Digital Dentures

Course Author(s): Swati Ahuja, BDS, MDS
CE Credits: 2 hours
Intended Audience: Dentists, Dental Hygienists, Dental Assistants, Dental Students, Dental Hygiene Students, Dental Assistant Students
Date Course Online: 06/02/2023
Last Revision Date: NA
Course Expiration Date: 06/01/2026
Cost: Free
Method: Self-instructional
AGD Subject Code(s): 670

Online Course: *www.dentalcare.com/en-us/ce-courses/ce662*

Conflict of Interest Disclosure Statement

- Dr. Ahuja reports no conflicts of interest associated with this course. She has no relevant financial relationships to disclose.

Short Description

Digital denture fabrication has undergone several improvements in the last decade. The purpose of this course is to review this technology, including advantages and disadvantages, and how to incorporate traditional records with various fabrication techniques.

Course Contents

Overview

Digital denture fabrication has undergone several improvements in the last decade. The purpose of this course is to review this technology, including advantages and disadvantages, and how to incorporate traditional records with various fabrication techniques.

Learning Objectives

Upon completion of this course, the dental professional should be able to:

- Understand the advantages and disadvantages of digital dentures.
- Learn to incorporate traditional records with CAD-CAM technology.
- Learn various methods/techniques of fabrication of digital dentures.
- Understand the differences between the milled and printed prosthesis.
- Understand the applications of digital dentures.

Introduction

Computer-aided design and computer-aided manufacturing (CAD-CAM) /Digital complete dentures are now considered to be a great alternative to conventional complete dentures.[1] The technology has undergone several improvements in the last decade leading to an exponential increase in the number of providers and systems available in the market today. CAD-CAM complete dentures can utilize materials with improved properties compared to conventional dentures. Several studies have reported very high levels of patient satisfaction with CAD-CAM dentures. CAD-CAM dentures can be fabricated in a fewer number of appointments and have a superior fit. Hence, they are extremely beneficial in nursing home patients and medically compromised patients who are not able to make multiple visits to the practitioners.[1] The digital data acquired through the process can be used for the rapid future fabrication of spare or replacement dentures when needed.[1]

Digital dentures (milled or printed) may be fabricated using a fully digital protocol (intraoral scanning of hard and soft tissues) or a combination of conventional and digital fabrication techniques (conventional impressions, maxillo-mandibular records, and digital designing and fabrication of the prosthesis). Currently, the majority of clinical studies utilize a combination of conventional impressions and maxillomandibular relationship procedures with digital processing and fabrication techniques for digital denture fabrication.[1] The armamentarium required for the registration of various records, the software, and the training needed prior to using a system varies from one system to another. Initially, it was imperative to buy the trays, materials, and equipment compatible with that system as well as fabricate the prostheses through the specific manufacturer (closed system). However, with the continuous advancements in this field, several open digital systems have emerged. These systems permit the practitioner to use their trays/instruments for impressions and records and send them

to the manufacturer/laboratory for scanning, designing, and fabrication of digital prostheses. They also permit in-house fabrication of the prostheses when the armamentarium is available in the clinical setting. The open systems provide great flexibility and also help reduce the overall treatment cost.

Conventional Complete Dentures

Complete dentures (Figures 1, 2) aid in maintaining phonetics, aesthetics, and occlusal support in edentulous patients.2 However, there are several limitations associated with conventional complete dentures. The fabrication process involves several clinical appointments (a minimum of 5-6 for fabrication and more for adjustments) thereby resulting in high treatment costs.[1,3] It also involves complex laboratory procedures that require substantial human intervention and extensive material manipulation thereby affecting the turnaround time, accuracy, and expenses.[3,4] If the patient were to lose his/her denture it is impossible to quickly fabricate the same prostheses, as the entire process needs to be repeated.

There are also several reported disadvantages associated with conventionally processed polymethylmethacrylate (PMMA) materials including increased polymerization shrinkage, susceptibility to microbial adhesion, radiolucency (lack of radio-opacity), allergic potential, and degradation of the mechanical properties of the material over time.[5]

Figure 1. Conventional Complete Dentures
Images Courtesy of Dr. Goodacre

Digital Complete Dentures

Computer-aided design and computer-aided manufacturing (CAD-CAM) technology has been successfully used for the fabrication of fixed prostheses for the last two decades.[4] However, the application of this technology to the fabrication of removable complete dentures has only recently come to light.[4] The first attempt at fabricating a computer-aided-designed-computer-aided-manufactured (CAD-CAM) complete removable dental prosthesis was initiated by Maeda et al. in 1994,[6] however, a detailed overview of the technique and concept was not available until 2012.[7]

Initially, digital dentures were considerably more expensive to fabricate than conventional complete dentures.[8-10] This was in part associated with the closed format of the digital denture fabrication process; there were very few systems/manufacturers available, and it was imperative to buy the trays, materials, and equipment compatible with that system as well as fabricate the prostheses through the specific manufacturer (closed system). Since the last decade, there have been several advances in the technology of digital denture fabrication, a rapid increase in the number of providers, and the development of open digital systems. These systems also permit the in-house fabrication of digital dentures when the milling machines/ printers are available in dental clinics.[11]

Digital dentures are suitable for all skeletal relationships.[12] Digital complete dentures

Figure 2. Digital Complete Dentures - designed and fabricated using CAD-CAM technology.

have superior material properties and several studies have reported very high levels of patient satisfaction with them.[13] The advantages and disadvantages of digital dentures are listed below:

Advantages:[1]

1. *Fewer clinical visits:*[1,13] The fabrication of digital complete dental prostheses requires a fewer number of clinical steps compared to conventional complete dentures; It is possible to record all the clinical information in one appointment and place the CAD-CAM dentures at the next appointment.

2. *Simplified and reduced laboratory steps:* The laboratory procedures are greatly reduced and simplified as the arduous task of teeth setting and denture processing are accomplished with CAD-CAM technology.[1,13,14]

3. *Superior retention and fit:* Digital complete dentures are reported to have superior retention and fit compared to conventional complete dentures due to minimal fabrication distortion.[15]

4. *Lower incidence of sore spots:* As the digital dentures are milled from a prepolymerized block of acrylic resin, there is reduced polymerization shrinkage and a lower incidence of sore spots and microbial colonization.[16]

5. *Superior physical and mechanical properties:* Digital complete dentures are reported to have superior physical and mechanical properties compared to conventional complete dental prostheses thereby permitting the fabrication of digital denture bases with a reduced thickness.[14,15]

6. *Minimal denture tooth movement:* Digital fabrication results in minimal denture tooth movement thereby decreasing the need for repeated occlusal adjustments.[17]

7. *Try-in:* Digital technology can be used to print a trial prosthesis that can be used to evaluate the aesthetic and function prior to its finalization.[1]

8. *Rapid fabrication of a spare/new prosthesis:* Fabrication of digital prostheses helps generate a repository of digital data which enables rapid fabrication of a spare or new prosthesis, without any clinical appointments.[14] This reproducibility is particularly helpful for patients who are medically debilitated and cannot visit the dental office. The new replacement denture will have the exact form as the previous denture thereby facilitating quick patient adaptation.

