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College of Dentistry

CAD CAM In Restorative Dentistry

A Graduation Project

Submitted to the Conservative Department , College of Dentistry, University of Baghdad

By: Dania Rahim Hussain

Supervised by:

Dr. Yasameen Hasan Motea

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Certification of the Supervisor

I certify that this thesis entitled "**CAD CAM In Restorative Dentistry"** was prepared by **Dania Rahim Hussain** under my supervision at the College of Dentistry/ University of Baghdad in partial fulfilment of the requirements for the for the B.D.S. Degree.

Signature

Dr. Yasameen Hasan Motea

B.D.S., M.Sc.

(The supervisor)

Dedication

This work is dedicated to my supervisor for her guidance, encouragement and support…

To my family, my father and my mother, for their great support and for always believing in me.

Thank you from all my heart.

Dania

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1. Introduction

The latest innovations in technology made almost all things possible in this world. The lost-wax precision casting of gold alloys, dough modelling and curing of acrylic resins and powder sintering of dental porcelains were originally developed for dentistry and are well established as conventional dental laboratory technologies. 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 laboratory technician‟s primary role in dentistry is to perfectly copy all of the functional and aesthetics parameters that have been defined by the dentist into a restorative solution. It is an architect/builder relationship. Throughout the entire restorative procedure, from initial consultation through treatment planning, provisionalization and final placement, the communication routes between the dentist and the dental technician require a complete transfer of information pertaining to existing, desired and realistic situations and expectations to and from the clinical environment[(1)]. Functional components, occlusal parameters, phonetics and aesthetics are just some of the essential information which dental technician completes with his skills and experience. As dentistry evolves into the digital world of image capture, computer design, and the creation of dental restorations through robotics, the dental laboratory must evolve as well. Computer-aided design/Computer-aided manufacturing (CAD/CAM) restoration gives us that option[(2)] .

CAD / CAM systems in dentistry consist, basically, of three components [(3)]:

• The first component is a device that reflects the preparation of teeth and other supporting tissues and is responsible for spatial data digitalization (CAI - Computer Aided Inspection).

• The second component consists of computer which plans and calculate body form of restoration, equivalent to the area of CAD-s.

• The third component represents a numerically controlled milling machine which from the basic shape produces dental restoration, corresponding CAM area. As a rule, there are recommended additional processing such as polishing or individual preference by a dental technician or doctor.

2. Evolution of CAD-CAM systems

Computer-aided design and manufacturing were developed in the 1960s for the use in the aircraft and automotive industries. Dr. Francosis Duret was the first person to develop CAD/CAM device, making crowns based on an optical impression of the abutment tooth and using a numerically controlled milling machine in 1971. He produced the first CAD/CAM dental restoration in 1983 [(4)].

Dr. Andersson developed the Procera Method of manufacturing high-precision dental crowns in 1983. Dr. Duret later developed the Sopha system in 1984[(4)].

Dr. Andersson was the first person to use CAD/CAM for composite veneered restorations[(5).] In 1987, Mörmann and Brandestini discovered CEREC system, which was the first dental system to combine digital scanning with the milling unit . The E4D Dentist system, which was introduced in 2008 permits same-day in–office restorations along with CEREC system [(4)].

3 .CAD/CAM components

3.1 Scanner

Under the term 'scanner' one understands, in the area of dentistry, data collection tools that measure three-dimensional jaw and tooth structures and transform them into digital data sets [6].

Basically there are two different scanning possibilities:

a) optical scanners

b) mechanical scanners

a) Optical scanners

The basis of this type of scanner is the collection of three-dimensional structures in a so-called 'triangulation procedure'.

Here, the source of light (eg. laser) and the receptor unit are in a definite angle in their relationship to one another.

Through this angle the computer can calculate a three-dimensional data set from the image on the receptor unit [6]. Either white light projections or a laser beam can serve as a source of illumination (Fig. 1).

The following can be named as examples of optical scanners on the dental market:

- Lava Scan ST (3M ESPE, white light projections.
- Everest Scan (KaVo, white light projections).
- es1 (etkon, laser beam).

Fig.(1): Optical scanner Of CAD/CAM System

b) Mechanical scanner

In this scanner variant, the master cast is read mechanically line-by-line by means of a ruby ball and the three-dimensional structure measured. The Procera Scanner from Nobel Biocare (Göteborg) is the only example for mechanical scanners in dentistry (Fig.2).

This type of scanner is distinguished by a high scanning accuracy, whereby 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 [7] .

The drawbacks of this data measurement technique are to be seen in the inordinately complicated mechanics, which make the apparatus very expensive with long processing times compared to optical

Fig.(2):mechanical scanner Of CAD/CAM System

3.2 Design software

Special software is provided by the manufacturers for the design of various kinds of dental restorations (Fig 3). 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[(6)].

