Review Article

CAD-CAM Technology in Dentistry: A Brief Review

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Abstract

The twentieth century can be considered as a hallmark of advancement in the field of dentistry. Advancements include new materials, techniques, and types of equipment. CAD-CAM (Computer-Aided Design-Computer-Aided Manufacturing) is one of the techniques which was introduced to improve the designing and creation of dental restoration such as crowns, veneer, dental implant restorations, fixed dentures, inlays, onlays, and complete denture. These changes in technology are truly revolutionizing the way dentistry is practiced and how laboratories are fabricating restorations. They act as a platform for digital dentistry making prostheses with better longevity and survival rate. The purpose of this article is to give an in-depth knowledge of CAD-CAM technology.

Keywords: *CAD-CAM, Veneer, dental implant restoration, Digital dentistry,*

Introduction

CAD-CAM was introduced in 1971 to the field of technology by Francois Duret. **(**1**)** It designs the three-dimensional planning of a workpiece on the computer screen with subsequent automated production by a computer-controlled machine tool. **(**2**)** The conventional casting procedure leads to various errors such as shrinkage of wax, expansion of investment material or model, porosities during the casting procedure. This technology helps in reduces these errors making prosthesis better in terms of precision and fit. In 1980 CEREC system was introduced by Mormann & Brandestini.

In 1983 Anderson developed a Procera method for manufacturing high precision dental crowns. He was the first person to use CAD-CAM for composite veneer restorations. In 2007 creation of Cadent iTero and the 2008 E4D Dentist system makes it possible to fabricate a crown in-office within the same appointment. **(**3**)** Various CAD-CAM systems are Cercon system, Everest system, Celay system, Dcs Precident, BEGO Medifacturing, iTero, Etkon system.

Components of CAD-CAM

There are three components of CAD-CAM

1.Scanner/ Digitalizing

2.Computer-aided design

3.Computer-aided manufacturing

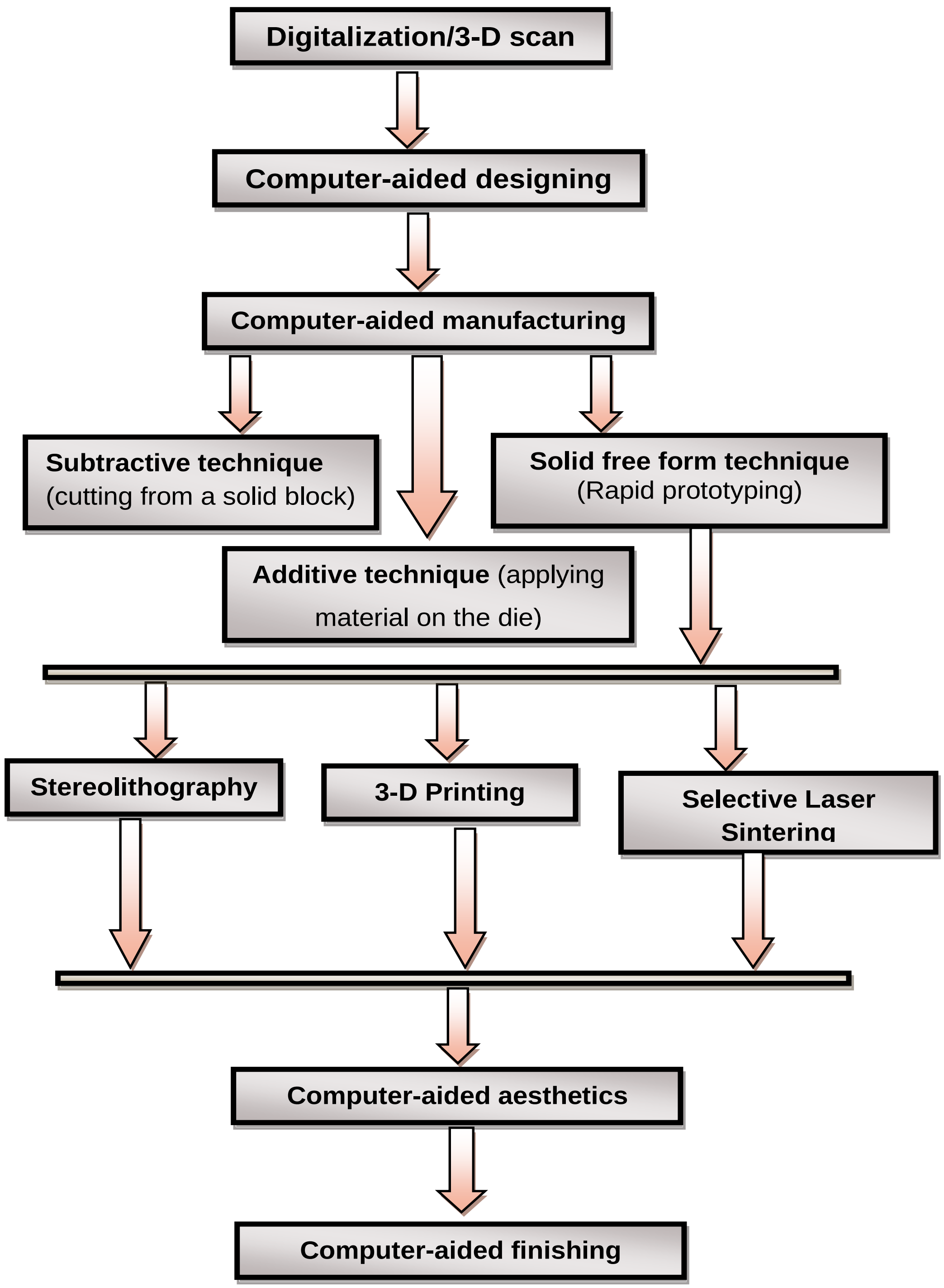
Digitalization/3-D scan
Computer-aided designing
Computer-aided manufacturing
Subtractive technique
(cutting from a solid block)
Solid free form technique
(Rapid prototyping)
Additive technique (applying
material on the die)
Stereolithography
3-D Printing
Selective Laser
Sintering
Computer-aided aesthetics
Computer-aided finishing

