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Digital dentures - A review

[1]Dr. D. K. Prasanna, Department of Prosthodontics and Crown & Bridge, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

[2]Dr. Y. Siva Kiran Babu, Department of Prosthodontics and Crown & Bridge, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

[3]Dr. A. Venkat Reddy, Department of Prosthodontics and Crown & Bridge, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

[4]Dr. Sitaram Prasad Kasina, Department of Prosthodontics and Crown & Bridge, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

Corresponding Author: Dr. D. K. Prasanna, Department of Prosthodontics and Crown & Bridge, St. Joseph Dental College, Duggirala, Eluru, Andhra Pradesh, India.

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Abstract

Modern dental practice implies an increased application of information and communication technologies with endless options for preserving oral and stomatognathic health. There are numerous advantages to facilitate the work of the dentist, but also patients that are becoming more demanding in terms of aesthetics, with the clearly expressed desire for the minimum of staying and delaying in the dental office. The use of digital technology to fabricate dental restoration and prostheses minimizes clinician effort, laboratory time, materials and expenses.

A whole new revolution of digital dentistry started its journey after Francois Duret develop a dental CAD/CAM device in 1983 and first demonstrated its action at the International Congress of the French Dental Association in November 1985. From then until now various digital advancements which include CAD/CAM, digital radiography, digital smile designing, digital face bows and virtual articulators, digital occlusion and TMJ analysis and digital photography have been developed.

With the advent of digital dentistry the diagnosis or record keeping has been made easy with the help of digital x-rays and intraoral cameras. In addition, the procurement of measurements and data which are pertinent to the fabrication of the prosthesis have been made feasible with the CBCT, and 3D capture of data, either by scanning a cast or by direct intraoral scanning thereby making CAD/CAM procedures like rapid prototyping a reality.

Keywords: Dentures, Impression, CAD CAM

Introduction

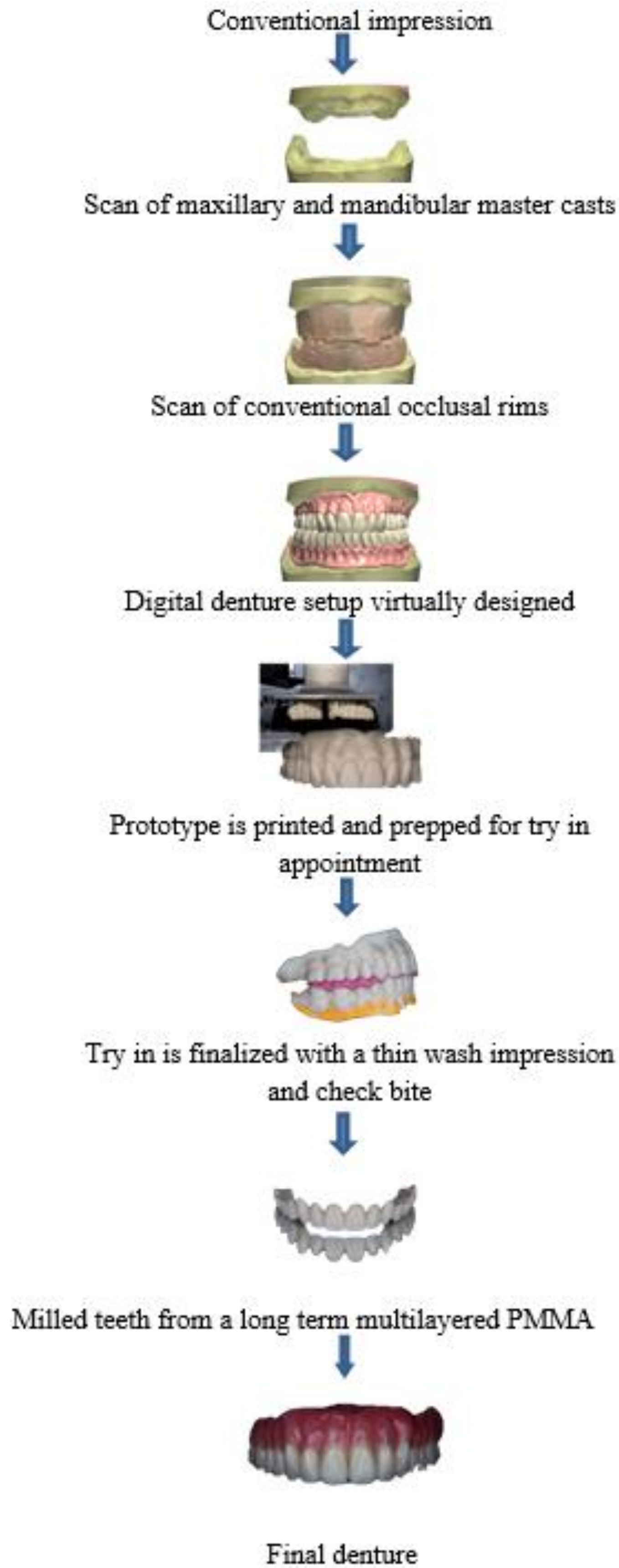
Nowadays, the CAD CAM technology became one of the most important developments happened in the dental field at the twenty-one century. The manufacturing of dental restorations and devices using CAD CAM subtractive behaviour was successful in many situations and so used widely in tooth or implant-supported fixed prosthodontics and operative dentistry.