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. The basis therefore is often standard transformation language (STL) data. Many manufacturers, however, use their own data formats, specific to that particular manufacturer, with the result that data of the construction programs are not compatible with each other[(6)]..

The systems available on the market are differentiated mostly in their construction software. While many systems emphasis an indication spectrum that is as broad as possible, other manufacturers place emphasis on intuitive use and user-friendliness [(6)].

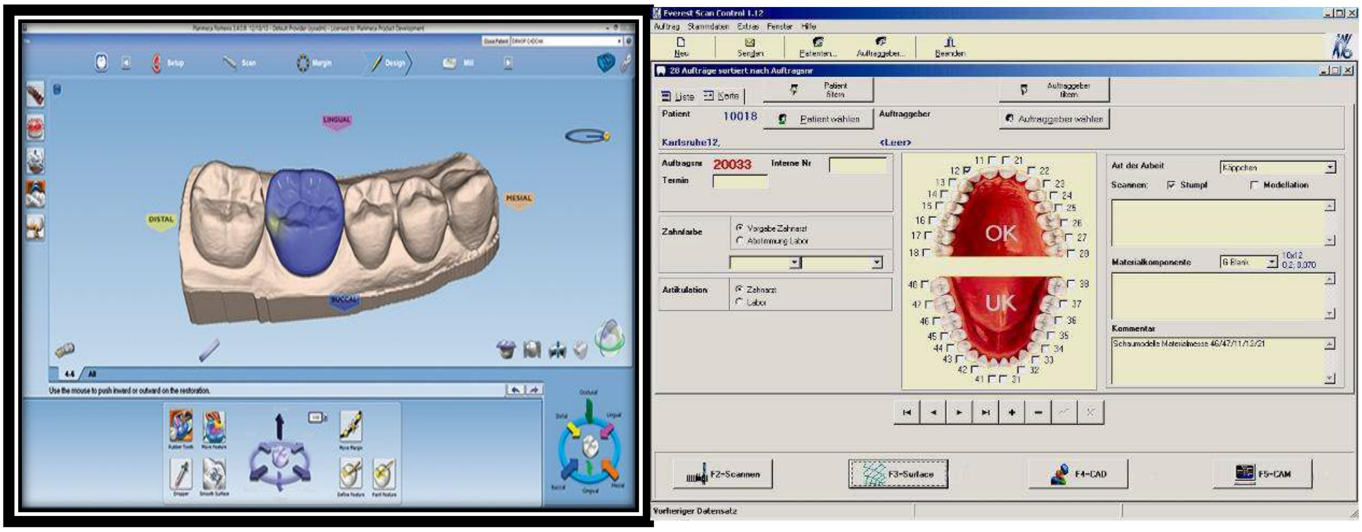

Fig.(3):CAD Software /For Dental prosthesis Design

3.3 Processing devices

The construction data produced with the CAD software are converted into milling strips for the CAM-processing and finally loaded into the milling device. Processing devices are distinguished by means of the number of milling axes [(8)] :

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

a) 3-axis milling devices:

This type of milling device has degrees of movement in the three spatial directions.Thus, the mill path points are uniquely defined by the X -, Y -, and Z – values (Fig. 4) [(8)].

The calculation investment is therefore minimal. A milling of subsections, axis divergences and convergences, however, is not possible. This demands a virtual blocking in such areas. All 3-axis devices used in the dental area can also turn the component by 180° in the course of processing the inside and the outside[(8)] .

The advantages of these milling devices are short milling times and simplified control by means of the three axes. As a result, such milling devices are usually less costly than those with a higher number of axes[(8)] .

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

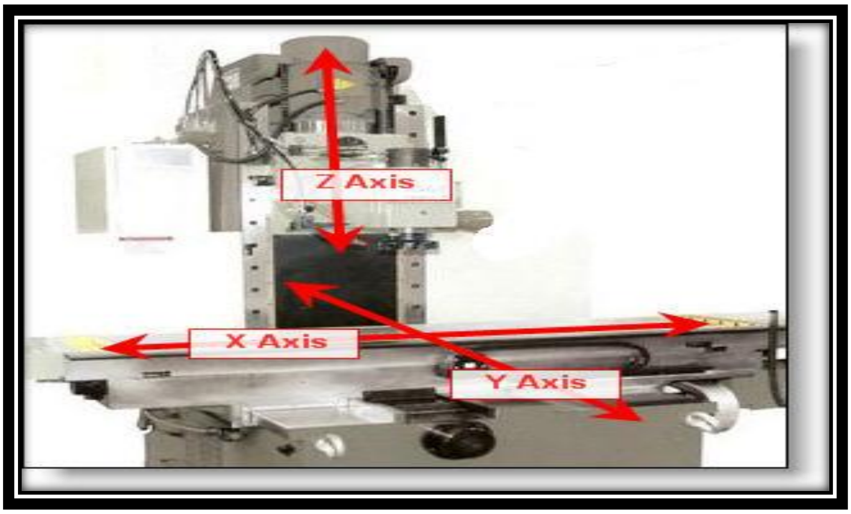

Fig.(4): 3 axis Machine Of CAD/CAM System

b) 4-axis milling devices:

