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Role of CAD/CAM technology in prosthetic dentistry-A review

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Introduction

[CAD/CAM] In dentistry and prosthodontics, computer-aided design and computer-aided manufacture are used to enhance the design and production of dental prostheses, such as crowns, veneers, inlays and onlays, fixed bridges, dental implant restorations, removable or fixed dentures, and orthodontic appliances [1-3]. This method is frequently employed in the manufacturing of aircraft and automated spare parts [2]. Although this technology is well established in fixed prosthodontics, the discipline of detachable prosthodontics is still in its infancy [4]. Following the success of CAD/CAM in implant and fixed prosthodontics, full dentures were introduced [5]. A novel method for designing and creating entire dentures has emerged: computer-aided design and computer-aided manufacturing (CAD/CAM) [6] . Due to the absence of appropriate CAD software until recently, CAD/CAM was used in the production of entire dentures [7].

Selective laser sintering (SLS), selective laser melting (SLM), and selective laser stereolithography (SLA), as well as multi-jet modelling in jet technology, 3D printing, and solid ground curing, are CAD/CAM techniques used in dentistry. [8] The functional and biomechanical requirements for retention, stability, support, reciprocation, encirclement, and passivity must be met by components made for RPDs [9].

Rapid prototyping is an example of an additive manufacturing process, although computer-aided technology can also be used for subtractive manufacturing processes like computerized numerical control machining [10]. A computer-aided design and a computer-aided surgical and radiographic guidance are made for dental implant procedures using an intraoral scanner and a milling unit [11].

Simplicity and optimization are two key CAD/CAM goals in the creation of prosthetic structures with good quality and aesthetics [12–14]. The field of prosthodontics has used CAD/CAM technologies since the 1980s. In recent times, this technology has been used to create personalized implants, templates for implant placement, bone transplants, bone resections, and for treatment planning and extraoral prosthesis manufacturing [15-17] .

History

In 1971, Duret introduced CAD/CAM technology to the dental industry. In order to create the crown, inlay, or Pontic in 1979, Heitlinger and Rodder milled an approximation of the stone form [18]. The CEREC system was first developed by Mormann & Brandestini in 1980. In 1983, the first CAD/CAM dental restoration was produced [18]. Fujita was interested in adapting the manufacturing procedures to the dental care sector in 1984. Germany's Siemens Dental, now known as SIRONA, develops the CEREC system in 1985. The "CHAIR SIDE ECONOMICAL RESTORATION OF ESTHETIC CERAMIC" system was introduced in 1987. The Procera system, created by Dr. Andersson in 1987, signalled the start of a new era for dental CAD-CAM systems [18]. In 1989, Nobel BioCare AB created PROCERA and CDS Dental (Switzerland) created DCS President.

In 1990, Girrbach Dental GmbH in Pforzheim, Germany, founded Digident.

In 1991, Mikrona Technologies, Spreitenbach, Switzerland, created Celay.

In 1993, Cicero (Ciceron Dental Systems, Hoorn, NL) was founded.

The Siemens Corporation created the CEREC [19] system of the second generation in 1994. The third generation CEREC [20] system was created by Sirona, Benheim, Germany, in 1999. the founding of Cercon Smar in 1995.

In 2001, the creation of Etkon (etkon AG, Gräfelfing, D), Everest (KaVo, Leutkirch, Germany), Lava (3M ESPE AG, Germany), and other projects were completed. Bego Meddifacturing (Medical Bego, Bremen) was founded in 2002.The XawexDental System (ZrNprocess, I-Mes, Eiterfield) and Perfactory (envisiontec, Gladbeck, D) were both developed in the year 2003.The Dental Designer 3Shape system was developed in 2005 and the Cadent iTero system was released in 2007. The E4D Dentist System and the Lava Chairside Oral Scanner (COS) were created in 2008 [21] .

Process of CAD/CAM

1. A CAD/CAM system makes use of a process chain that involves scanning, design, and milling stages.

2. The scanning tool transforms the prepared teeth's shape into three-dimensional (3-D) units of information to create a 3-D map (point cloud). The operator uses the computer to construct a restoration shape, and the milling machines employ that tool path to produce the restoration shape from a restorative material [22] .