9. *Cost:* The cost of a digital complete dental prosthesis eventually turns out to be less than the cost of a conventional acrylic complete dental prosthesis as the number of clinical appointments and laboratory procedures are significantly reduced.[4,13,15]

10. *Standardization and quality control:* Digital dentures may permit improved standardization in clinical research and quality control on complete dentures as well as implant-retained overdentures.

Disdvantages:

1. Specialized clinical training required: Fabrication of digital complete dental prostheses requires specialized clinical training and there is a learning curve attached to it.[14]

2. Time: Dental practitioners need to invest considerable time in the planning, laboratory communication, and execution of digital complete dental prostheses.[14] However, experience with this new technology may help speed up these procedures.

3. Compromised esthetics: When the try-in procedure is eliminated, it precludes the assessment of the esthetics, phonetics, and occlusion prior to the fabrication of the definitive prostheses. This may result in patient dissatisfaction and failure of the treatment rendered.[13]

4. Bond between the artificial teeth and the denture base: There is a concern regarding

the bond between the artificial teeth and the prepolymerized denture base being sub-optimal.[18] Milling/printing the denture as a single unit (along with the artificial teeth) helps circumvent this problem.[19]

Use of Intraoral Scanners in Digital Denture Fabrication

Recently, few preliminary studies have suggested using intraoral scanners (IOS) for recording the denture-bearing tissues of edentulous patients.[20-24] The listed advantages of IOSs include the capability of registering a truly mucostatic (no pressure) impression, decreased patient discomfort, elimination of stresses associated with impression deformation, and efficient space utilization.[21] However, the scan accuracy is affected by the length and distribution of the edentulous area, the skill of the operator, and the size of the IOS tip.[20-24] Other limitations of this technology include the following:[20-25]

- Inaccurate registration of highly mobile tissues as the software deletes the areas that are not steady over time thereby making it impossible to incorporate functional movements.[22]
- Challenge to capture the borders in a consistent and reproducible way
- Inability to use various methodologies of impression-making such as pressure, selective pressure, or minimal pressure
- Difficulty in assessing the compressibility of the oral mucosa
- The complexity of recording the mandibular edentulous arch due to the movements of the tongue
- The challenge associated with aligning scans of edentulous arches in the correct relation to each other

Though there are a few practitioners who can successfully use the IOS for recording denture-bearing tissues of edentulous patients (Figure 3), most still need to use conventional impressions until there are further advancements in this technology.[20-24]

Methodology of Digital Denture Fabrication

Digital dentures may be fabricated using a completely digital protocol or a combination of conventional and digital fabrication methods.[26]

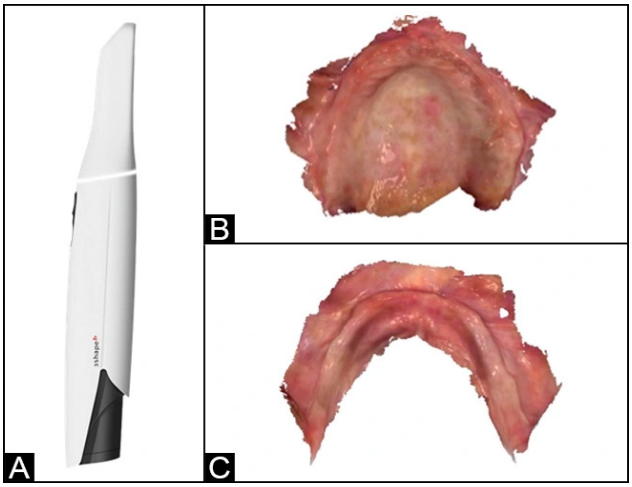

Figure 3. (A) Intraoral scanner **(B)** Scanned image of the maxillary edentulous arch **(C)** Scanned image of the mandibular edentulous arch (Lower right image)

Image A obtained from 3shape.com

However, it is challenging to digitally register the interocclusal records and the functional impressions, thus the full digital workflow for complete denture rehabilitation remains questionable.[20-25]

A combination of conventional impressions and maxillomandibular relationship recording procedures with digital designing, production, and processing techniques helps fabricate predictable prostheses.[1] The armamentarium, the records, the software, and the training varies from one system to another. However, using a system that permits the practitioner to use their trays/instruments for impressions and records (an open digital system) which can then be sent to the manufacturer/laboratory for scanning, designing, and fabrication of digital prostheses provides flexibility and helps reduce the overall treatment cost.[27]

Digital Denture Fabrication

Three basic steps for digital denture fabrication include data acquisition, data processing (designing), and prosthesis manufacturing.[28]

- *Data acquisition:* The data may be registered using an intra-oral scanner (IOS) in the dental practitioner's office that helps acquire the information directly from the patient's oral cavity or by making conventional impressions

(or master casts) and records. The conventional impressions (or master casts)/ records are then sent to the laboratory where they are scanned using extra-oral scanners. The data acquired from the IOS is electronically sent to the laboratories.

- *Data processing:* Data processing is accomplished using reverse engineering and computer-aided designing (CAD) software programs.
- *Prosthesis manufacturing:* The prosthesis may be manufactured through the subtractive or additive method. With the subtractive method, the denture base is milled from a prepolymerized resin block while additive manufacturing, also known as 3-dimensional (3D) printing comprises of techniques that fabricate the prosthesis layer by layer.

Figure 4. Miller Denture Base
Images Courtesy of Dr. Goodacre

Milling

Milling is the most popular method of fabricating digital dentures. Once the design of the prosthesis is approved, the CAD stereolithography (STL) file is sent to a milling software that directs the milling machine to perform a series of movements. The artificial teeth may be either milled with the prosthesis (monolithic) or milled individually or as a complete arch in tooth shade material, or selected from a prefabricated series and bonded to the milled denture base (Figures 4 & 5).[29]

Monolithic dentures are resistant to staining. They also help alleviate the concern of debonding of the teeth from the denture base, however, the prostheses may have a monochromatic appearance with a not-as-favorable esthetic outcome.[5] To circumvent this problem, some manufacturers have developed resin blanks with several layers that help fabricate denture bases with polychromatic teeth that mimic the dentin and enamel thereby improving the esthetics.[5]

Milled complete denture bases have an excellent fit owing to the elimination of the polymerization shrinkage inherent in traditional fabrication processes of polymethyl methacrylate (PMMA) dentures.