In addition to the three spatial axes, the tension bridge for the component can also be turned infinitely variably (Fig. 5). As a result it is possible to adjust bridge constructions with a large vertical height displacement into the usual mould dimensions and thus save material and milling time[8].

Example: Zeno (Wieland-Imes).

c) 5-axis milling devices:

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) (Fig. 5). This enables the milling of complex geometries with subsections[8].

Example in the Laboratory Area: Everest Engine (KaVo).

Example in the Production Centre: HSC Milling Device (etkon).

The quality of the restoration does not necessarily increase with the number of processing axes. The quality results much more from the result of the digitalisation, data processing and production process[8].

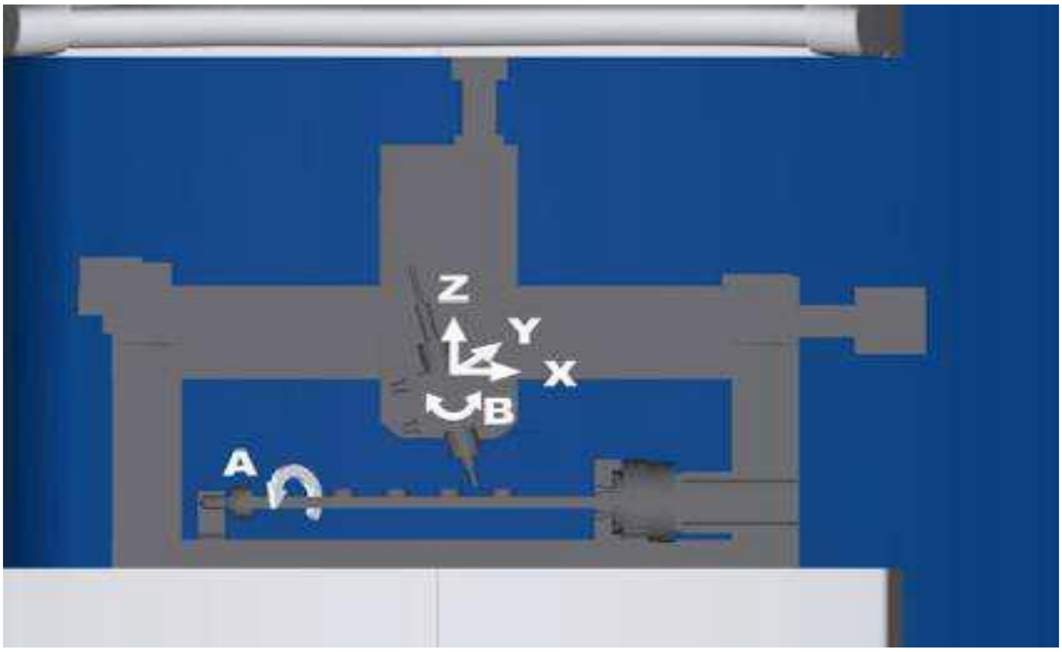

Fig.(5): 5axis Machine Of CAD/CAM

4. General Classification Of CAD/CAM Systems:

Based on their production methods systems have been divided into the following [9] :

1. In office system:

Most widely used is Cerec System. Intraorally scanning of the preparation and selection of appropriate materials is done by this system due to which the restorations can be fabricated and seated within a single appointment[9] .

2. CAD/CAM- Dental laboratory systems:

The indirect systems scan a stone cast or die of the prepared tooth, in the dental lab (eg Cerec-in lab). Many of these systems produce copings after which the dental technician adds esthetic porcelain to the restoration[9] .

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

Technologies using CAD/CAM with network machining center which means outsourcing the framework fabrication using an internet have been introduced as the design and fabrication of the framework for high strength ceramics is technique sensitive [9] .

5. Most Common CAD/CAM Systems:

Cercon:

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 (1,350C) for 6 to 8 hours [9] (Fig.6).

Fig.(6): Cercon System

Everest:

The Everest system consists of scan, engine, and therm components (Fig. 7). In the scanning unit, areflection 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. Its machining unit has 5-axis movement that is capable of producing detailed morphology and precise margins from a variety of materials. Examples: leucite reinforced glass ceramics, partially and fully sintered zirconia, and titanium [10].

