The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

CAD/CAM AND ITS CLINICAL APPLICATIONS IN DENTISTRY

*Ponjayanthi V, *Femin David, **T. Sreelal, ***T. C. Giri, ***Aparna Mohan

*P.G Students, **Professor and Head of the department, ***Reader, Dept of Prosthodontics, Sree Mookambika Institute of Dental Sciences, Kulasekaram, Kanyakumari, Tamilnadu | Corresponding Author: Dr Ponjayanthi V. E-mail: vdponjayanthi@gmail.com

Abstract:

Production stages are now becoming more automated in the field of dentistry. Over the last two decades, computer assisted designing and manufacturing of highly durable and aesthetically satisfying prosthesis become the centre of focus. CAD/CAM generated dental restorations have many advantages that include: the access to almost defect-free, prefabricated and controlled materials; an increase in the reproducibility and quality of the restorations and also data storage that commensurate with a standardized chain of production; it will provide an improvement in planning, increase in efficiency and improvement in precision.

Key words: standard transformation language, subtractive manufacturing, additive manufacturing, digital implant prosthesis, computer navigated surgery.

Introduction

CAD-CAM is an acronym for COMPUTER AIDED DESIGNING – COMPUTER AIDED MANUFACTURING. Use of computer systems to assists in creation, modification, analysis and optimization of design. CAD-CAM usage in dentistry began in mid-1980s. CAD-CAM is a field of dentistry and prosthodontics using CAD-CAM, to improve the design and creation of dental restorations, especially dental prosthesis, including crowns, inlays, veneers, onlays, fixed bridges, dentures and fixed dental implant restorations. CAD-CAM has become the centre of attention, because of its potentiality to deliver a highly durable and aesthetically satisfying restoration on the same day of patient visit.

CAD-CAM Components:

All CADAD-CAM system consists of three components.

1. A digitalisation tool/scanner
2. A software
3. A production technology.

Scanner:

A scanner or digitalization tool is used to transform object's geometry into digital data, that can be processed by system.[1] Basically there are two different type of scanners available:

1. Optical scanner
2. Mechanical scanner

The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

Optical Scanner:

In optical scanners white light projections or a laser beam can serve as a source of illumination.[1] the basis of this type of scanner is the collection of three dimensional structures in a 'triangulation procedure'. In this system, the light source and the unit containing the receptor are arranged in a definite angle to another. Through this angle the computer can calculate a three dimensional data set from the image on the receptor unit[2].

Example: Lava Scan ST (3M ESPE, white light projection), es1 (etkon, laser beam)

Mechanical Scanner:

In mechanical scanners, the prepared master cast is read line-by-line mechanically by means of a ruby ball and the structure is measured three-dimensionally. The diameter of the ruby ball is set to the smallest grinder in the milling system, with the result that all data collected by the system can also be milled.[3,4]

Example: Procera scanner from Noble biocare (fig 1)

Design software:

It processes data and, depending on the application, produces a data set for the product to be fabricated.[2]

Example: exocad, CEREC SW 4.5, TRIO software Suite, Planmeca PlanCAD 6.0

Various data formats are used to store the data for construction. The basically used format is standard transformation language (STL) data.

Processing Device:

It transforms the construction data set produced with CAD software into the desired product. They are of two types namely

1. Subtractive manufacturing
2. Additive manufacturing

Subtractive manufacturing:

Subtractive manufacturing is a process by which 3D objects are constructed by cutting the materials from a solid block of material.

Processing devices are classified based on the number of milling axes (fig 2):

- 3-axis devices
- 4-axis devices
- 5-axis devices.

X,Y,Z- 3 spatial directions, A- tension bridge, B – milling spindle

3 axis milling devices:

The 3 axis milling device has degrees of movement in all the three spatial directions. In this system the mill path points are defined by X -, Y -, and Z – values. All 3-axis devices applied in the dental field can be able to turn the component by 180° in the course of processing the outside and the inside. A milling of axis divergences, subsections and convergences, is not possible. This demands a virtual blocking in such areas.[1]

Examples of 3-axis devices: in Lab (Sirona), Cercon brain (DeguDent), Lava (3M ESPE).