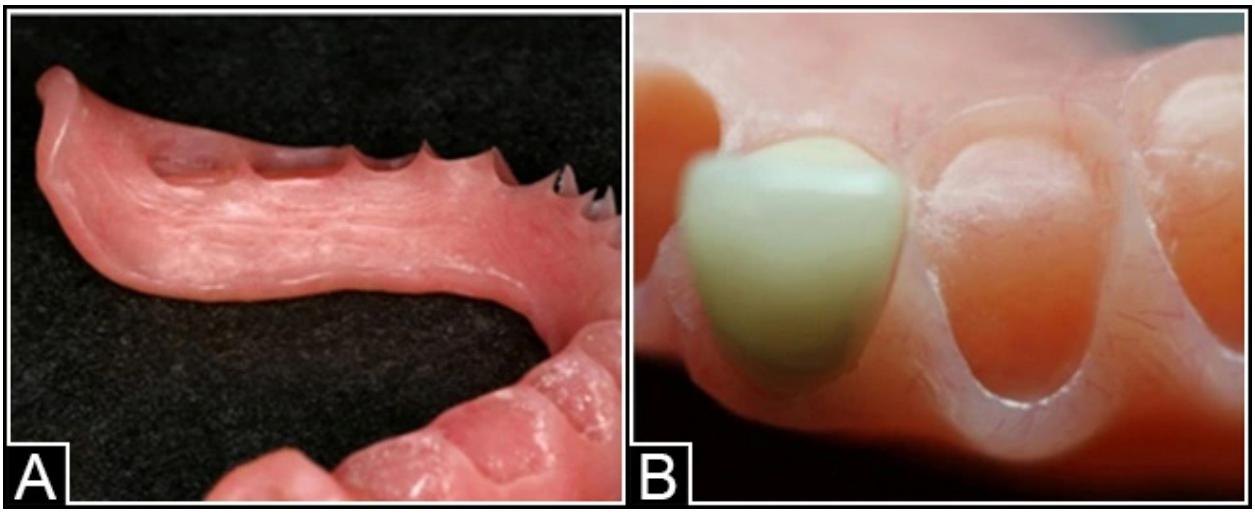

Figure 5. (A) Milled denture base **(B)** Prefabricated teeth bonded to the milled denture base
Images Courtesy of Dr. Goodacre

Milled complete dentures have a superior fit, dimensional stability, flexural strength, and surface hardness compared to conventional and 3D-printed dentures.[5,30-33] The disadvantage of milling a denture is that a large portion of the blank remains unused and is wasted during the process and they are more expensive compared to 3D-printed dentures.[5,30-32]

3D-Printing

The first 3D-printed denture was developed by Dentca in 2015.[5] 3D printing is also termed additive manufacturing (AM) or rapid prototyping (RP). In 3D printing the denture base is printed in pink material, the artificial teeth may be either printed with the prosthesis (monolithic) or printed individually or as a complete arch in tooth shade material or selected from a prefabricated series and bonded to the printed denture base. 3D-printed dentures are more cost-effective than milled dentures.[5] 3D-printed dentures have an inferior fit, dimensional stability, flexural strength, and surface hardness compared to conventional and milled dentures.[5,30-33] The advantage of 3D printing is minimal material wastage and that they are more time and cost-effective compared to milled dentures. Currently, 3D-printed complete dentures are indicated as interim or immediate dentures. They may also be used for the fabrication of custom trays or record bases for conventional workflows.

Various Protocols for Digital Denture Fabrication

Various protocols can be used for the fabrication of CAD-CAM dentures depending on the clinician's comfort level, laboratory, and the system utilized.[34] Based on the number of clinical steps required for the placement of the dentures, the protocol can be classified as a 4-step protocol, a 3-step protocol, or a 2-step protocol.

4-Step Protocol for Digital Denture Fabrication

1st Appointment

❒ During the first appointment, the master impressions are made using the patient's existing denture; thermoplastic, heat moldable stock impression trays (Figure 6); or custom trays. If custom trays are required, primary impressions are made during the initial consultation appointment and custom trays (fabricated on the primary casts) are kept ready for this appointment.

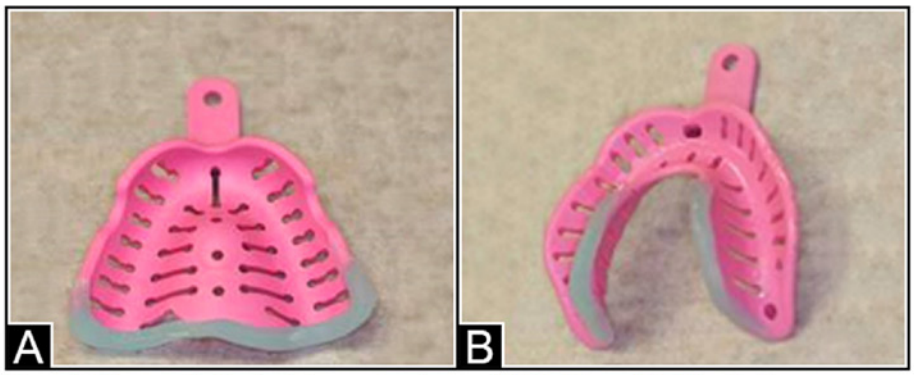

Figure 6. Thermoplastic stock impression trays **(A)** Maxillary **(B)** Mandibular

❒ The master impressions (Figure 7) are digitized using intraoral/extraoral scanners. Printed or conventional trial bases with wax occlusal rims are fabricated for the next appointment.

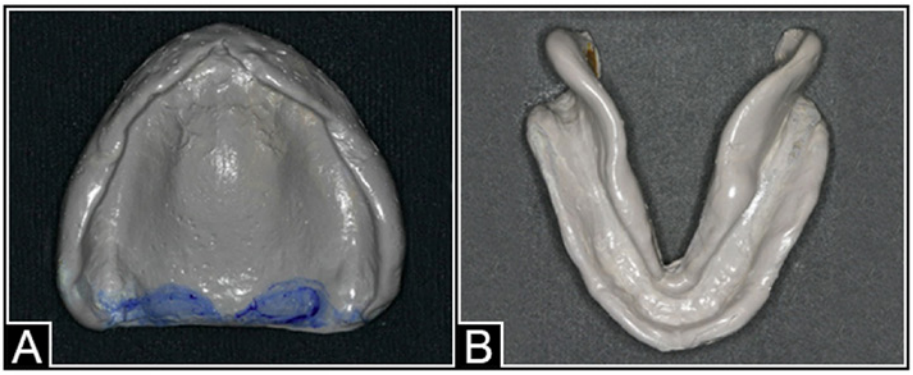

Figure 7. Maxillary and Mandibular master impressions

2nd Appointment

❒ During the second appointment, the **shade** and the **mold** of the prosthetic teeth are selected.
❒ Various extraoral and intraoral patient images (for digital smile designing) are recorded.

It is prudent to check with manufacturers/laboratories regarding the molds of teeth available in their repository prior to this appointment.

❒ The maxillary wax occlusal rim is adjusted clinically as per the esthetics and phonetics of the patient.
❒ The midline, high smile line, and canine lines are carved into the maxillary wax rim.
❒ An image of the patient smiling with the maxillary wax occlusal rim placed in the oral cavity is recorded (Figure 8).

