Review Article

DOI: 10.7860/JCDR/2023/61740.18005

Digital Dentures- The Future of Complete Dentures in Oral Rehabilitation

Dentistry Section

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ABSTRACT

The conventional method of fabricating Complete Dentures (CDs) consists of many clinical and laboratory steps, making it more susceptible to certain problems and inevitable errors. With the advances in the field of technology, these errors can be avoided or minimised. Digital technology making use of computers for designing and or manufacturing CDs is referred to as digital dentures. In this, entire dentures are made by machining the denture's bases using Computer-Aided Design and Manufacturing (CAD/CAM). Technology's quick development in the form of CAD/CAM has had a significant impact on all areas of dentistry, but notably prosthodontics and restorative dentistry. This system has not only simplified the process of fabrication of CDs but also reduced the clinical chairside time, number of dental appointments and helped to deliver error free dentures. It also helps to store the data in digital form which can be utilised further for fabricating other sets of dentures for that particular patient. The most important advantage over conventional denture is that, it lacks polymerisation shrinkage of the acrylic resin and exhibit high strength. Furthermore, it also eliminates laboratory work time. The provision of prosthodontic treatment requires the patient, a qualified physician, and competent laboratory personnel on various levels. The goal of the current review article was to demonstrate how modern technology may replace the traditional approach not only by making labour easier but, also by enabling precise full denture production.

Keywords: 3-dimensional printing, Conventional denture, Milling

INTRODUCTION

Technology is one of the greatest boons to mankind. It involves the utilisation of scientific knowledge to fabricate, scan and plan or design tools and equipments, that will help to make living easier. Technologies improve the effectiveness of practice management. Additionally, decision making in clinical practice is becoming more and more supported by instructional software and intelligent assistants. Such technologies are used in dentistry and it is called digital dentistry [1,2]. Digital dentistry is a broad word that alludes to the use of computer expertise and information to aid in product design, analysis, and production [3]. Rapid Prototyping (RP) and Computerised Numerical Control (CNC) are two subtractive types of manufacturing that might be produced with this technology machining [4]. By laying down successive layers of the specified material to construct an item, additive manufacturing or printing uses the pictures produced by digital files. While subtractive manufacturing physically removes material to get the desired geometry by cutting or milling using the pictures from a digital file [5]. RP a novel strategy, is now used in the dental field. It is possible to organise the dentition, occlusion, form, angulations, and the flange in various colours using the appropriate design software and hardware [6]. As a result, it is anticipated that soon, medical informatics would create entire dentures for sale rather than laboratory technicians.

Components of CAD/CAM

1. Intraoral scanners: The digital impressions are made by intraoral scanners/cameras. The intraoral cameras are the optical scanners and are available in two types: single image cameras for example, iTero (Align Technology), PlanScan (Plan- meca), CS 3500 (Carestream Dental LLC), and Trios (3 shape) cameras; and the video cameras such as Lava Chairside Oral Scanner (COS), Apollo DI (Sirona) and OmniCam (Sirona) systems. Laboratory scanners are classified into: 1) optical scanners that use the projection of a measuring light grid on the structure to be recorded under a definite angle. The computer calculates the 3-dimentional (3D) data of the dental structure from the image of the depth modulated measuring grid; and 2) mechanical scanners that scan the master cast and obtains the 3D measures. An example is procera scanner from nobel biocare [7].

2. Software for designing virtual restorations: Design softwares are provided by the manufacturer for different types of dental restorations. Designs for coping of Fixed Partial Denture (FPD), full coverage veneer crown, partial veneers, inlays, onlays, temporaries, post and core, pontic designs, FPD, implant FPDs, prosthetically driven implant guides, the framework for removable partial dentures, etc are available in the software. Even different tooth morphologies are also available in the internal digital libraries of this software [8]. However, there is always a need for manual alterations as the morphological features show modifications. Or else, the database of the biogeneric tooth morphology can be used to identify and imitate the individual occlusal morphology of a patient. The CAD model can be seen on the screen of the monitor can be rotated and magnified to assess the critical area and the accuracy before transferring the file to the milling [9].

3. Milling device: Milling is the last phase in the production of restoration by CAD/CAM. In this phase, a restoration is formed from the CAD model into bodily parts by either additive or subtractive method. This body is then finished and polished before being delivered. The most common technology used is CNC machining. CNC uses machine tools that are power-driven to shape the selected material to desire geometry which is guided by the software [5]. The milling units are of two types: 1) dry/wet/milling and grinding in this some specific amount of materials needs dry milling and others need wet milling; or 2) According to the number of axes (3,4 or 5 axes) in this the 4 axes and 5 axes moves up and down in a linear fashion through different axes (X, Y, Z). The main difference is the number of rotations, the block/disc can rotate around X-axes only (A rotation), but in the 5 axes, the block/disc rotates around X-axes (A rotation) and the spindle rotates around Y axes (B rotation) [10]. For example, Direct Metal Laser Sintering (DMLS), Stereolithography

(SLA), scan, spin, and Selectively Photocuring (3SP), polyjet and Direct Light Projection (DLP) are some of the processes used in additive technology [10].