4-axis milling devices

In addition to movement in 3 spatial directions, these devices also have rotatable tension bridge. Hence, a large vertical height displacement into the usual mould dimensions can be done during bridge constructions and thus save material and milling time.[1]

Eg: Zeno (fig 3)

5 axis milling device

With a 5-axis milling device there is also, in addition to the three spatial dimensions and the rotatable tension bridge (4th axis), the possibility of rotating the milling spindle (5th axis) . This enables the milling of complex geometries with subsections, as for example, lower jaw FPDs on converging abutment teeth (fig 4).[1]

Milling Variants:

Dry Processing:

Dry processing is applied mainly with respect to zirconium oxide blanks with a low degree of pre-sintering.[5]

This offers several benefits:

• Less investment costs for the milling device

• No moisture absorption is seen by the die zirconium oxide mould, as a result of which no initial drying times is needed for the ZrO_2 frame prior to sintering.

Wet processing:

In wet processing the carbide cutter or milling diamond is protected by a spray of cool liquid to prevent overheating of the milled material (fig 5). This kind of processing is necessary for all metals and glass ceramic material and processing of zirconium oxide ceramic with a higher degree of pre-sintering. A higher degree of pre-sintering will leads to reduction in shrinkage factor that in turn will enables less sinter distortion.[5] Examples: Zeno 8060 (Wieland-Imes), Everest (KaVo), inLab (Sirona).

Additive manufacturing:

It is known as 3D printing because it describe a manufacturing approach that builds objects one layer at a time, adding multiple layer to form an object. It is also known as rapid prototyping. It can be used for construction of metal structures either directly in metals or metal alloys like RPD, FPD, polymerized prosthesis and silicone prosthesis or indirectly by lost wax process or printing in burn out resins.

Types:

1. Selective Laser sintering- (Laser powder forming technique) mainly used in manufacturing of thermoplastic materials and metals by powder

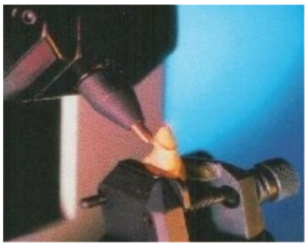

Fig 1

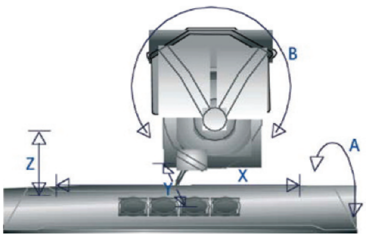

Fig 2

Fig 3: Wieland- Imes

Fig 4

Fig 5

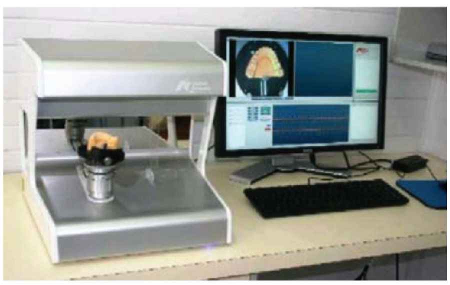

Fig 6

Fig 7

The journal of
PROSTHETIC
AND IMPLANT
DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

bed fusion method.[6]

2. Stereolithography – used in manufacturing of UV curable resins , metals and ceramics by VAT photopolymerization method.[6]

3. Fused deposition modeling- for manufacturing of thermoplastic materials and waxes.

4. Selective electron beam melting.

5. Inkjet printing technologies

CAD/ CAM Production Concepts in Dentistry:

Three different production concepts are available in dentistry, depending on the location of each component of the system, it includes

- Chairside production
- Laboratory production
- Centralised fabrication in a production centre.