Further, the additive rapid prototyping technologies can fabricate organic complex configurations which were very difficult to be milled with subtractive method. Consequently, it is suitable for human anatomy structures and highly-detailed prosthetic appliances such as removable partial denture, complete denture, maxillofacial prosthesis and implant surgical guide stents. This innovative method relied on what is called “Layered manufacturing” where a 3D standard triangulation language (STL) file of an object decomposed into cross-sectional layer representations and then an automated fabrication machine will receive the numerical inputs of these configurations to form the prototype. In this way, additive methods are more advantageous and many problems, usually accompanied by milling, can be easily overcome. The ability of the additive prototyping technique is to create minor details such as undercuts, voids, and complex internal geometries which are lack even in milling machines with multiple-axes.

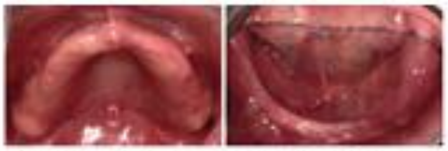
Techniques for fabrication

a) Complete denture

Digital denture work flow 01



Digital denture work flow -02



Preoperative conditions. A, Maxilla. B, Mandible

Occlusal records. A, Occlusion rims with hard wax mounted on 3D-printed baseplates.
B, Adapted occlusion rims register occlusal plane and other information needed for tooth arrangement.

Frontal view of scanned casts and occlusion rim alignment.

Digital workflow for denture design. A, Setting occlusal plane: lateral view of aligned casts and occlusion rims. B, Tooth selection and proposal for tooth arrangement. C, Tooth position can be modified according to information integrated in occlusion rims. D, Software proposal for denture base design.

A, Definitive denture design. B, Clinical evaluation of trial dentures. C, Definitive dentures delivered to patient.

First method

The ultimate goal is to make definitive edentulous impressions that will capture the edentulous ridges and borders along with functional soft tissue. Additionally, the impressions should record muscular and phonetic positions suitable for placing prosthetic denture teeth digitally.

Mandibular impression making

The mandibular edentulous impressions can be made by using either a custom tray or a stock tray that can be molded to conform to the shape of each patient's arch and provide the required border extensions. A medium-body and a light-body poly vinyl siloxane impression material is used to complete the impression. An accompanying neutral zone impression is made on the occlusal surface of the tray by removing impression material that may have extended onto the tray's occlusal surface and coated with adhesive. Medium-body vinyl polysiloxane impression material is then dispensed along the entire occlusal surface of the tray, from each retromolar pad area of the tray to the handle, at a vertical height sufficient to reach the level of the canter of the retromolar pads bilaterally and patient is instructed to do all the movements of tongue, lips, cheeks.

Mandibular anterior tooth positioning impression

Impression material adhesive is applied and medium-body impression material is dispensed over this exposed anterior region. As soon as the patient finishes pronouncing the word "Christmas," the lower lip is pulled anteriorly away from the impression material and the tray removed so the anterior material can polymerize without being displaced by the lower lip. Production of the sounds required forming the letters, "Q" and "U", and saying the word, "Christmas," activates the muscles of the chin to form the mandibular anterior denture base.