Figure 8. The patient smiling with the maxillary wax occlusal rim placed in the oral cavity

❒ Next, the mandibular wax occlusal rim is adjusted to achieve an optimal OVD and the interocclusal records are registered as per the current prosthodontic procedures (Figure 9).

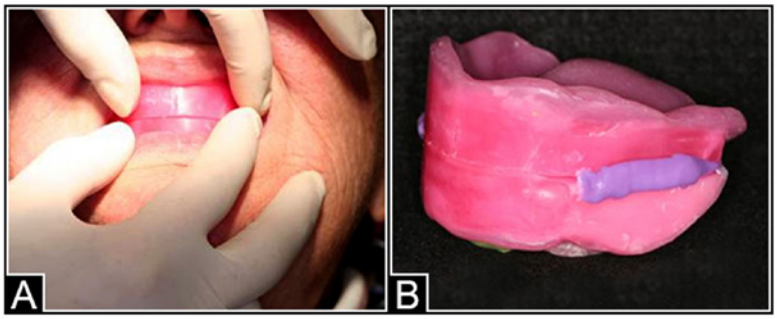

Figure 9. **(A)** Registration of the interocclusal records **(B)** Interocclusal records registered

❒ The trial denture bases with the clinically adjusted wax occlusal rims and the records are sent to the laboratory to be digitized using the extraoral scanners. The files are integrated with the digital case and aligned with the digitized tissue surfaces. The dedicated software (CAD phase) is used to appropriately relate the maxillary and the mandibular virtual casts with each other (Figure 10). The ideal path of insertion and the degree of undercut blocking are determined in the software and the functional borders of the denture are designed. The orientation of the occlusal plane is determined by the digitized wax rims. The prosthetic teeth selected are set digitally on the virtual casts and the CAD files are sent to the practitioner for a digital preview of the teeth set-up. Once, the digital preview is approved (Figure 11), a digital prototype is printed for the try-in appointment. 3D printing is generally used to obtain the prototype of the denture as it is generally faster, economical, and easier to use compared to milling.

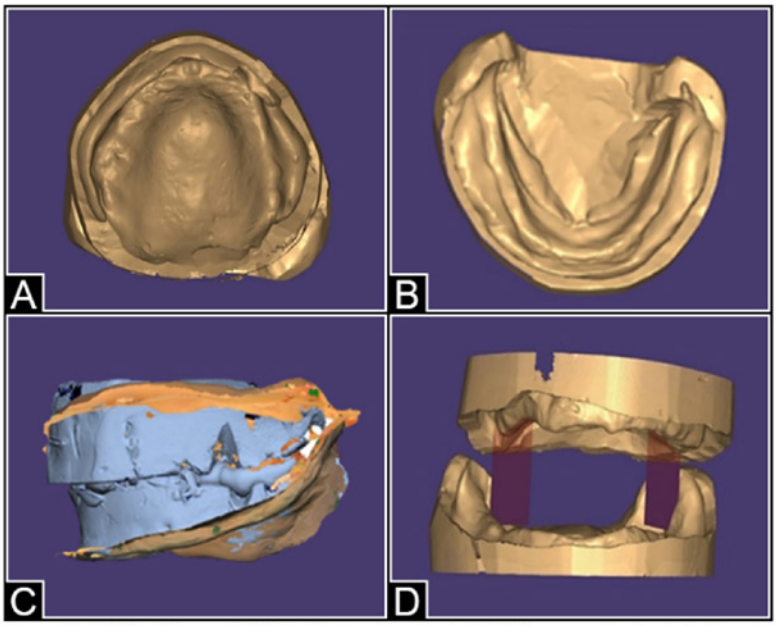

Figure 10. **(A)** Maxillary and **(B)** Mandibular virtual casts **(C & D)** appropriately related to each other

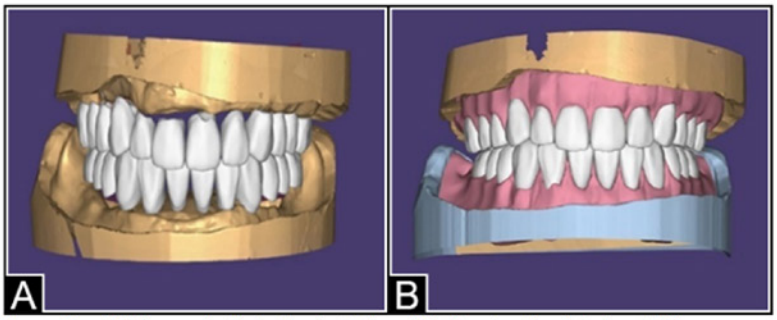

Figure 11. **(A)** The prosthetic teeth selected are digitally set on the virtual casts **(B)**

3rd Appointment

❒ During the third appointment, the entire planning is tested 3 dimensionally using the prototype (Figure 12). The denture prototype helps assess the OVD, CR, phonetics, and the esthetics of the patient. However, it may be challenging to appreciate the esthetics of the printed prototype as it is monochromatic; To overcome this problem, the laboratory may be instructed to apply pink composite on the facial aspect to create the pink part of the denture or replace the printed teeth and the trial base in the anterior regions with the prefabricated prosthetic teeth and modeling wax respectively. However, the latter technique would increase laboratory-related expenses, hence, may be reserved for exacting patients.

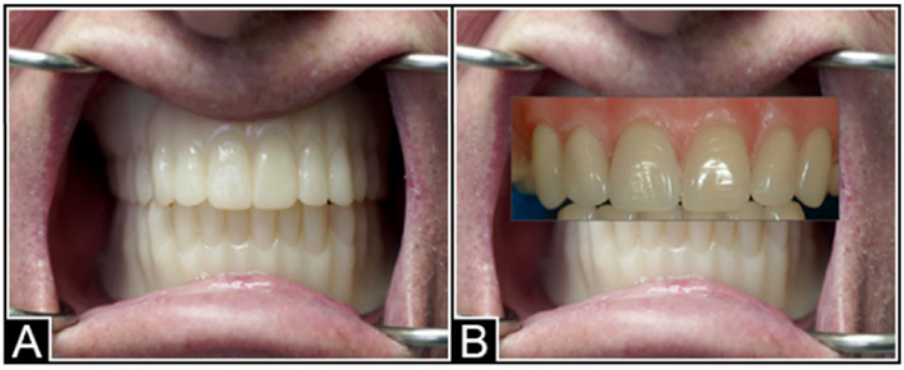

Figure 12. **(A)** Prototype is tested clinically in the patient's mouth
(B) The printed teeth in the anterior regions are replaced with the prosthetic teeth and wax

❒ Changes may be made to the prototype as required. Once the try-in is approved by the patient, the CAD files are sent to the CAM facility for digital denture fabrication. If changes were made to the prototype during the try-in appointment, the clinically adjusted prototypes are scanned again and the data derived from them are used for prosthesis fabrication. Digital definitive prostheses may be fabricated through the milling (subtractive) process or the 3-D printing (additive) process. Several digital denture protocols advocate eliminating the try-in procedure to expedite the fabrication process. However, this may result in poor esthetic outcomes necessitating denture remakes at an additional cost and time.