Fig. (7)Everest In Lab Of CAD/CAM System

Lava:

This system uses yttria stabilized tetragonal zirconia poly crystals (Y-TZP) which have greater fracture resistance than conventional ceramics.Lava system (Fig.8) uses a laser optical system to digitize 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 [9] .

Fig. (8):Lava CAD/CAM System

Procera:

This system (Fig.9) has combined pantographic reproduction with electrical discharge (spark erosion) machining. It uses an innovative concept for generating its alumina and zirconia copings [10].

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. The Procera restorations have excellent clinical longevity and strength [10].

Fig.(9): Procera CAD CAM system.

DCS Precident:

It is comprised of a Preciscan laser scanner and Precimill CAM multitool milling center. It can scan 14 dies simultaneously and mill up to 30 framework units in 1 fully automated operation [9].

Materials used: 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 titaniumand fully dense sintered zirconia [10].

CICERO System:

The computer integrated crown reconstruction was developed by CICERO Dental System B.V. (Hoorn, The Netherlands). The CICERO method for production of ceramic restorations uses official scanning, ceramic sintering, and computer assisted milling techniques to fabricate restorations with maximal static and dynamic occlusal contact relations. The system makes use of optical scanning, near net-shaped metal, ceramic sintering and computer-aided fabrication techniques [11] .

CEREC SYSTEM:

The computer- aided design/computer-aided manufacture (CAD/CAM) CEREC (computer-assisted CERamic REConstruction) system is used for electronically designing and milling restorations [12] (Fig.10) .

Fig. (10) CEREC CAD CAM system

CEREC 1:

In this, the ceramic block could be turned on the block carrier with a spindle and feed against the grinding wheel, which grinds the ceramic block to a new contour with a different distance from the axis at each feed step[12].

CEREC 2:

The introduction of an additional cylinder diamond enables the grinding of partial and full crowns. It introduced the design of the occlusion in three modes: extrapolation, correlation and function. However, the design still was displayed two-dimensionally [13].

With CEREC 1 and CEREC 2, an optical scan 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 [13].

CEREC 3:

This system skipped the wheel an introduced the two bur-system. The “step bur”, reduced the diameter of the top one third of the cylindrical bur to a small-diameter tip enabling high precision form grinding with reasonable bur life [12].

The most significant factor for three-dimensional scanning with the Cerec 3 intraoral camera is that tooth preparations for crowns and inlays have a unique characteristic: all points of interest can be seen from a single viewing line, representing the preparation and insertion axes, respectively [13].

CEREC in Lab:

Is a laboratory system in which working besides a laser-scanned and a digital image of the virtual model is displayed on a screen. After designing the coping or framework, the laboratory technician inserts the appropriate VITA In-Ceram block into the CEREC in Lab machine for milling. The technician then verifies the fit of the milled coping or framework [10].

E4D Dentist System:

Presently it is the only system besides CEREC that permits same day in-office restorations. This system includes a laser scanner (Intraoral digitizer), a design center and a milling unit. The scanner is placed near the target tooth, and has 2 rubber feet that hold it to specific distance from the area being scanned.

As each picture is taken, the software gradually creates a 3D image. The design system automatically detects the finish lines and marks them on the screen. As soon as the restoration is approved, the data are transmitted to either the in-house milling machine or a dental laboratory. The office milling machine will then manufacture the restoration from the chosen blocks of ceramic or composite [14].

Fig.(11):E4D System Of CAD/CAM

6.Materials available for the use with CAD CAM

Almost all types of fixed (crowns, bridges, implant abutments, inlays and onlays) and removable (removable partial dentures) dental restorations in addition to orthodontic appliances can be constructed using CAD CAM technology [8].

Different CAD CAM systems are compatible with different types of materials (Table 1). Silica-based ceramics, infiltrated ceramics and oxide high performance ceramics (Aluminum Oxide and Yttrium stabilized Zirconium Oxide) are the most widely used materials with CAD CAM technology [8]. The materials are available in blocks and are either mono-chromatic or poly chromatic [15]. In addition to ceramics (Table 2), metals (titanium, titanium alloys and chrome cobalt alloys), waxes and resin materials may be used with dental CAD CAM systems[8].

Fig.(12): materials used in CAD CAM system.