Maxillary impression making

Maxillary edentulous impressions also can be made with either a custom or stock impression tray. The maxillary impression is made so as to accurately record the edentulous ridge morphology and the border extensions. On the facial surface of the tray, the light-body impression material should be extended as far as possible occlusally beyond the flanges by muscular and manipulative movements made during the border molding. It is through this process that the tissue contacting facial surfaces of the denture are formed. The morphology of the palate is recorded by placing medium-body vinyl polysiloxane impression material onto the cameo surface of the palate, replacing the impression intraorally, and instructing the patient to pronounce few words. The lingual alveolar consonants are examples of key sounds that can be used to record palatal morphology. Additionally, because it has been proposed that single word tests are not reliable when assessing phonetics, sentences should be read aloud by the patient covering the range of sibilants (/s/, /z/, /sh/, /zh/, /ch/, and /j/) and other sounds that produce contact between the tongue and palate.

Maxillary anterior tooth positioning

The faciolingual and incisocervical locations of the maxillary anterior prosthetic teeth have traditionally been determined by using tooth visibility and lip support. Phonetics and the lip position at rest also can be used to help identify the area where denture teeth can be appropriately located. While pronouncing the word "thank", the tongue molds the lingual aspect of the impression material and helps to locate the approximate faciolingual position of the lingual surfaces of the anterior teeth. Pronouncing the letter, "V", helps to identify the incisal length of the impression material and thereby establishes the approximate location of the incisal edge of the maxillary central incisors.

Occlusal vertical dimension, tooth positioning, and interocclusal records

The maxillary and mandibular impressions are used as record bases to establish the occlusal vertical dimension and make interocclusal records. Following complete closure without interference between the 2 impressions, a scalpel is used to create notches in the impression material. The maxillary impression is placed intraorally so the midline can be marked on the impression with a permanent marker and the buccal corridor space can be assessed. By using the impressions as record bases-wax rims, the ppreviously selected maxillary anterior teeth are arranged in the impression and the tooth size, form, and colour verified. Facial and lingual putty indices of the form of the maxillary anterior phonetic impression can be made for use as guides in arranging the anterior teeth. A vinyl polysiloxane interocclusal record material is injected intraorally so it can flow into the notched occlusal surfaces and around the teeth. The patient's mandible is then immediately guided to its retruded contact position, and the mandible is closed to the appropriate occlusal vertical dimension. At this stage, the impressions and interocclusal record are scanned, the teeth arranged virtually in the scanned impressions, and the surfaces of the bases refined in the computer. The resulting data is then exported to a milling machine for fabrication of the dentures.

Second technique

Select thermoplastic moldable trays depending upon the size of residual ridge. Initially, border the mold with heavy-body material and make the definitive impression with a regular-set light-body Material to create a cast. Choose the correct size anatomic measuring device by using the calliper to measure the widest part of the residual ridge. With the existing dentures in the mouth, assess the occlusal vertical dimension and rest position. Place both AMDs into the mouth and attach the ruler. Align the ruler parallel to the interpupillary line and record the angle that will be used to correlate the completed AMD to the virtual mounting with software algorithms. Guide the patient's mandible back and trace lateral, anterior, and posterior excursions on the mandibular tray with the bearing pin to create the Gothic arch tracing. Stabilize the AMD by liberally injecting maxillomandibular relationship record material into the area between the maxillary and mandibular AMD trays. Once the proper transparent guide is chosen, establish the desired gingival height and mark it on the prescription. Mark the midline and incisal edge for the anterior teeth on the lip support. Place composite resin onto the transparent guide and adhere this to the lip support. With the AMD in the mouth, verify the esthetics and OVD. Send both the completed impressions and the final AMD to the laboratory for fabrication of the dentures.

B) Removable partial denture

The cast was fixed on the scanner table and was scanned using desktop structured-light 3D scanner. The 3D model was aligned and the polygon mesh was tuned automatically. Finally, the 3D model was exported as STL file format. Model was imported to reverse engineering software and the path of insertion of the RPD was selected through anterior tilting of the 3D model in the sagittal plane. The model view was then shifted to top view where the entire model undercut areas became invisible.

A pen-tablet was used as an input device to facilitate designing process. Using the trim with curve tool, simplified shaped-saddles were drawn by 0.5 mm. All connectors were then offset outside the model by 0.25 mm to represent connectors' relief. The next step was converting the surface components into a solid volume. The surfaces were thickened by shell tool to form 2 mm thickness in outside direction. The RPD framework was formed but with sharp angles (90˚) at peripheries. The production process started by 3D printing machine. The CO_2 laser type generated framework from polymer power at 70 watt to sinter the polymer into a solid form with layer-by-layer sequence.