Chair Side Production:

All components of the CAD/CAM system are located in the dental surgery. In this type of production, the tooth preparation can be scanned intraorally and by selecting appropriate materials, the dentist can fabricate the restoration and cement it in a single appointment.[7]

Example: CEREC System (fig 6)

Laboratory Production:

In this system the impression or the master cast will be send to the laboratory. Then the process of scanning, designing and processing the restoration will takes place in the laboratory.[7]

Example: i- Tero, Lava C.O.S, CEREC AC (fig 7)

Centralised production :

In this system the data sets produced in the dental laboratory sent to the production centre, where restorations will be produced with a CAD/CAM device in the milling centre and the prosthesis will be sent to the responsible laboratory and to the dentist.[7]

Materials used for CAD/CAM:

CAD/CAM devices generally process the following materials:

Metals:

At present chrome cobalt alloys, titanium, titanium alloys are processed using CAD-CAM milling devices.

Examples: Everest Bio T-Blank (KaVo, pure titanium), coron (etkon: non-precious metal alloy).

Resin materials:

Used for the milling of lost wax frames for casting technology. Used directly as crown and FPD frameworks for long term provisional or for full anatomical long term temporary prosthesis. Prefabricated semi-individual polymer blanks (semi-finished) with a dentine enamel layer are also available (artegralim Crown, Merz Dental).[1]

Silica based ceramics

Grindable silica based ceramic blocks are used by CAD/CAM systems for the manufacturing of veneers, inlays, onlays, partial crowns and full crowns (anatomically partially reduced, fully anatomical). Various manufacturers now offer blanks with multicolored layers [IPS Empress CAD Multi (Ivoclar Vivadent), Vitablocs TriLuxe (Vita)], for the production of full anatomical crowns. Lithium disilicate ceramic blocks are particularly important and are used for full anatomical anterior and posterior crowns, for copings in the anterior and posterior region and for three-unit FPD frameworks in the anterior region due to their high mechanical stability of 360 MPa.[8,9] Glass ceramics are particularly well suited to chairside application as a result of their translucent characteristics, similar to that of natural tooth structure.[10]

Infiltration ceramics

Infiltration ceramics are processed in porous, chalky condition as grindable blocks and then infiltrated with lanthanum glass.

• Vita In-Ceram Alumina (Al_2O_3): is suitable as crown copings in both anterior and posterior region.

• Vita In-Ceram Zirconia (70% Al_2O_3, 30% ZrO_2): suitable for crown copings in the anterior and posterior region, three-unit FPD frameworks in the anterior and posterior region.[11]

• VITA In-Ceram Spinell ($MgAl_2O_4$): Has the highest translucency of all oxide ceramics and is thus recommended for the production of highly aesthetic anterior crown copings, in particular on vital abutment teeth and in the case of young patients.

Aluminium Oxide (Al_2O_3)

Aluminium oxide is indicated in the case of crown copings in the anterior and posterior area, primary crowns and three-unit anterior FPD frameworks.[12]

Examples of grindable aluminium oxide blocks: InCoris Al (Sirona), In-Ceram AL Block (Vita).

Yttrium Stabilised Zirconium Oxide (ZrO_2, Y-TZP):

Zirconium dioxide is a high-performance oxide ceramic with high flexural strength and fracture toughness compared with other dental ceramics offer the possibility of using this material as framework material for crowns and FPDs, and, in appropriate indications, for individual implant abutments.[13]

Examples of Zirconium oxide blocks: Cercon Smart, Lava Frame (3M ESPE), Ceramics.

Significance for the Dentist

Digital impression:

It is a positive replica of the oral structures. For the success of fixed partial dentures like ceramic restorations internal fitness and marginal adaptation are important.[14] As there is no dimensional inaccuracy or changes in the impression or the cast because the impression will an optical impression and the cast are 3D printed/ milled using polyurethane or styrofoam material. No need for disinfection of the impression, it is easy to sore and comfortable for the patients and it reduces the patient treatment time.