Table (1): List of CAD CAM systems, manufacturer and type of materials used

Commercial Name	Manufacturer	Restorations	Materials
Chairside systems			
Cerec 3	Sirona Dental System	Inlays, onlays, Veneers, Crowns	Zirconia, Alumina Oxide, Ceramic, Resin
E4D Chairside	D4D Technologies, L.L.C	Inlays, onlays, Veneers, Crowns, Bridge frameworks, copings	Zirconia, Ceramic, Composite
Laboratory systems			
Cercon	DeguDent GmbH	Crowns, bridges	Zirconia
Cercon	DeguDent GmbH	Crowns, bridges	Zirconia
Cerec MC XL	Sirona Dental Systems	Inlays, onlays, Crowns, bridges, copings	Zirconia
Everest	Kavo Dental Corporation	Inlays, onlays, Veneers, Crowns, bridges	Zirconia, Titanium, ceramic
inLab CAD/CAM	Sirona Dental System	Inlays, onlays, Veneers, Crowns, Bridge frameworks, copings	Zirconia, Alumina, Ceramic
In-Visio DP 3D printer	3D System Corporation		Light cured Resin
Lava	3M ESPS	Crowns, bridges	Zirconia
Neo System	Cynovad	Crowns, Bridges	Resin, Zirconia, Titanium
Perci-Fit	Popp Dental Inc	Crowns, Bridges	Zirconia, Titanium
Procera Forte	Nobel Biocare	Bridges, Copings, Abutments	Zirconia, Alumina, Titanium
Procera Piccolo	Nobel Biocare	Bridges, Copings, Abutments	Zirconia, Alumina, Titanium
Turbodent	U-best Dental Technology Inc	Crowns, Bridges	Zirconia, Titanium
WaxPro	Cynovad	Crowns, Bridges, Copings	Wax

Table (2) Shows different types of dental ceramics used with CAD CAM systems

Material name	Material type
Virablocks Mark II	Feldspathic ceramic
Cerec	Feldspathic ceramic
IPS Empress CAD CAM	Leucite re-enforced glass-ceramic
In-ceram Alumina	Glass infiltrated alumina
In-ceram Zirconia	Glass infiltrated alumina with zirconia
Procera	Polycrystalline alumina
Lava Zirconia	Polycrystalline zirconia (Y-TZP)

Ceramic (zirconia) can be used in different stages of sintering (hardness): semi-sintered and fully sintered[8] .

At the semi-sintered (green stage) stage, the material is used in a soft stage; during the design and milling the restoration is made over sized, to allow for a shrinkage of around 20.0 – 25.0 % during the sintering (firing) process used to confer superior physical properties. Fully sintered blocks can also be milled with some CAD CAM systems; with this type of density, there will be no shrinkage in the material, which is considered an advantage, because it will reduce the firing cycles and delivery time[8]. However, it takes more time to mill a fully sintered block and will cause more tool wear. There is therefore a tradeoff between the time for firing cycles for the pre-sintered blocks and the time it takes to mill a fully sintered block, but on balance, the latter is likely to be more time efficient[8] .

7.Stages in fabrication of prosthesis with CAD/CAM technology[12]

1. Computer surface digitization
2. Computer-aided designing
3. Computer assisted manufacturing
4. Computer-aided esthetics
5. Computer-aided finishing

The last two stages are more complex and are still being developed for inclusion in commercial systems[12] .

1.Computer surface digitization

Scanning of prepared tooth is done either with LED based or Laser based scanners [12] **.**

***LED based scanner:**

A small hand held video camera with a 1cm wide lens (scanner) when placed over the occlusal surface of the prepared tooth, emits infrared light which passes through an internal grid containing a series of parallel lines. The pattern of light and dark stripes which falls on the prepared tooth surface is reflected back to the scanning head and onto a photoreceptor, where its intensity is recorded as a measure of voltage and transmitted as digital data to the CAD unit [12] (Fig.13).

Fig.(13):LED Based scanner

***Laser based scanner:**

A high speed laser takes digital scans of the preparation and proximal teeth to create an interactive 3D image. Rapid scan allows automatic capture of digital images at the operator's preferred speed to scan in the mouth or extra-orally on conventional impressions or models(Fig 14), all without powder. Newer laser based scanners can scan at subgingival level based on optical coherence (OCT) [12] .

At least 9 scans are required to produce the image. There are stabilizers present with the scanning device.

If scanned image is correct it will appear in green color, if it is near correct it appears in yellow color but if scanned image does not meets the requirements software discards the image and shows it in red color [16].

Optical camera, LASER surface scanning device, three dimensional (3-D) scanning device (digitizer), photogrammetry, computed tomography (CT-Scan), magnetic resonance imaging(MRI), 3-D ultrasonography etc. are some of the technologies used for computer surface digitization [17].

Fig.(14):Laser Based scanner

A ***B***

Fig. (15): A -intra oral B-extra oral scanners

2. Computer-aided designing (CAD)

A three-dimensional image of the die is produced over the screen and can be rotated for observation from any angle. 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[17](Fig.16) .