CAD/CAM equipment

1. The initial scanning phase, computer surface digitization (CSD), offers two sub-options: [23,24]

A. Equipment for optical scanning

B. Equipment for mechanical scanning

A] Optical scanning apparatus:

A scanning method based on a collection of 3-D structures is the triangulation operation. Using this angle, a computer may create 3-D data from the image on the receptor unit. Lighting options include using a laser beam or white light. The patient's mouth is directly scanned to get the direct scanner image. In an indirect scanner, the cast or impression is scanned to get data [25]. Optical scanner illustrations [23] Everest Scan, KaVo, es1, etkon, Lava Scan ST, and 3M ESPE.

Complex mechanics, high cost, and lengthy processing times are drawbacks.

B] Mechanical scanning apparatus:

In this kind of scanning apparatus, the poured cast is mechanically read line-by-line by means of a ruby ball, and the object is measured in three dimensions and distinguished by a high degree of scanning precision. Then, milling would be used to develop and produce all digital data collection [26,27]. The downsides of this approach include the fact that it is more expensive, time-consuming, and difficult than other scanners.

The second part is the designing step:

After a three-dimensional image has been obtained using one of the scanning methods, the digitized data is designed in the computer before being used by the construction software.

The third and last part is the manufacturing phase:

In this step, a milling machine with computer assistance and high-quality disks or burs used to cut the restoration from ingots converts the digital data of the restoration into a physical output. This method is referred to as "subtractive method " [26,27].

Devices for milling processing

For the CAM - processing stage, the digitizing data created with a particular CAD software are converted to milling strips and loaded onto the milling machine.

Three milling axes on processing devices can move in three different directions. They use huge solid block subtraction manufacturing technology [23]

a. Three-axis milling:

It moves in three different spatial directions with a degree of movement. It indicated X, Y, and Z values. During the milling process, the component rotates 180 degrees. They can mill from the top or bottom of the stock material but cannot mill undercuts, which is sufficient for regular crown and bridge work.

CNC milling machines, for instance [23, 28].

b. Four-axis milling:

The machine may move in all four directions at once. Its indicated X, Y, and Z as well as the tension bridge's ability to rotate during work without any restrictions makes it simple to regulate bridge construction with a long displacement in a vertical direction into the customary mold dimension.

For instance, Wieland-Imes and Zeno [23].

b. Five-axis milling:

This technique allows for complicated geometries with milled subsections in addition to the three spatial dimensions and the rotating tension bridge. As an illustration, Everest Engine [23].

One kind of CAD/CAM system is

1. chair-side production/office-based equipment.
2. Manufacturing in a lab.
3. Consolidated output in a centre of industry [28].

Chair-side production:

The patient's chair is where dental restorations are made. Digitalization tools take the place of a traditional impression. The four currently available digital impression products are iTero (Cadent, Carlstadt, NJ, USA), E4D Dentist (D4D Technologies, Richardson, TX, USA), Lava COS (3M ESPE, St Paul, MN, USA), and CEREC AC (Sirona, Charlotte, NC, USA). Red light laser reflection off of the tooth structure is used to reserve the ED4 [D4D TECH] captures. In-office design and milling can be combined with CEREC and E4D devices [29,30]. By using a LAVA Chairside oral scanner continuously transmit a video of the teeth, it adopts an entirely different methodology. For the cameras to record the topography, LAVA and CEREC uses powder [31].

Advantages: It provides the patient indirectly constructed restorations in a single session and cuts down on chair side time.

Laboratory Production

This type of production follows the same [comparable] operating sequence as the conventional production between the dentist and the laboratory. The dentist sends the impression to the lab, which creates a master cast first. The final CAD/CAM production stages are completed entirely in the lab. Software for dental design processes three-dimensional data with the aid of a scanner. Following the CAD procedure, the data is transported to a specialized milling machine, which generates a fit of the framework that can be assessed and adjusted using the master cast [32].

Advantages: The final restoration will perfectly resemble the temporary [29].

Centralized Production

'Satellite scanners' are utilized in the dental laboratory to connect with the production centre online for centralized production. Data sets are created and transferred to the production centre from the dental laboratory. The prosthesis is then sent to the lab by the production centre. As a result, steps 1 and 2 of dental laboratory production take place while step 3 occurs in the middle.

Benefits: Lower cost and increased fabrication efficiency.

CAD/CAM in prosthetic dentistry

1.CAD/CAM technology in implant Prosthodontics:

Biocompatible materials with sufficient mechanical qualities are employed for implant abutments in implant prosthodontics [33]. (CAD/CAM) produced user abutments are created to achieve accuracy and precision. Primary abutments are made from commercially pure titanium using automated milling technology [34].