The steps involved in producing CDs using CAD/CAM and RP [11-13]

- An anatomic impression is made with irreversible hydrocolloid impression material of the edentulous arches.
- The impressions are poured in dental stone and primary casts are made. The primary cast is scanned with scanners (3Shape Trios 3 colour scanner).
- Special trays are designed for the final impressions using the software (3Shape Dental System 2016).
- Special Tray is fabricated by rapid prototype by transferring the Standard Tessellation Language (STL) file format to the stereo-lithography CAD software generated by 3D systems. This file is subjected to trays to the 3-dimensional printer software application to attain the printable files.
- Final impressions are made by using ImpregumPenta; 3M European Society for Paediatric Endocrinology (ESPE).
- The master casts are poured and then scanned.
- With rapid prototypes, occlusal rims are also fabricated with baseplates. The design of the baseplates that are created in the STL files are transferred to the 3D printer through the software application for printing with the material of choice.
- The occlusal rims are made by adding hard wax to the base plates.
- The lip support, occlusal plane height and direction, and vertical dimension of occlusion are all noted. The occlusion rims are adapted to record the pertinent details for the tooth arrangement such as lip support, length of the maxillary anteriors, midline, vertical dimension of occlusion and the height of occlusal plane.
- The jaw relationship is recorded and the facial bow is employed for orientation. For the purpose of recording and establishing the centric relation, the ArcusDigma II (KaVo Dental GmbH) is utilised as a virtual articulator. Hard wax is used to support the paraocclusal spoon, which is fitted over the mandibular occlusion rim. As per the suggested procedure and workflow advised by the manufacturer, notes are made over the upper and lower rims occlusally and the centric relation is documented. The recording material is then applied to the occlusal side of the rims' generated notches. Until the material has entirely polymerised, the mandible is positioned into the observed jaw relation and maintained there.
- To align the casts, the definitive castings are put on the occlusion rims, which are then scanned buccally along with the cast bases as a single object. To enhance scanning, little scratches are created on the rims. To improve alignment, notches are carved into the surface of the cast.
- The software (3Shape dental system) is used to organise the design process.
- The procedure is followed when designing the full dentures. The primary workflow steps are, in brief, orienting the occlusal plane, identifying anatomic landmarks, blocking the undercuts, selecting teeth from the available libraries, arranging teeth in accordance with the desired occlusal concept, taking into account the specifics of the occlusion rims, designing and finishing the denture bases. Once the design process is complete, an STL file for the denture bases is generated. During the STL file production process, the CAD application automatically builds sockets for bonding teeth in the denture bases.
- Then, using the STL files as a starting point, the CAM application constructs a comparable project in a 25 mm high poly (methyl methacrylate) block and provides the equivalent output for the specific milling machine.
- Commercially, available teeth are selected during the design process and attached to the milled denture bases using a bonding compound with a methacrylate foundation.

Additive Manufacturing

Additive manufacturing involves 3D printing and laser melting technology and on the other hand [6].

Materials used for CAD-CAM milled dentures by additive manufacturing

- **Polymers:** Traditional provisional materials are divided into dimethacrylates, also known as bis-acryl/composite resins, and monomethacrylates, sometimes known as acrylic resins. Examples of these materials are light-polymerisable urethane dimethacrylate and bisphenol A-glycidyl dimethacrylate [14].
- **Ceramics:** Using zirconia ceramic suspensions, zirconia crowns were manufactured directly with inkjet technology [14].
- **Metals:** The process of making metal based appliances, mostly out of titanium, chrome-cobalt, and other alloys, is known as selective laser sintering [14].

Subtractive Manufacturing

Subtractive manufacturing involves machining and milling and laser ablation technology which is considered to be better than additive manufacturing [6,15].

Materials used for CAD-CAM milled dentures by subtractive manufacturing [16]: The materials used by subtractive manufacturing involves:

- **Waxes:** Wax patterns for different restoration operations are digitally developed and machined, which saves time and money. They are mostly made of acrylate polymers.
- **Poly Methyl Methacrylate (PMMA):** PMMA, a synthetic polymer, is produced by polymerising methyl methacrylate. PMMA is a millable block that may be used for FPDs and long lasting single crowns.
- **Composite resins:** PMMA, a synthetic polymer, is produced by polymerising methyl methacrylate. PMMA is a millable block that may be used for FPDs and long lasting single crowns.
- **Metals:** Due to the absence of miscasting possibilities for the final restoration, chrome-cobalt, titanium, and noble/high noble gold millable metals have been an appealing addition to the CAD/CAM materials.
- **Ceramics:** There are several varieties of millable ceramics for CAD/CAM technology [6].
- Infiltrated ceramics/resins (typically referred to as hybrid ceramics)
- Silicate ceramics:
    - Feldspathic ceramics.
    - Leucite-reinforced ceramics.
    - Lithium disilicate ceramics.
- Oxide or polycrystalline ceramics.
    - Aluminum oxide ceramics.
    - Zirconium oxide ceramics.

- 3 mol% yttria-tetragonal zirconia polycrystals (3Y-TZP).
- 4 mol% yttria-partially stabilised zirconia (4Y-PSZ).
- 5 mol% yttria-partially stabilised zirconia (5Y-PSZ).

