic is resistant to the oral environment.

3.Itis time effective.

4.Reducedlabour.

5.High marginal accuracy.

6.Good quality.

7. It can calculate, design, and build the copings, which can be cemented to yield a well-seating bridge.
8 It allows the dentist to review the preparation and impression, and make immediate adjustments to the preparation and/or retake the impression if necessary, prior to its being sent to the milling unit or a laboratory.
9. A digital impression also means that patients do not have to have impression material and trays used, saving them discomfort[25].
10. By using zirconium as implant abutment, light transmission into the gingival sulcus is allowed, thus preventing the grey of opaque metal parts from showing through peri-implant tissue[25.]

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CONCLUSION:

The advent of computer graphics and CAD-CAM have revolutionized dentistry. It is now possible to provide the equivalent of a cast restoration with a single appointment. Several systems are under development, each providing different characteristics and advantages. Some permit the clinician to be actively involved in the design process; others provide complete automation, freeing the clinician for other tasks[23].

Some use technologies similar to those already used in dentistry; others draw technologies that are state-of-the-art in engineering or manufacturing but not dentistry. Some aspects, like optical "impressions," are fairly technique sensitive. Others like the DentiCAD digitizer are forgiving and easy to use. Some systems are easy to use; others require expert users. Some are initially expensive; others are relatively less so[23].

Exciting changes are occurring in producing restorations. CAD CAM systems are available and more are being introduced continually. Clinicians must decide if and when it is cost effective to integrate this technology into their practice and which system is the best for their practice[23].

Results achieved must be analyzed with caution, but the extraordinary speed of development of this technology in industry affirms that it will be rapidly and definitively accepted in the dental profession. Its future evolution could be spectacular considering its numerous possibilities[24].

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