Fixed Prosthesis:

The production of long-term temporary prostheses, from single unit to full bridge, coping, 3/4th crown, full crown, veneers is possible, as a result of the use of a virtual wax up on the computer, become faster, more convenient and more predictable.[1]

Removable Prosthesis:

Commercially available CAD/CAM dentures include

- AvaDent digital denture
- Baltic denture
- 3shape Dental system
- Dentca system

Using CAD/CAM it is possible to deliver the complete denture in two visits. Less chairside time needed and is more comfortable for the patient.[15]

Digital Implant Prosthesis:

Numerous implant planning softwares are available which aids in accurate placement of implants.

The two types of computer assisted implant surgeries includes,

The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

1. Computed guided(static) surgery
2. Computer navigated (dynamic) surgery

Computer guided surgery:

CAD/CAM designed surgical guide is used for accurate placement of the implants.[16]

Computer navigated surgery:

The computer navigated surgery is a direct method, where the position, angulations and the distance of implant to the vital structures can be viewed directly on the screen during implant placement. It helps in more accurate placement of implants.

Conclusion:

CAD/CAM system enables the dentist to provide highly durable and esthetically satisfying restorations on the same day of patient visit. It is more time saving and comfortable for the patient. The introduction of new systems and the evolution of current systems demonstrate expanded capability and improved quality of the prosthesis.

References:

1. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. British Dental Journal, 2008; 204(9):505-511.
2. Mehl A, Gloger W, Kunzelmann K H, Hickel R. A new optical 3-D device for the detection of wear. J Dent Res 1997; 76: 1799-1807.
3. May K B, Russell M M, Razzoog M E, Lang B R. Precision of fit: the Procera All Ceram crown. J Prosthet Dent 1998; 80: 394-404.
4. Webber B, McDonald A, Knowles J. An in vitro study of the compressive load at fracture of Procera All Ceram crowns with varying thickness of veneer porcelain. J Prosthet Dent 2003; 89: 154-160.
5. Sriram S, Shankari V, Chacko Y. Computer Aided Designing/ Computer Aided Manufacturing in Dentistry (CAD/CAM)- A Review. International Journal of Current Research and Review.2018;10:20-24
6. Dawood A, Marti B, Jackson V S. 3D printing in dentistry. British Dental Journal. 2015;219(11):521-529.
7. Uzun G. An overview of dental CAD/CAM systems, Biotechnology & Biotechnological Equipment.2008; 22(1):530-535.
8. Sorensen J A, Choi C, Fanuscu M I, Mito W T. IPS Empress crown system: three-year clinical trial results. J Calif Dent Assoc1998; 26: 130-136.
9. Taskonak B, Sertgoz A. Two-year clinical evaluation of lithia-disilicate based all-ceramic crowns and fixed partial dentures. Dent Mater 2006; 22: 1008-1013.
10. Sorensen J A, Kang S K, Avera S P. Porcelain composite interface microleakage with various porcelain surface treatments. Dent Mater 1991; 7: 118-123.
11. Raigrodski A J, Chiche G J. All-ceramic fixed partial dentures, Part I: in vitro studies. J EsthetRestor Dent 2002; 14: 188-191
12. Tinschert J, Zwez D, Marx R, Anusavice K J. Structural reliability of alumina-, feldspar-, leucite-, mica- and zirconia-based ceramics. J Dent 2000; 28: 529-535.
13. Curtis A R, Wright A J, Fleming G J. The influence of surface modification techniques on the performance of a Y-TZP dental ceramic. J Dent 2006; 34: 195-206.
14. Ruthwal Y, Parmar S, Abrol S, Nagpal A, Gupta R. Digital Impression: A New Era in Prosthodontics. IOSR Journal of Dental and Medical Sciences.2017;16(6):82-84.
15. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data J Prosthet Dent 2012 Jan;107(1):34-46.
16. Yong L T, Moy P K. Complications of Computer aided design/ Computer – Aided- Machining-Guided (NobleGuideTM) Surgical Implant Placement: An Evaluation of Early Clinical Results. Clinical implant dentistry and related research. 2008;10(3):132-127.