Advantages of digital fabrication of CDs

- There are fewer appointments needed.
- The milling of prepolymerised acrylic resin increases the strength and adaptability of the dentures by causing the acrylic foundation to contract.

- Decrease in the risk of infection.
- Using the digital information that has been recorded, it is simple to fabricate the denture and make a trial denture.
- Superior clinical and technical quality control [7].

Disadvantages of digital fabrication of CDs

- Cost expensive.
- Patients' comfort-Direct sensors are hard and sometimes thick and not flexible.
- The trial insertion appointment is missing.
- The basis for dentures and artificial teeth can be milled using blocks with varying hues and desired qualities. Both, a high abrasion resistance and an attractive look are required for artificial teeth. Cutting fake teeth from a monoblock is challenging. Therefore, just the base of the denture is cut from the milling blocks, and the fake teeth are then glued to the bases of the dentures.
- Manufacturing challenge caused during impression making, recording occlusal vertical dimensions, and maintenance of lip support, as faced in the procedures used in the conventional process [17].

Limitation(s) of CAD/CAM Technology

The intraoral camera records the structure that is visible to the camera lens. The margins masked by blood, saliva, and/or soft tissues are not recorded accurately. Additive technology of CAD/CAM makes use of polymeric and metallic materials and not ceramics. Digital impressions are less accurate for the complete arch than conventional. The zirconia frameworks have a less accurate fit for CD prosthesis [4,6].

Clinical performance and patient-related outcomes for digital complete denture

Giving patients greater treatment options is one of the key aims of integrating modern technologies into dental practices. Few clinical research have been done using small sample sizes, especially on milled digital dentures, either as case reports or as pilot prospective cohorts [4]. Digital CDs made from pre-polymerised resin retain their shape substantially better than traditional dentures [18]. The aesthetics of digital dentures continue to be a barrier when compared to the clinical outcomes of traditional dentures [19]. Studies have shown that, upon relining, more adjustment sessions were needed than predicted by the makers (up to 40% of the digital dentures) [14,16]. The less consultations needed for the fabrication as additionally, the positive early outcomes have improved the public's image of the use of a 3D-printed complete set of dentures was given to 35 totally edentulous individuals in a prospective clinical investigation [20]. The analysis was done in three appointments using a limited amount of digital workflow. The initial and final functional impressions were performed during the first and second sessions, documentation of the maxillo-mandibular relationship, and tooth selection done [20]. After that, the moulds are filled, and then the teeth are designed and set-up using a computer programme, which increases the productivity of the process and yields superior results. A sophisticated nano-composite and digital light projection manufacturing were used to construct the whole dental prosthesis. With the aid of two skilled prosthodontists, the authors evaluated stability and retention after the placement of dentures at various time intervals using the modified Kapur index. They found a significant improvement in denture stability and retention (p-value=0.05). A statistically significant improvement in satisfaction was seen in the QoL included into oral health [20].

Wang C et al., conducted a systematic review and found that, the majority of investigations revealed occlusal trueness and adaptability of digital CDs with clinically acceptable values [21]. The highest mismatch of the intaglio surface was reported in the posterior palatal seal area and border seal area, and the digital CDs demonstrated similar or better adaptability than conventionally produced discs. In terms of denture correctness, the fabrication method, CAD-CAM system, and long-term service were statistically significant. Clarification is required regarding the factors related to the CAD-CAM process, the analytical approach, and the statistical indicators, as well as, the accuracy of digital discs according to the cast's shape. Regarding the superiority of CAD-CAM milling and 3D printing with relation to denture precision, no conclusive conclusions can be drawn [21]. Kang YJ et al., did a randomised, single-blinded cross-over clinical trial to evaluate of digitally fabricated CDs versus conventional CDs. They found that in terms of masticatory effectiveness and pronunciation, the digital CDs performed worse than the traditional CDs. Internal adaption and overall patient satisfaction, however, were comparable between analogue and digital CDs. This finding shows that, at the very least for temporary use, intraoral scans and CDs made using additive manufacturing may be appropriate for edentulous patients [22]. Zupancic Cepic L et al., did a prospective, randomised cross-over study on clinical efficiency and patient satisfaction towards digital versus conventional dentures [23]. They discovered a tendency towards digital dentures being more clinically effective than traditional dentures, whereas, the type of manufacture had no bearing on patient happiness.

CONCLUSION(S)

The introduction of digital technology in CD fabrication has streamlined and simplified the treatment process. Design softwares that are used in digital dentures are relatively efficient in standardising the clinical results that helps in improving the current workflow. Proper knowledge and skills to use these tools will aid in developing better dentures within less clinical time and appointments. However, further clinical research is still required before drawing firm findings.

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AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Nov 23, 2022
- Manual Googling: Feb 21, 2023
- iThenticate Software: Mar 02, 2023 (13%)

ETYMOLOGY: Author Origin

Date of Submission: **Nov 22, 2022**
Date of Peer Review: **Jan 09, 2023**
Date of Acceptance: **Apr 18, 2023**
Date of Publishing: **May 01, 2023**