4th Appointment

❒ During the fourth appointment, the digital dentures are clinically adjusted, finished, polished, and placed in the oral cavity using conventional prosthodontic procedures (Figure 13). However, the process is much faster with digital dentures as the teeth movement during processing is minimal and the fit of the prostheses is superior.[15,17]

Figure 13. **Digital dentures placed in the oral cavity**

3-Step Protocol for Digital Denture Fabrication

1st Appointment

❒ During the first appointment, the master impressions are made using the patient's existing denture; or thermoplastic, heat moldable stock impression trays (Figure 14).

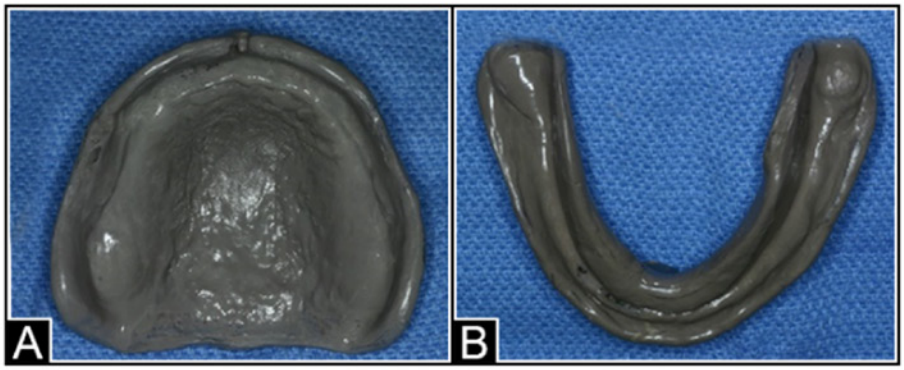

Figure 14. **(A)** Maxillary and **(B)** Mandibular master impressions.

❒ The lip ruler is used to measure the length of the upper and lower lip in repose, and full smile (Figure 15). The length of the lip at rest guides in positioning the incisal edges of the central incisors (depending on the desired incisal display at rest). The upper lip length in full smile (high smile line) aids in determining the cervical position of the maxillary central incisors. Both these measurements guide in selecting the optimal length of the central incisors.[35]

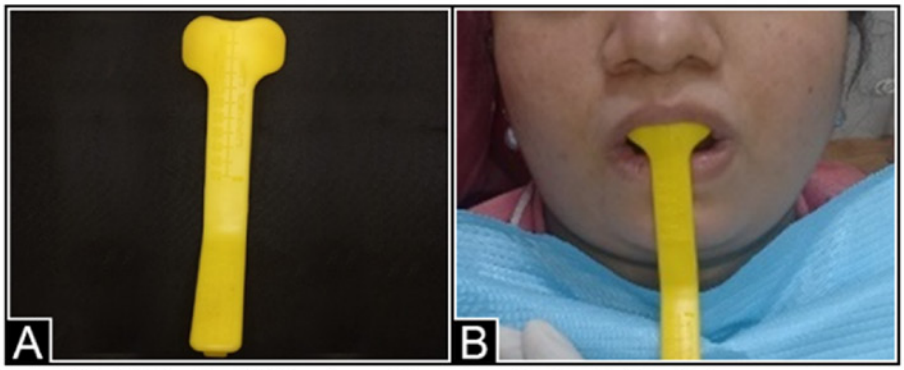

Figure 15. **(A)** Lip ruler **(B)** Lip ruler used to measure the length of the lip in repose

❒ The mold of the prosthetic teeth (small, medium, or large) is selected using the interalar form selector (Figure 16).[35]

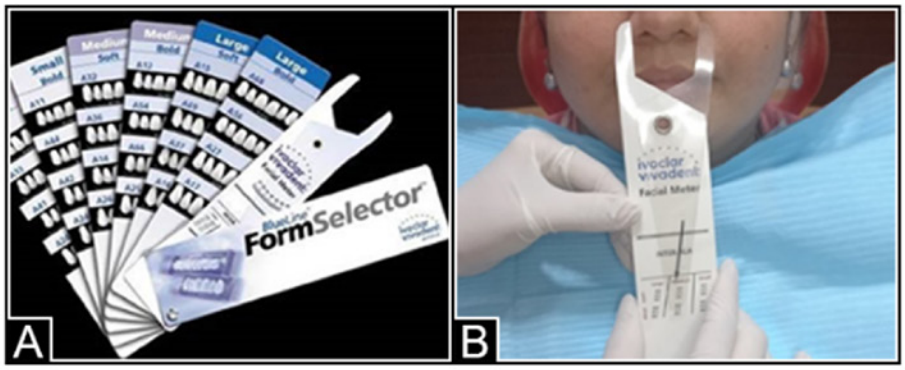

Figure 16. **(A)** Interalar form selector **(B)** Interalar form selector used for selecting the mold of the prosthetic teeth.

❒ The master impressions and the records are sent to the laboratory to be digitized using the extraoral scanners. Trial denture bases with wax occlusal rims are fabricated on the master casts. The lip ruler measurements are used to determine the inciso-cervical position of the central incisors, which are then used to optimally position the lateral incisors and the canines. Anatomical averages are used for determining the midline and the position of the maxillary anterior teeth labio-lingually; The facial surfaces of the maxillary central incisors are positioned 12 millimeters anterior to the posterior border of the incisive papilla (Figure 17);[35,36] The canine cusp tips are positioned along the line that passes through the center of the incisive papilla.[35,36] Once the maxillary anterior teeth are set manually on the maxillary wax occlusal rim, the mandibular anterior teeth are set over the crest of the ridge. The horizontal and vertical overlap between the maxillary and the mandibular teeth will be assessed during the try-in appointment (the horizontal overlap is usually set at 1mm; however, the vertical overlap will vary depending on the occlusal scheme selected for the patient.) The occlusal plane is estimated based on the position of the hamular notches, the retromolar pads, and the incisal edges of the maxillary and mandibular incisors, and a prototype is fabricated for the try-in appointment (Figure 18).

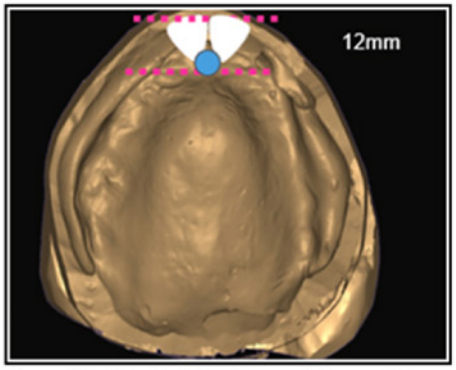

Figure 17. The facial surfaces of the maxillary central incisors are positioned 12 millimeters anterior to the posterior border of the incisive papilla.