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 sends commands to the CAM unit, for fabricating the restoration[17] .

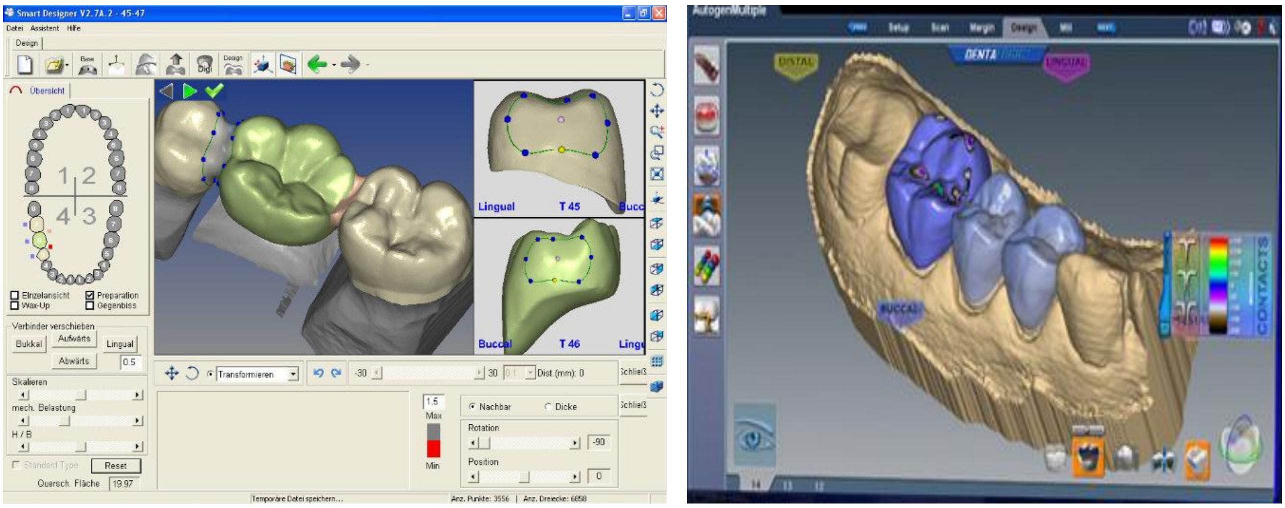

Fig.(16): CAD CAM software design

3.Computer-aided manufacturing (CAM)

Third and the final stage is Computer-aided manufacturing (CAM). The CAM technologies can be divided in three groups according to the technique used [16] **(Fig. 17):**

a. Subtractive technique from a Solid Block:

In this stage the milling is done with computerized electrically driven diamond disks or burs which cut the restoration from ingots. The CAM technique most commonly applied in manufacturing frameworks for single crowns and the size of the material blocks available for the milling units limits the size of the FPDs[16].

b. Additive technique (by applying Material on Die):

Here in this technique Alumina or Zirconia is dry pressed on the die and the temperature is raised to a temperature similar to the pre sintering state. At this stage, enlarged and porous coping is stable. Its outer surface are milled to the desired shape and coping, removed from die, and sintered into the furnace for firing to full sintering [17] .

c. Solid free form fabrication:

This category new technologies originating from the area of Rapid Prototyping (RP), which have been adapted to the needs of dental technology[18] .

Rapid Prototyping Techniques

1) Stereolithography 2) Selective Laser Sintering (SLS) 3) 3-DPrinting 4) Fused Deposition Modeling (FDM) 5) Solid GroundCuring 6) Laminated Object Manufacturing (LOM) [19] .

Stereolithography (Perfactory, Delta Med, Frieberg, Germany): It is the technique for creating 3 dimensional objects in which a computer controlled moving laser beam is used to build up the required structure layer by layer .Occlusal splints and diagnostic templates for oral implantology can be produced withthis technique. .herence tomography (OCT) [19] .

Selective Laser Sintering: Starts by converting the CAD data in series of layer. These layers are transferred to the additive SLS machine which begins to lay the first layer of powder. As the laser scans the surface, the material is heated and fuse together. Once the single layer formation is completed, the powder bed is lowered and the next layer of powder is rolled out smooth and subjected to laser. Hence layer by layer formation of the object takes place [19].

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 [19].

Fig.(17) : CAD CAM milling process.