Advantages include being made of titanium, having precise emergence profiles, absolute coronal preparation, a 6° inclined implant axis, and being fashioned like a natural tooth. They also reduce chair time. The majority of the benefits of stock are present in bespoke CAD/CAM abutments, along with enhanced biocompatibility and the finest possible interaction with implant fixture [35].

2.CAD/CAM technology in Removable Prosthodontics:

Using CAD-CAM software, an impression is scanned or an intra-oral scanner or digitiser is used to create a 3D virtual model of a cast partial denture, which is then milled out to provide the final product with accurate and precise details. Cast partial dentures can be made using Co-Cr alloys, commercially pure titanium, and Ti-6Al-4V alloy by applying CAD-CAM technologies. William et al. show a technique for fabricating a detachable partial denture framework utilizing CAD/CAM technologies [36,37]. The photo polymeric framework is printed and then scanned in a lab scanner to create the framework design, which is drawn on the working cast. The photo polymeric framework is printed and then scanned in a lab scanner to create the framework design, which is drawn on the working cast. Through a process called Direct Metal Laser Sintering, the framework can be produced entirely from chromium-cobalt [38].

3. The use of CAD/CAM in fixed prosthodontics:

Data is recorded using a scanner and the Chair-side Economical Restoration of Aesthetic Ceramic [CEREC] equipment in a lab used to design and create 3D restorations. A ceramic ingot is being milled by two diamonds in a milling chamber. For precise and correct prosthetics, porcelain build-up is accomplished through visually beautiful repair.

Advantage: Cut down on chair side time [39, 40].

4. The use of CAD/CAM in maxillofacial prosthodontics:

A resin model is created using the lithographic technique, after which a wax pattern is created. Following this, a computer-aided milling machine completes the three-dimensional imaging. Data is entered into a computer and the prosthesis is machined. Using this technique, silicone maxillofacial prostheses are created [41].

5.The use of CAD/CAM technology in the creation of removable complete dentures:

CAD/CAM has become a novel method for creating entire dentures [42,43]. Han et al. explained in 2017 that software was used to analyse models and occlusal information to create entire dentures. Clinical operations and a prototype 3-dimensional artificial tooth arrangement software show that CAD programs have advanced as a result of the practical arrangement of artificial teeth in CAD CAM complete dentures [44].

6. Using CAD/CAM to create surgical guidelines for implant placement:

Conventional surgical guides were employed as a control for the manual inspection of implant axis deviation. Bibb et al. described the stainless-steel surgical guides that were first reported for custom-fitting surgical guides using SLM technology [45,35].

7. Diagnostic Esthetic and Functional Splint (DEFS) in CAD/CAM

The reversible, preventive, and non-invasive nature of DEFS makes it an excellent tool for assessing the restorative validity and patient acceptance of prosthetic rehabilitation. Due of their high resistance and flexibility, polycarbonate and acetal resin are durable options for CAD/CAM creation [46-48].

Advantage: Affordable aesthetics, pleasant function, and rehabilitation of young patients with dental abnormalities [49].

8. Full-mouth rehabilitation using CAD/CAM

During thorough complete-mouth therapy in elderly individuals, adaptation of the occlusal vertical dimension (OVD) frequently presents specific obstacles [50]. Extraoral and intraoral photos were taken to help the dental laboratory worker become familiar with the clinical setting. Casts were created after diagnostic impressions were taken. Using Face Hunter and a transfer fork, a 3D facial scan was produced.

Advantage: Highest level of effectiveness and quality with a low intervention rate [53].

Summary

To improve in accuracy and versality CAD/ACM system has been continued as a part of routine dental practise. Based on the patient demands a combination of both conventional and advancement technologies are practised in upcoming period.

References

1. Tamrakar A, Rathee I, Mallick R *et al*. CAD/CAM IN Prosthodontics - A Futuristic Overview. Annals of Dental Specialty. 2014; 2(1):14-20.
2. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am, 2011, 559-570.
3. Rekow D. Computer-aided design and manufacturing in dentistry: a review of the state of the art. J ProstheticDent. 1987; 58(4):512-516.
4. Srinivasan M, Cantin Y, Mehl A *et al*. CAD/CAM milled removable complete dentures: an *in vitro* evaluation of trueness. 2017; 21(6):2007-2019.
5. Ettinger R, Beck J, Jakobsen J. Removable prosthodontic treatment needs: a survey. Prosthet Dent.1984; 51(3):419-427.