2nd Appointment

❒ During the second appointment, the esthetics and phonetics are evaluated with the try-in prostheses (Figures 18 & 19), and adjustments are made as required.[35] Having the anterior teeth set in the wax rim for this appointment helps save clinical time and helps in getting the patient's feedback regarding the shade, shape, and position of the anterior prosthetic teeth during this appointment.

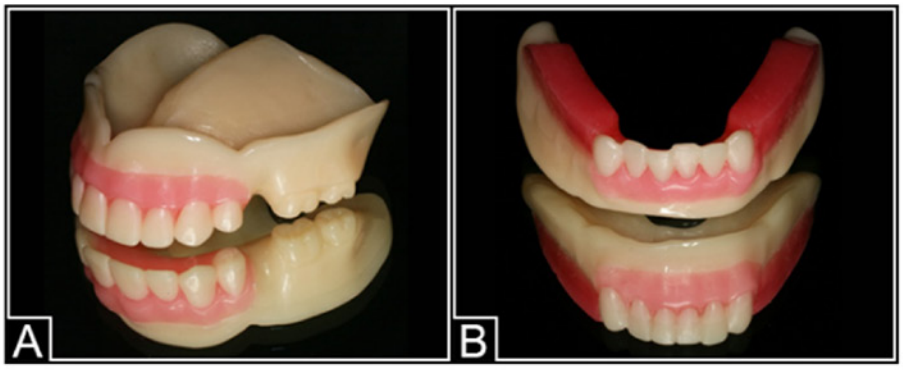

Figure 18. Avadent- Wagner try-in prostheses
Image courtesy Dr. Goodacre

Figure 19. Try-in prostheses evaluated in the patient's mouth.

❒ The OVD is established, and the CR record is registered at the established OVD as per the current prosthodontic principles (Figure 20).

Figure 20. Interocclusal records registered with the try-in prostheses.

❒ The records are sent to the laboratory to be digitized using the extraoral scanners. The mandibular posterior teeth are set virtually on a line extending from the tip of the mandibular canine to the retromolar pads (Figure 21). Next, the maxillary posterior teeth are set virtually against the mandibular teeth to ensure optimal occlusion and optimal overlap between the maxillary and mandibular teeth. The CAD files are sent to the CAM facility for digital denture fabrication.

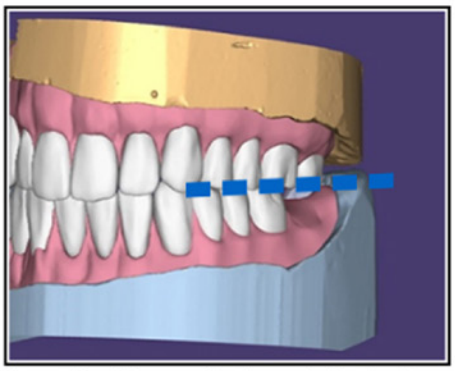

Figure 21. The mandibular posterior teeth are set virtually on a line extending from the tip of the mandibular canine to the retromolar pads.

3rd Appointment

❒ During the third appointment, the digital dentures are clinically adjusted, finished, polished, and placed in the oral cavity as per the conventional prosthodontic procedures (Figure 22). However, the process is much faster with digital dentures as the teeth movement during processing is minimal and the fit of the prostheses is superior.

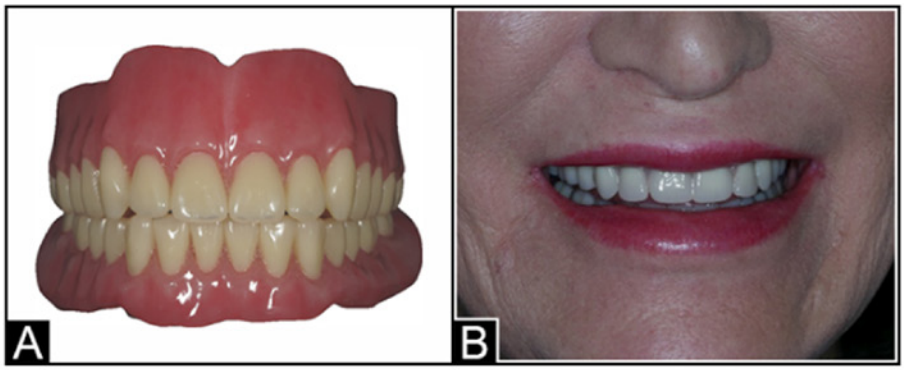

Figure 22. Digital dentures (A), placed in the oral cavity (B).

2-Step Protocol for Digital Denture Fabrication

1st Appointment

There are many proponents of the 2-step digital denture fabrication protocol. These protocols promote the elimination of the try-in procedure which may result in poor esthetics and patient dissatisfaction. The 2-step protocol requires considerable experience in the clinical and laboratory aspects of digital workflow.

The 2-step protocol is not suited for all patients; however, it can be successfully used for patients with immediate/transitional dentures that need an improvement in fit but have acceptable esthetics, occlusion, and occlusal vertical dimension with the existing prostheses. During the first appointment:

- ❒ The interocclusal record is registered.
- ❒ The intaglio surface of the denture is relieved.
- ❒ The interocclusal record is placed in the mouth and a functional reline impression of the existing prosthesis is made with soft lining material/vinyl polysiloxane (VPS) impression material.
- ❒ The denture (with the functional impression) and the records are scanned with an IOS scanner (Figure 23).

Figure 23. The denture (with the functional impression) and the records are scanned with an IOS scanner.
Image courtesy Dr. Goodacre

- ❒ The data is electronically sent to the laboratory for printing/milling of the new denture.

2nd Appointment

During the second appointment, the milled/printed dentures are adjusted, finished, polished, and placed in the patient's mouth.

Applications of Digital Dentures

- *Fabrication of immediate dentures:* The digital protocol can be applied to the fabrication of immediate dentures. The steps involve making digital/conventional impressions, conventionally registering the interocclusal records, assessing the position of the existing natural teeth in the mouth, and recording the changes required to be made to the existing tooth positions. All the records are sent to the laboratory where they are scanned for digital denture fabrication. The teeth are virtually extracted from the virtual casts and prosthetic teeth are planned in optimal locations based on the clinical records. A try-in prosthesis may be printed for the try-in procedure if needed. The digital dentures are milled or printed, natural teeth are extracted and the digital dentures are placed in the oral cavity using conventional prosthodontic procedures.
- *Fabrication of radiographic guide:* Radiographic markers can be attached to the digital prostheses or the prototype dentures and then they can be used as a radiographic guide while recording a cone beam computerized tomography (CBCT) scan. The data obtained from the CBCT scan can be used to plan implant positions and also fabricate a surgical guide which will help with the 3D placement of the implants. The data generated during the fabrication of the prototype can then be used as a guide for framework fabrication and milling of the definitive prostheses.
- *Fabrication of implant-supported overdentures:* The protocol used for the fabrication of complete dentures can also be used to fabricate an implant-supported overdenture. However, there are a few minor variations, they include the following:
  - The attachments are selected based on the height of the mucosal cuff and are attached to the implants.
  - A processing spacer is placed over the attachments.
  - Conventional/digital impressions and records are made with the attachments and the processing spacer in the mouth.
  - All the records are sent to the laboratory and scanned for digital denture fabrication. Recesses are planned in the denture base in the location of the overdenture attachments and the retentive elements of the attachments are picked up chairside at the time of prosthesis placement.
- *Fabrication of implant-supported fixed prostheses:* The data generated during the fabrication of the prototype/transitional denture can be used as a guide for framework fabrication and milling of the definitive fixed prosthesis as the same tooth positions are used throughout the treatment.