All procedures used were simple and did not require experienced operator. In addition, the whole steps were time saving and reduce overall materials consumed during RPD framework production. If a 3D printing service was used, the cost of the RPD prepared from 3D printed framework was approximately equal to those prepared by conventional technique. It should be noted also that 3D printing technology is much cheaper than other rapidly prototyping techniques. The use of digital surveying was a simple, fast, and precisely determined operation. The role of surveyor and conventional tools like analysing rod, carbon marker, and wax trimmer were combined into two simple steps; selecting undercuts and blocking them with flat surfaces. Another recommendation is fully digitizing the RPD framework production by the use of direct laser sintering technique (DLS). Although DLS technique will be timesaving, it will add more cost to the outcome. Currently, prototyping using metal powders using Titanium, Chromium Cobalt, and Stainless steel are available for rapid prototyping technology.

Advantages of digital dentures

- Saves time and one visit for in-office systems
- Avoid the need for gag- induced impressions
- Cross-infection control
- An optimal occlusal scheme can be developed with only minimal adjustments.

- Patients no longer need to have provisional restorations, which take time to fabricate and fit
- Quality is extremely high because measurements and fabrication are so precise
- Reduced number of patient visits, which is especially beneficial to elderly patients
- Superior strength and fit of dentures due to use of prepolymerized acrylic resin blocks for milling.
- Reduced potential for dentures to harbour microorganisms and minimize resultant infections.
- Complete denture therapy is a non-invasive and reversible form of intervention.
- Reduced cost for the patient
- Easily reproducible (creation of duplicate dentures) due to stored digital data.
- Improved potential for standardization in clinical research on complete dentures as well as implant-retained overdentures
- Elimination of waxing steps in removable partial denture fabrication; and thus reduces the potential for errors resulting in better quality control in the dental lab.
- The determination of RPD insertion axis is automatic, and the identification of retentive areas is rapid, reducing the preparation time for the removable prosthesis.
- Decreased duration of prosthesis manipulation.
- Less manual working steps
- Less interruptions in the working process
- One-set aligned artificial tooth design may increase the acrylic's durability
- Quicker model analysis and faster set-ups
- Higher stability and therefore less fracturing due to the tooth segments
- Adaptation of CAD/CAM complete dentures to underlying tissue is good
- The micro-porosity is also reduced because the dentures are milled from the pre-polymerized PMMA (polymethyl methacrylate) acrylic resin blocks.
- The quality of dental prostheses has improved significantly by means of standardised production processes.

Disadvantages of digital dentures

- Lack of opportunity for clinicians and patients to evaluate a trial denture intraorally by few manufacturers like Avadent.
- Digital equipment is very expensive
- Trained operator is required to operate and maintain the device
- Good and up to date laboratory support is required
- Those with small mouth may have difficulty with this procedure
- The initial cost of the equipment and software is high, and the practitioner needs to spend time and money on training
- Dentists without a large enough volume of restorations will have a difficult time making their investment pay off
- Digital scanning requires the same type of soft-tissue management, retraction, moisture control, and hemostasis that is so important for conventional impressions
- CAD CAM technology does not replace the need for skilled dental laboratory technicians
- Lack of opportunity for clinicians and patients to evaluate a trial denture intraorally
- No long-term studies on the durability of the restorations
- The limitations and disadvantages of the current commercial systems are that optimally assessing OVD,

MMR, lip support, and maxillary incisal edge position is challenging; establishing the mandibular occlusal plane is impossible

- Manufacturing challenge caused by impression-taking and OVD-recording procedures, MMR transfer, and maintenance of lip support, which are all similar to the procedures used in the conventional processs

Conclusion

The Contemporary digitally enhanced dental practice has endless options for preserving oral health and provides next to natural aesthetics with an enhanced approach, reduced treatment time, minimized error potential and better-quality assurance. These reasons rightly explain present day dentistry being called golden age of dentistry. Dental restorations produced with computer assistance have become more common in recent years. Most dental companies have access to CAD/CAM procedures, either in the dental practice, the dental laboratory or in the form of production centres. As a result of continual developments in computer hardware and software, new methods of production and new treatment concepts are to be expected, which will enable an additional reduction in costs. Savings in time and labour have the potential to reduce costs, and the promise of faster, high-quality restorations should appeal to patients.

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