8. Advantages And Disadvantages Of CAD/CAM Technology

*Advantages

The advantages of using CAD/CAM technology can be summarized as [1,20] :

1. Applications of new materials – High strength ceramics that are expected to be the new materials for FPDs frameworks have been difficult to process using conventional dental laboratory technologies. Therefore, this challenged to apply CAD/CAM processing. Due to successful use of all-ceramic crowns, all ceramic systems have become a viable treatment options[20] .
2. Time effectiveness.
3. Reduced laboratory.
4. Quality control.
5. Patients often experience irritation in, sensitivity in and/or difficulty in cleaning temporized teeth. With this system temporaries become obsolete, thus making uncomfortable and unaesthetic transition times a thing of past. Also, there is diminished chance of bacterial invasion during this phase, decreased pulpal stress resulting from excessive cleaning, drying or trauma, and decreased need for the additional tooth manipulation[1] .
6. It is not always possible for the dentist to create a full arch of precisely parallel preparations. The computer can calculate, design, and build the copings, which can be cemented to yield a well-seating bridge [1].
7. Scanning an image and viewing it on a computer screen 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. This ensures no calls from a laboratory that the impression is defective. This review, as well as seeing a preparation multiple times its normal size on a screen, can result in improved preparations[1] .

8. A digital impression also means that patients do not have to have impression material and trays used, saving them discomfort[18].

9. Latest innovation in CAD/CAM system allows occlusion to be viewed and developed in dynamic state[18].

***Disadvantages**:

1. The primary consideration in a CAD/CAM purchase is the length of the learning curve, which may range from a few days to several months and may result in the loss of office production and loss of patient treatment time[1].

2. Other major problem is the potential for the dental team to resist the system‟s use and the clinician‟s lack of confidence in using a computerized system[1].

3. Capital costs of these systems are quite high and rapid large scale production of good quality restoration is necessary to achieve financial viability[20].

4. Matching the patient‟s tooth shade to the blocks of materials used to fabricate the restorations can be a challenge to the dentist initially[20].

5. Some CAD/CAM system relies on margin capture for digitization, thus making subgingival margin capture challenging[1].

6. CAD/CAM is ever advancing technology. Upgrades and updates are to be expected. The existing software takes no time to become obsolete. It is wise to question how long the technology has been on the market and how soon a revision will become available. Thus, the dentist may need to budget for monthly expenses for technical support and software up gradation[1].

9. Significance for the dentist

In recent years, the use of CAD/CAM technology has above all strongly influenced dental-technical production procedures. If one ignores chairside prostheses, the significance of this technology for the dentist is not immediately clear. In recent years, CAD/CAM production has clearly expanded the palette of materials for dental prostheses by providing access to new ceramic materials with high dependability [(21)] . The stability values of zirconium oxide ceramics permit, in many areas of indication, the use of this material as an alternative to metal frames for permanent prostheses [(22)].

The production of long-term temporary prostheses has, as a result of the use of a virtual wax up on the computer, become faster, more convenient and more predictable. This method has already been implemented by computer-generated long-term temporary restorations, since it can be modified, by changing the form, to the functional and aesthetic satisfaction of the patient during a clinical test phase[(22)].
The production of the definitive prosthesis should also be carried out by CAD/CAM technology and represents merely a copying process of the temporary prosthesis into the definitive prosthesis by a different material[(22)].

In spite of all the benefits of these new methods, the dentists working procedures will have to be adapted to the methods of CAD/CAM and milling technology. These include appropriate tooth preparations with the creation of a continuous preparation margin, which is clearly recognizable to the scanner, for example in the form of a chamfer preparation. Shoulderless preparations and parallel walls should be avoided[(22)] .

On the basis of present knowledge, a tapered angle of between 4° to 10° is recommended. Subsections and irregularities on the surface of the prepared tooth as well as the 'creation of troughs' with a reverse bevel preparation margin can be inadequately recognized by many scanners[(22)] (Fig. 18).