Limitations of Digital Dentures

- *Adjustments and relines associated with IOS use:* When the IOS is used to record the denture-bearing tissues, relines and repeated adjustments of the intaglio surface and borders are needed to achieve an optimal fit of the digital prostheses.[20]
- *Suboptimal esthetics due to elimination of try-in:* Several digital protocols advocate the elimination of try-in procedures to save time and cost as they permit virtual evaluation of patient esthetics.[37] However, the prostheses may not have the desired result when placed in the patient's mouth thereby resulting in patient dissatisfaction and treatment failure.
- *Learning curve:* Fabrication of digital complete dental prostheses requires specialized clinical training and there is a learning curve attached to it. To achieve a successful outcome, the dental practitioner needs to invest time and effort in assessing digital previews and should also actively participate in electronic communication with the laboratory.[14]
- *Impossible to digitally register the interocclusal records:* It is currently impossible to digitally register the interocclusal records (for patients without existing dentures) and challenging to record digital functional impressions, thus the full digital workflow for the complete denture rehabilitation remains questionable.[20-25]
- *Inability to balance digital dentures:* It is not possible to balance digital dentures during the designing phase of denture fabrication.

Summary

Conventional and digital approaches can be combined together to reduce the number of clinical visits and increase the patient's acceptance. The use of open digital systems allows dental professionals to use growing digital technology without affecting practice efficiency.

Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: *www.dentalcare.com/en-us/ce-courses/ce622/test*

1. Increased cost associated with the fabrication of conventional complete dentures is most likely associated with all the following EXCEPT one, which one is the exception?

A. Laboratory procedures
B. Number of appointments
C. Material manipulation
D. Manual labor
E. Materials used

2. Which of the following is the most likely disadvantage of the two-appointment digital denture?

A. Compromised esthetics
B. Increased incidence of microbial colonization
C. Increased number of clinical visits
D. Poor fit
E. Poor mechanical properties

3. It is not possible to balance digital dentures during the designing phase of denture fabrication. When the IOS is used to record the denture-bearing tissues optimal fit of the digital prostheses is achieved.

A. The first statement is true, and the second statement is false.
B. The first statement is false, and the second statement is true.
C. Both statements are true.
D. Both statements are false.

4. As per the anatomical average measurements, the facial surfaces of the maxillary central incisors are positioned _____ millimeters anterior to the posterior border of the incisive papilla.

A. 8
B. 10
C. 12
D. 14
E. 16

5. What appointment is the final prosthesis delivered in the Avadent-Wagner protocol?

A. First appointment
B. Second appointment
C. Third appointment
D. Fourth appointment
E. Fifth appointment

6. What does the upper lip length in a full smile aid in determining?

A. cervical position of maxillary central incisors.
B. incisal position of maxillary central incisors.
C. labio-lingual position of the maxillary incisors.
D. mesiodistal inclination of the maxillary incisors.

7. Which of the following has been the most common concern associated with the fabrication of digital dentures?

A. Decreased flexural strength
B. Debonding of teeth
C. Poor fit
D. Poor mechanical properties
E. Staining

8. All of the following are limitations of the intraoral scanner EXCEPT one, which is the exception?

A. Difficulty in assessing the compressibility of the oral mucosa
B. Difficulty in aligning scans of edentulous arches in the correct relation to each other
C. Inaccurate registration of highly mobile tissues
D. Inability to use various methodologies of impression-making
E. Increased difficulty in registering the scans of the maxilla compared to the mandible

9. What is the most common disadvantage of the subtractive method of digital denture fabrication?

A. Compromised dimensional stability
B. Decreased surface hardness
C. Inadequate flexural strength
D. Increased cost and wastage
E. Poor fit

10. Which of the following statement best describes why the full digital workflow for complete denture rehabilitation remains questionable?

A. It is challenging to digitally register the functional impressions
B. It is challenging to digitally register the interocclusal records
C. It is challenging to digitally register the interocclusal records and the functional impressions
D. It is challenging to digitally register the interocclusal records, the functional impressions, and set the teeth.