Figure 1

Computer surface Digitalizing

3-D digitalization can be carried out either directly or indirectly. Directly or intraoral digitalization involves scanning within the oral cavity and indirectly or extraoral digitalization includes scanning of the master cast or dental impressions. (4)

In direct digitalization reproduction of the data can be affected by the saliva, blood, movement of the patient, and most importantly by the reflection from the glossy tooth surface. This reflection can be controlled by applying an even layer of Titanium oxide or Magnesium oxide powder within a thickness of 13-85 microns to the glossy, lucent surface of the tooth. (5) However with the advancement of technology new CAD-CAM system such as the Lava system has been introduced that does not require any powder to scan. The most preferred method for digitalization is indirect or extraoral digitalization.

Scanning means data collection tools that measure the three-dimensional jaw and tooth structures and transfer them to digital data. Scanners or 3D digitizers can be laser-based or LED-based. Scanners are classified into two categories:

1. Mechanical scanner
2. Optical scanner

Mechanical scanner:

A mechanical scanner involves a ruby ball that reads the master cast line by line and three-dimensional data is collected. Examples: Procera, Forte, etc. The diameter of the ruby ball is set equal to the smallest grinder use in the milling unit. (6)

Advantages: Highly accurate

Disadvantages:

- Expensive
- Technique sensitive
- More time consuming as compared to optical scanners
- Very sensitive to any motion as a slight movement of the patient during scanning can compromise the quality of data.

Optical scanner:

It includes a light source and the receptor unit that is held at a definite angle to one another. The Computer uses this angle to calculate a three-dimensional data set from the image. **(**7**)** It depends on the principle of "Triangulation Procedure". The light source could be a laser beam or white light projections. Example: Everest Scan, Lava Scan ST.

Computer-aided Designing:

Once the scanning is completed, 3-D image processing is done and digitized data is entered into the computer.

Computer-aided Manufacturing:

Manufacturing is done using either subtractive or additive techniques. Milling can be dry or wet processing. Dry processing is used with a low degree of pre-sintering with zirconium oxide blocks. Wet processing includes the diamond or carbide cutter protected by a spray of cool liquid (water) to avoid overheating. **(**8**)**

Subtractive technique:

The subtractive technique includes electrically driven diamond milling burs which cut the restoration from the block.

The milling unit can be classified according to the number of milling axis:

1. 3-axis devices
2. 4-axis devices
3. 5-axis devices

3-axis devices:

These include milling points in three different spatial directions i.e. x-axis, y-axis, and z-axis. These three-axis milling devices can turn the component by 180 degrees, used in the fabrication of dental restoration in the processing of inner and outer aspect of the restoration. Examples: LAVA, Lab

4-axis devices:

It includes milling points in three different spatial directions along the tension bridge rotation included as a fourth component. Example: Zeno (Winland–Imes)

5-axis devices:

It includes three directional spatial directions and a Tension Bridge along with the fifth component that is the rotation of the milling spindle. Example: Everest Engine (KaVo)

By increasing the number of milling axis, fabrication of complex restoration becomes easier.

Additive technique:

It uses dry pressed or a slurry of Alumina or Zirconia on the die. Temperature is raised to a pre-sintering state. Large and porous coping at this stage is stable and the external surface is milled to the desired shape, removed from the die, and later sintered in the furnace for full sintering.

Rapid prototyping:

It is also known as the generative manufacturing technique.