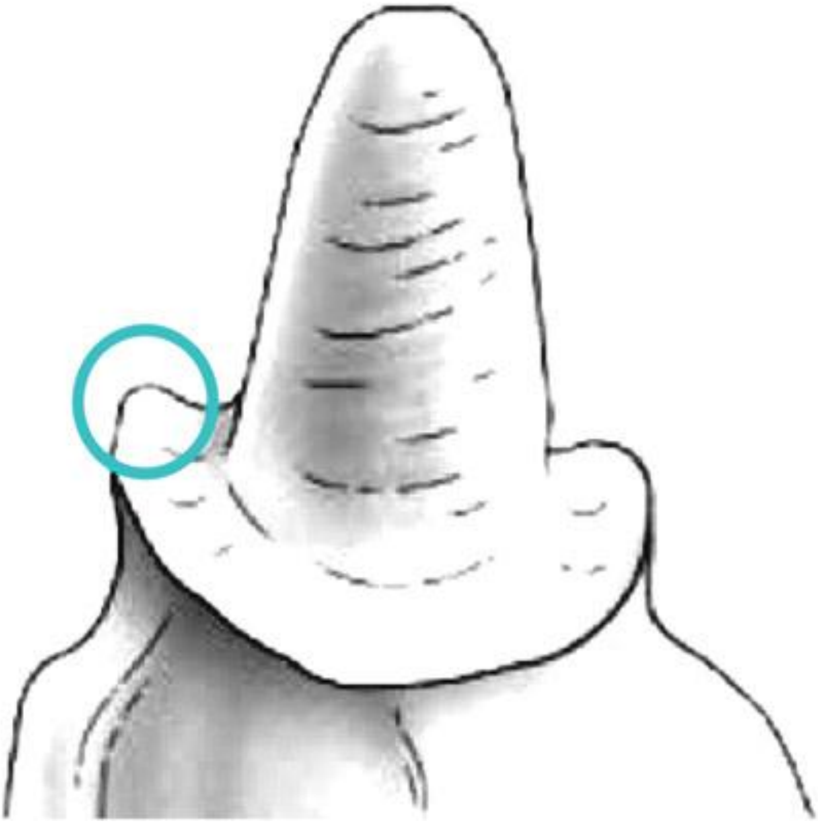

Fig.(18): Revers bevel preparation Making The preparation Hardly Detectable By The CAD/CAM

In addition, sharp incisor and occlusal edges are to be rounded. Sharp and thinly extending edges as well as 90° shoulders in a ceramic restoration can result in a concentration of tension; in addition sharp edges cannot be milled exactly using rounded grinders in the milling device. The diameter of the smallest grinder is 1 mm in most systems, so structures smaller than 1 mm cannot be milled precisely. The result is an inaccurate fit[22]. A 360 degree shoulder or chamfer preparation is considered to be the appropriate marginal preparation geometries for CAD/CAM produced all-ceramic restorations. In the case of FPDs, the abutment teeth cannot show any divergence [22].

The precision of fit that can be achieved with the assistance of CAD/CAM systems is reported to be 10-50 µm in the marginal area [23]. Thus, the demands of the literature concerning marginal adaptation of dental restorations can be reached with this technology; in addition, this production process achieves an industrial standard that does not have to deal with the variations of manually produced prostheses[24].

10.Limitations and future CAD/CAM technology

The cameras are line of sight, which means that the camera can only record what is visible to the camera lens. Therefore, those structures or margins obscured by saliva, blood, or soft tissue are not visible to the camera and will not be accurately recorded [25].

The absence of glass-ceramics in a disc form is a deficiency. Once it becomes available in disc form, the pressing technique will most likely vanish. Furthermore, additive technology is limited to polymeric and metallic materials and thus far does not include ceramics in dentistry. One more limitation is the limited full arch accuracy of digital impressions as compared with conventional impressions [26].

Furthermore, it has been noted that zirconia frameworks on teeth requiring longer curved frameworks are subjected to a greater sintering distortion than the shorter straight frameworks, which may potentially affect fit and adaptation. The zirconia frameworks exhibit accurate fit for partial arch prosthesis only [27].

In the future, ultrasound impressions will be implemented using ultrasonic waves, which have the capability to penetrate the gingiva non-invasively without retraction cords and not be affected by saliva, sulcular fluid, and blood. This will lead to decisive advancements, as detailed cleaning and drying of the oral cavity and associated tooth structure will become unnecessary, as well as reducing treatment time and increasing patient comfort compared with optical impressions [28].

Furthermore, the restorations will be fabricated through laser milling[29] and/or direct inject printing of zirconia and glass ceramics[30]. Additionally, in the future, ultrasound impressions will be used in concert with monolithic restorations .

11. Conclusion

An array of CAD/CAM systems have evolved, but dental CAD/ CAM systems are, still in their infancy. Developments are continuing on both existing and new systems. With each iteration, the capabilities of these systems expand, and improvements in technique sensitivities, user friendliness, computing power, and the quality of the restorations are usually evident as well. But as the future approaches, the systems and materials available to us will continue to evolve, improve, and enhance dentistry.

"The ideal CAD / CAM system" for many years is a dream of many researchers. Since the precision of restorations made by CAD / CAM technology in the function of all the individual errors of procedures and equipment, and that scanning is the initial source of possible inaccuracies, the higher resolution scanner will most significantly contribut to the quality of the entire system.

The introduction of new technologies leads to the improvement of services in the field of dental medicine, as confirmed by patient satisfaction (95%). Accessibility prices to patients is very satisfactory (91%). On the issue that producing restoration is short, patient satisfaction was 96%. Asked whether dental restorations are giving a natural feeling?, patient satisfaction is 100%. The new technologies development of services in the dental medicine acquire aesthetic character. The use of CAD / CAM technology significantly shortens the time of creating prosthetic work, and CAD / CAM systems are easy to use.

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