References / Additional Resources

1. Bidra AS, Taylor TD, Agar JR. Computer-aided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspectives. J Prosthet Dent. 2013 Jun;109(6):361-6.
2. Soboleva U, Rogovska I. Edentulous patient satisfaction with conventional complete dentures. Medicina (Kaunas). 2022;58(3):344.
3. Smith, P.B.; Perry, J.; Elza, W. Economic and clinical impact of digitally produced dentures. J. Prosthodont. 2021;30:108-12.
4. Arakawa I, Al-Haj Husain N, Srinivasan M, Maniewicz S, Abou-Ayash S, Schimmel M. Clinical outcomes and costs of conventional and digital complete dentures in a university clinic: A retrospective study. J Prosthet Dent. 2021 Feb 17:S0022-3913(20)30799-X.
5. Anadioti E, Musharbash L, Blatz MB, et al. 3D printed complete removable dental prostheses: a narrative review. BMC Oral Health 20, 343 (2020). https://doi.org/10.1186/s12903-020-01328-8.
6. Maeda Y, Minoura M, Tsutsumi S, Okada M, Nokubi T. A CAD/CAM system for removable denture. Part I: Fabrication of complete dentures. Int J Prosthodont. 1994;7(1):17-21.
7. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. J Prosthet Dent. 2012;107(1):34-46.
8. Baba NZ, Goodacre BJ, Goodacre CJ, Müller F, Wagner S. CAD/CAM complete denture systems and physical properties: a review of the literature. J Prosthodont. 2021;30:113-24.
9. Maragliano-Muniz P, Kukucka ED. Incorporating digital dentures into clinical practice: flexible workflows and improved clinical outcomes. J Prosthodont. 2021;30:125-32.
10. Deng K, Chen H, Wang Y, Zhou Y, Sun Y. Evaluation of functional suitable digital complete denture system based on 3D printing technology. J Adv Prosthodont. 2021;13(6):361-72.
11. Lo Russo L, Zhurakivska K, Guida L, Chochlidakis K, Troiano G, Ercoli C. Comparative cost-analysis for removable complete dentures fabricated with conventional, partial, and complete digital workflows. J Prosthet Dent. 2022 May 31:S0022-3913(22)00204-9.
12. Jurado C, Sayed M, Fu CC, Villalobos-Tinoco J, Tsujimoto A. Computer-aided design and computer-aided manufacturing (cad/cam) complete dentures for atrophic alveolar ridges: Workflow combining conventional and novel techniques. Cureus. 2022 Jan 10;14(1):e21093.
13. Mubaraki MQ, Moaleem MMA, Alzahrani AH, Shariff M, Alqahtani SM, Porwal A, Al-Sanabani FA, Bhandi S, Tribst JPM, Heboyan A, Patil S. Assessment of conventionally and digitally fabricated complete dentures: a comprehensive review. Materials (Basel). 2022 May 28;15(11):3868.
14. Bonnet G, Batisse C, Bessadet M, Nicolas E, Veyrune JL. A new digital denture procedure: a first practitioners appraisal. BMC Oral Health. 2017 Dec 20;17(1):155.
15. Janeva NM, Kovacevska G, Elencevski S, Panchevska S, Mijoska A, Lazarevska B. Advantages of CAD/CAM versus conventional complete dentures - A review. Open Access Maced J Med Sci. 2018 Aug 4;6(8):1498-1502.
16. Villias A, Karkazis H, Yannikakis S, Theocharopoulos A, Sykaras N, Polyzois G. Current status of digital complete dentures technology. Prosthesis 2021;3(3):229-44.
17. Goodacre BJ, Goodacre CJ, Baba NZ, Kattadiyil MT. Comparison of denture tooth movement between CAD-CAM and conventional fabrication techniques. J Prosthet Dent. 2018;119(1):108-15.
18. Choi JJE, Uy CE, Plaksina P, Ramani RS, Ganjigatti R, Waddell JN. Bond strength of denture teeth to heat-cured, CAD/CAM and 3D printed denture acrylics. J. Prosthodont. 2020; 29: 415-21.
19. Han SY, Moon YH, Lee J. Shear bond strength between CAD/CAM denture base resin and denture artificial teeth when bonded with resin cement. J Adv Prosthodont. 2020;12(5):251-58.
20. Rasaie V, Abduo J, Hashemi S. Accuracy of intraoral scanners for recording the denture bearing areas: A systematic review. J Prosthodont. 2021 Jul;30(6):520-39.
21. Afrashtehfar KI, Alnakeb NA, Assery MKM. Accuracy of intraoral scanners versus traditional impressions: a rapid umbrella review. J Evid Based Dent Pract. 2022;22(3):101719.

22. Abduo J, Elseyoufi M. Accuracy of intraoral scanners: a systematic review of influencing factors. The European Journal of Prosthodontics and Restorative Dentistry. 2018 Aug;26(3):101-121.
23. Kontis P, Güth JF, Schubert O, Keul C. Accuracy of intraoral scans of edentulous jaws with different generations of intraoral scanners compared to laboratory scans. J Adv Prosthodont. 2021 Oct;13(5):316-26.
24. Chebib N, Imamura Y, El Osta N, Srinivasan M, Müller F, Maniewicz S. Fit and retention of complete denture bases: Part II - conventional impressions versus digital scans: A clinical controlled crossover study. J Prosthet Dent. 2022 Aug 30:S0022-3913(22)00464-4.
25. Lo Russo L, Ciavarella D, Salamini A, Guida L. Alignment of intraoral scans and registration of maxillo-mandibular relationships for the edentulous maxillary arch. J Prosthet Dent. 2019 May;121(5):737-40.
26. Lee H-J, Jeon J, Moon HS, Oh KC. Digital Workflow to Fabricate Complete Dentures for Edentulous Patients Using a Reversing and Superimposing Technique. Applied Sciences. 2021; 11(13):5786.
27. Lo Russo L, Salamini A. Removable complete digital dentures: A workflow that integrates open technologies. J Prosthet Dent. 2018 May;119(5):727-732.
28. Punj A, Fisselier F. Digital dentistry for complete dentures. A review of digital dentistry versus conventional approaches to complete dentures. Decisions in Dentistry. September 2020;6(8):12-14,16.
29. Soeda Y, Kanazawa M, Arakida T, Iwaki M, Minakuchi S. CAD-CAM milled complete dentures with custom disks and prefabricated artificial teeth: A dental technique. J Prosthet Dent. 2022 Jan;127(1):55-58.
30. D'arienzo LF, Casucci A, Manneh P, D'arienzo A, Borracchini A, Ferrari M. Digital workflow in complete dentures: A narrative review. © ARIESDUE 2020; 12(4):743-50.
31. Herpel C, Tasaka A, Higuchi S, Finke D, Kühle R, Odaka K, Rues S, Lux CJ, Yamashita S, Rammelsberg P, Schwindling FS. Accuracy of 3D printing compared with milling - A multi-center analysis of try-in dentures. J Dent. 2021 Jul;110:103681.
32. Abualsaud R, Gad MM. Flexural Strength of CAD/CAM Denture Base Materials: Systematic review and meta-analysis of in-vitro studies. j Int Soc Prev Community Dent. 2022 Apr 8;12(2):160-70.
33. Srinivasan M, Kamnoedboon P, McKenna G, Angst L, Schimmel M, Özcan M, Müller F. CAD-CAM removable complete dentures: A systematic review and meta-analysis of trueness of fit, biocompatibility, mechanical properties, surface characteristics, color stability, time-cost analysis, clinical and patient-reported outcomes. J. Dent. 2021, in press.
34. Steinmassl PA, Klaunzer F, Steinmassl O, Dumfahrt H, Grunert I. Evaluation of currently available CAD/CAM denture systems. Int J Prosthodont. 2017 Mar/Apr;30(2):116-122.
35. https://lmtmag.com/articles/avadent-avadent-wagner-ez-protocol, accessed 10/2/22
36. Solomon EG, Arunachalam KS. The incisive papilla: a significant landmark in prosthodontics. J Indian Prosthodont Soc. 2012 Dec;12(4):236-47.
37. John AV, Abraham G, Alias A. Two-visit CAD/CAM milled dentures in the rehabilitation of edentulous arches: A case series. J Indian Prosthodont Soc. 2019 Jan-Mar;19(1):88-92.

Additional Resources

- No Additional Resources Available.

About the Author

Swati Ahuja, BDS, MDS

Dr. Ahuja graduated with a BDS from Nair Hospital Dental College in 2002 and an MDS certificate in Prosthodontics from the University of Tennessee Health Science Center, Memphis, TN. She then joined the same University as an Assistant Professor in the Department of Prosthodontics where she worked for 3 and half years. She served as the editor for the Department of Prosthodontics at University of Tennessee Health Science Center, Memphis, TN for the next 6 years. She has lectured nationally and internationally on various prosthodontic topics at various dental conferences. She has more than 55 publications in peer reviewed national and international journals. Dr. Ahuja is also the co-author of the textbook titled, “Applications of the Neutral Zone in Prosthodontics.” Currently, she has a private practice in Mumbai.

Email: swatiahuja@gmail.com