It includes **stereolithography** – which uses a photosensitive resin, laser beam, and a moving platform. Layer by layer resin is polymerized with a laser beam to build as a prototype, the platform is lowered and subsequently, a new layer is added. It is successfully used in the fabrication of surgical templates for Implant placement. The technique is highly accurate but the material used is very expensive **(**9**)**.

3D printing – this technique is used in the fabrication of wax patterns or when nylon materials to be used. It fabricates wax patterns with resin-based materials. It uses a roller that collects a raw powder which gets fuses with the help of liquid adhesive supplied by ink-jet based printing head. Example: Wax Pro system that fabricates multiple wax patterns in no time with adequate marginal fit and finish.

Selective laser sintering: It also includes three components- laser beam, moving platform, and a roller. The roller helps to spread a layer of material on the platform formed by fusion with a laser beam. As layer by layer method is used to build up the prototype, the powder bed is lowered and subsequently, a new layer is rolled out smooth and subjected to the laser. Restoration fabricated by this technique is highly accurate but is very time-consuming (10).

Rapid Prototyping techniques prevent wastage of materials but have highly expensive tools, complicated machinery, and depend upon expertise to run the machinery.

Advantages

1. It prevents cross-contamination as no transfer of models or impressions to the lab or final crowns from the lab to the clinic which is the primary motive in the current Pandemic situation of COVID-19.
2. No impressions are required hence no need for autoclaving of trays or fabrication of customized trays.
3. Less time effective
4. Less labor required
5. Highly precise or good marginal accuracy.
6. Complex definitive restoration can be easily fabricated.
7. Prosthesis fabricated is highly aesthetic.
8. Prevent patient's discomfort by reducing chair side appointments.
9. The latest innovation allows occlusion to be viewed and developed in a dynamic state.
10. Increased productivity
11. Allow the dentist to review the preparation and make any changes if required.
12. In the fabrication of Zirconium abutment, prevent a typical grey of opaque metal through peri-implant tissue.
13. Fixed restorations can be given in a single visit.
14. It eliminates the use of laboratory equipment used in the conventional technique.
15. Complete dentures can be fabricated within two visits (11-12).

Disadvantages

1. Costly equipment and the software need to update regularly.
2. Waste of material as it is a subtractive technique so crowns are milled from the blocks leaving a lot of material to be wasted.
3. Milling tools are exposed to heavy abrasion and wear off easily running short working cycles.
4. It relies on the marginal capture so fabrication of sub-gingival margins can be difficult.
5. Cannot use different materials in the same prosthesis.
6. Technique sensitive
7. Matching the tooth shade with the block can be cumbersome.
8. A greater learning curve is required.
9. Microcracks can appear during the milling of the brittle materials.
10. Fabrication of complete denture can be somewhat difficult as it requires various software such as virtual articulators, placement of central bearing points, and different molds for teeth selection (12,13).

CAD-CAM in Removable Prosthodontics:

Fabrication of both complete, as well as removable partial dentures, can be done with CAD-CAM. It is best to use extraoral digitization as it is sometimes difficult to record proper vestibular depth with intraoral scanning. Milling of pure Titanium blocks or Ti-6Al-4V alloy for the fabrication of cast partial dentures. (14) However, the use of this technology is limited in removable prosthodontics.

Role of CAD-CAM in Fixed Prosthodontics:

Since the 1980s CAD-CAM had been used in the fabrication of crowns, veneers, inlays, onlays, provisional restorations. Preparation of tooth for placing prosthetic restoration followed by 3D scanning of either tooth structure or model to prepare final restoration Ceramic ingot or block is placed in the milling chamber. Two milling diamonds create the precise restoration. The porcelain build-up is done and the fit is confirmed in the patient’s mouth. (15)

CAD-CAM in Implantology:

1. CAD-CAM technology helps in both static as well as dynamic method for implant placement.

2. In static contributes to the fabrication of surgical template, Stereolithography has been successfully used in this.

3. In the dynamic method, the Computer Navigation system helps in precise implant placement.

4. Fabrication of Zirconium abutment to increase esthetics.

5. Fabrication of implant-supported prosthesis both removable as well as fixed.

6. Fabrication of titanium abutment or metal copings. (16)

CAD-CAM in Maxillofacial Prosthodontics

Maxillofacial prosthesis is a branch of prosthodontics that deals with the replacement of oral structures both intraorally and extraorally.

1. CAD-CAM technology helps in the fabrication of silicone or acrylic based maxillofacial extraoral prosthesis such as orbital, auricular prosthesis.

2. In the fabrication of intraoral prosthesis such as-radiation appliances, obturators.

3. One of the major advantages of using this technique is it preserve negative mold so there is no need to take impression every time as silicone prosthesis needs to be changed after every 2-3 year. (17)

Conclusion

This technology has changed the whole dental practice to a great extent. This article was an attempt to briefly review the basic concept, uses, advantages and disadvantages of CAD /CAM technology but the literature available on the subject is so vast that these can not be compiled in one article.

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