6. Infante L, Yilmaz B, McGlumphy E *et al*. Fabricating complete dentures with CAD/CAM technology. J Prosthet Dentistry. 2014; 111:351-5.
7. Pascu N, Dobrescu T, Opran C *et al*. Realistic scenes in CAD application. Proc Eng. 2014; 69:304-9.
8. E. Bae, I. Jeong, W. Kim, and J. Kim, “A comparative study of additive and subtractive manufacturing for dental restorations,” The Journal of Prosthetic Dentistry, vol. 118, no. 2, pp. 187–193, 2017.
9. H. Lee and K. Kwon, “A CAD-CAM device for preparing guide planes for removable partial dentures: a dental technique,” The Journal of Prosthetic Dentistry, vol. 122, no. 1, pp. 10–13, 2019.
10. Dankwort CW, Weidlich R, Guenther B, et al: Engineers’ CAx education—it’s not only CAD. Comput-Aided Design 2004; 36:1439-1450
11. DuVall NB. Fabricating a chairside CAD-CAM radiographic and surgical guide for dental implants: A dental technique. J Prosthet Dent. 2021 Jan;125(1):34-40. doi: 10.1016/j.prosdent.2019.11.019. Epub 2020 Feb 3. PMID: 32029216.
12. Sheridan RR, Verrett R, Haney S, Schoolfield J. Effect of Split-File Digital Workflow on Crown Margin Adaptation. J Prosthodont. 2017 Jun 9. doi: 10.1111/jopr.12606.
13. Yeung S, Aghvinian R, Aalam AA, Jivraj S. CADCAM approach to designing and fabricating a low-maintenance metal-acrylic resin implantsupported fixed complete dental prosthesis: A clinical report. J Prosthet Dent. 2021 May;125(5):719-722. doi: 10.1016/j.prosdent.2020.04.006. Epub 2020 Jun 20. PMID: 32576372.
14. Christensen GJ: In-offiice CAD/CAM milling of restorations: the future? J Am Dent Assoc 2008; 139:83-85.
15. Williams RJ, Bibb R, Eggbeer D, Collis J. Use of CAD/CAM technology to fabricate a removable partial denture framework. J Prosthet Dent. 2006; 96:96-9.
16. Hughes CW, Page K, Bibb R, Taylor J, Revington P. The custom-made titanium orbital floor prosthesis in reconstruction for orbital floor fractures. Br Oral Maxillofacial Surg. 2003; 41:50-3.
17. Kanazawa M, Inokoshi M, Minakuchi S, Ohbayashi N. Trial of a CAD/CAM system for fabricating complete dentures. Dent Mater J. 2011; 30:93-6.
18. Deran, H, Kumar, V, Seth, J, Sharma, 2014, ‘Computer Aided Milling in Prosthodontics: A Promising Technology for Future’ IJSS Case Report & Reviews, vol. 1, issue 1, pp. 23-7
19. Freedman M, Quinn F, 2007, ‘Sullivan M. Single unit CAD/DAM restorations: a literature review.’ J Irish Dent Assoc, vol. 53, pp. 38-45.
20. Dosi , T, Gupta D, Shetty N, Pagare S, 2014, ‘Advent Or Advancement: Cad/Cam - A Review’ International Journal Of Medical And Applied Sciences, vol 3, issue 2, pp. 168-74
21. Lee C, Alex T. CAD/CAM Dentistry: A new forum for dentist technician Teamwork. Inside Dentistry, Sep 2006: vol 2, Issue 7.
22. AlHelal A. Comparison of retention between milled and conventional denture bases: A clinical study. In: Loma Linda University Electronic Theses, Dissertations, and Projects.55(2)
23. Beuer F, Schweiger J, and Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Brit Dent J.2008 Vol.204 (9):505-511.
24. Tamrakar AK, Rathee M, Mallick R, Dabas S. CAD/CAM in prosthodontics - A futuristic overview . Annals of Dental Specialty.2014; Vol. 2(1):14-15
25. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations F. Beuer, 1 J.

Schweiger and D. Edelhoff British Dental Journal volume 204 No. 9 May 10 2008

26. 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.
27. 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.
28. Dunn DB, Lewis MB. CAD/CAM occlusal splints. A new paradigm. Aust Dent Pract 2011; 22:131.
29. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am, 2011, 559-570.
30. Dwivedi T, Jakhanwal I, Anupama T et al. CAD CAM in Prosthetic Dentistry: A Comprehensive Review. International Journal of Community Health and Medical Research. 2017; 3(2):56-59.
31. Algabri RS, Alqutaibi AY, Abo-Alrejal H, Al-Adashi O, Abdulrahman F. Effect of computer aided design/computer-assisted manufacture versus conventional occlusal splints on the management of temporomandibular disorders: A systemic review and meta-analysis. Int Dent Med J Adv Res 2017;3:1-9
32. Aeran H, Kumar V, Seth J, Sharma A. Computer aided designing–computer aided milling in prosthodontics: A promising technology for future. IJSS Case Reports Reviews 2014;1:23-7.
33. Rasperini G, Maglione M, Cocconcelli P, Simion M. In vivo early plaque formation on pure titanium and ceramic abutments: A comparative microbiological and SEM analysis. Clin Oral Implants Res 1998;9:357–364.
34. Oztürk AN, Inan O, Inan E, Oztürk B. Microtensile bond strength of CAD-CAM and pressed ceramic inlays to dentin. Eur J Dent 2007;1:91-6.
35. Bibb R, Eggbeer D, Evans P et al. Rapid manufacture of custom-fitting surgical guides. Rapid Prototyping Journal 2009; 15(5):346 – 354
36. Miyazaki T, Hotta y. Kunii J, Kuriyama S and Tamaki y. A review of Dental CAD/CAM: Current status and future perspectives from 20 years of experience. Dent Mat J. 2009; 28 (1): 44 56.
37. Sykes LM, Parrott AM, Owen CP *et al*. Applications of rapid prototyping technology in maxillofacial prosthetics. Int. J. Prosthodont 2004;17(4):454-459.The Journal of Prosthetic Dentistry, 89(2):145-160.
38. Alghazzawi T. Advancements in CAD/CAM technology: Options for practical implementation. Journal of prosthodontic researches. 2016; 60:72-84
39. Liu PR. A panorama of dental CAD/CAM restorative systems. Compend Contin Educ Dent 2005;26:507-8, 510, 512.
40. Vander ZelJ ,VlaarS,Ruiter W, Davidson,C, 2001,' The CICERO System for CAD/CAM Fabrication of full ceramic crown' J Prosthet Dent, vol 85,pp-261-6
41. Tamrakar A, Rathee I, Mallick R *et al*. CAD/CAM IN Prosthodontics - A Futuristic Overview. Annals of Dental Specialty. 2014; 2(1):14-20.
42. Infante L, Yilmaz B, McGlumphy E, et al. Fabricating complete dentures with CAD/CAM technology. J Prosthet Dent. 2014; 111:351–355.
43. Bidra AS, Taylor TD, Agar JR. Computeraided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspectives. J Prosthet Dent. 2013;109:361–6.
44. Charles J. Goodacre, Antoanela Garbacea, W. Patrick Naylor, Tony Daher, Christopher B. Marchack, and Jean Lowry. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. J Prosthet Dent. 2012;107:34-46
45. Bibb R, Eggbeer D, Williams RJ. Rapid manufacture of removable partial denture frameworks. Rapid Prototyping Journal 2006; 12(2):95 – 99.
46. Saeidi Pour, R.; Engler, M.L.P.D.; Edelhoff, D.; Prandtner, O.; Frei, S.; Liebermann, A. A patient-

calibrated individual wax-up as an essential tool for planning and creating a patient-oriented treatment concept for pathological tooth wear. Int. J. Esthet. Dent. **2018**, *13*, 476–492

47. Edelhoff, D.; Probst, F.; Ehrenfeld, M.; Prandtner, O.; Schweiger, J.; Liebermann, A. Interdisciplinary full-mouth rehabilitation for redefifining esthetics, function, and orofacial harmony. J. Esthet. Restor. Dent. **2019**, *31*, 179–189.
48. Edelhoff, D.; Stimmelmayr, M.; Schweiger, J.; Ahlers, M.O.; Güth, J.F. Advances in materials and concepts in fifixed prosthodontics: A selection of possible treatment modalities. Br. Dent. J. 2019, *226*, 739–748.
49. Edelhoff, D.; Beuer, F.; Schweiger, J.; Brix, O.; Stimmelmayr, M.; Guth, J.F. CAD/CAM-generated high-density polymer restorations for the pretreatment of complex cases: A case report. Quintessence Int. 2012, *43*, 457–467.
50. IDZ (Institut der Deutschen Zahnärzte). Fünfte Deutsche Mundgesundheitsstudie (DMS V). Deutscher Zahnärzteverlag; 2016.
51. Schweiger J, Guth JF, Edelhoff D, Stumbaum J. Virtual evaluation for CAD-CAM-fabricated complete dentures. J Prosthet Dent. 2017; 117(1):28-33.