State of the Art

CAD/CAM Technology for Complete Denture Fabrication

Tae H. Kim, DDS1
Sillas Duarte, Jr. DDS, MS, PhD2

1Section Chair, Removable Prosthetics, Division of Restorative Sciences, Ostrow School of Dentistry, University of Southern California, Los Angeles, California, USA.
2Chair, Division of Restorative Sciences, Ostrow School of Dentistry, Director, Advanced Program in Operative Dentistry, University of Southern California, Los Angeles, California, USA.

Correspondence to: Dr Tae Kim, Division of Restorative Sciences, Ostrow School of Dentistry, University of Southern California, DEN 4377, 925 W34th Street, Los Angeles, CA 90089-0641.
Email: thk@usc.edu
For decades, the fabrication of complete dentures has involved tedious and time-consuming processes. They include taking the preliminary impressions with stock impression trays, creating a study cast upon which custom trays will be fabricated, taking definitive impressions using the customized trays, constructing occlusal rims with wax, and recording maxillomandibular jaw relations. After these preliminary steps, artificial teeth setup takes place, followed by try-in to ensure proper jaw and occlusal relationships as well as patient comfort and satisfaction.

Undoubtedly, the entire complete denture fabrication process involves a number of visits by the patient, additional time consumed by the dentist, a significant amount of manual labor by the dental technicians, and the possibility of human error and dimensional instability of the dentures. Much effort has been directed toward reducing these processes.1–4

In recent years, the use of computer-aided design/computer-assisted manufacture (CAD/CAM) technology (Dentca) has allowed the fabrication of digitally fabricated complete dentures.5 Dentures created via CAD/CAM software are highly accurate, since there is no manual teeth setup.6 No plaster model, physical mounting highly, or wax-up is required.7 In addition, CAD/CAM dentures are convenient, as only two visits are required. Furthermore, intervention by dental technicians and the subsequent chances for human error are greatly reduced. CAD/CAM dentures remain permanently on record, allowing the digital data to be reused to fabricate duplicate dentures without the need for an additional visit. Lastly, digitally fabricated dentures could make a standardized and controlled study easier to develop and validate scientific data related to removable prostheses.8

The following case demonstrates the use of CAD/CAM technology to fabricate a natural-looking complete denture.

**PROCEDURES**

**Maxillary and Mandibular Impressions**

The two-piece impression trays provided with the Dentca system are used to take maxillary and mandibular impressions. Each tray has its own separate anterior and posterior components, which can be detached and are provided with a center pin and plate used for jaw relation records. The trays come in various sizes—small, medium, large, and extra large—to best fit the patient’s arch (Fig 1).

To record the maxillary impression, fast-setting heavy-body polyvinyl siloxane (PVS) impression material is first loaded onto the tray for the initial customization. The tray is placed in the patient’s mouth, seated over the arch, and firm finger pressure is applied on designated finger spots located on the bottom of the tray for 5 seconds, followed by border molding movements. Once the heavy-body PVS is set, any exposed areas of the tray are adjusted with a bur. The tray is then covered with light-body PVS in order to perform the final impression procedure.

The mandibular impression is recorded in exactly the same fashion, with mandibular border molding movements. As before, exposed areas are trimmed and then covered with light-body PVS, and the final impression is taken.

**Vertical Dimension and Centric Relation Recording**

The posterior segments of both trays are separated along the separation line using a blade (Fig 2). The center pin is attached to the mandibular tray (Fig 3). Gothic arch tracing is used to record the centric relation (CR) of the jaws, whereby the mandibular stylus draws lines on the maxillary plate to form the shape of an arrow. This requires use of a denture tracing pad (EZ-Tracer, Dentca) on the cameo surface of the maxillary tray (Fig 4). It is inserted with the maxillary tray into the patient’s mouth, and the center pin is adjusted clockwise with the fingers or a tweezer until the desired vertical height is reached (Fig 5). If the trays are in contact with each other at any point, those areas can be trimmed with a bur.
The trays are replaced in the patient’s mouth with the center pin attached to the mandibular tray. The patient’s mandible is guided from the anterior-most to the posterior-most position. The mandible is then moved laterally on each side from its most posterior position and then brought back into its posterior position (Fig 6). The arrow thus formed is the Gothic arch tracing, where the apex of the arrow on the maxillary tray represents CR (Fig 7). A small hole or depression is drilled into the apex to allow the center pin to fit into it during bite registration.

**Bite Registration**

The trays are seated back in the patient’s mouth, and the center pin snaps into the CR hole. Bite registration material is then injected between the trays. When the material sets, the trays are removed and evaluated for accurate positioning of the center pin within the CR hole or recess [Author: Is this sentence correct as edited?].

A ruler is used to measure the distance between the incisive papilla and the upper lip border. Once completed, the trays are disinfected and mailed to the Dentca manufacturer along with a printed denture order.

**CAD/CAM Process**

The maxillary and mandibular impressions are scanned to create virtual images of the edentulous arches using the specialized Dentca CAD software (Figs 8 and 9). Once the CAD process is complete, the virtual images of the dentures are transferred to a 3D printer to create try-in dentures. At this time, two different sets of try-in dentures are generated for the patient’s evaluation. The first setup has bold maxillary lateral incisors with minor crowding of the mandibular incisors (Figs 10 to 14). The second setup has soft maxillary lateral incisors with moderate crowding of the mandibular incisors (Fig 15 to 19). After try-in of both sets, the patient decides on the second setup for her final denture (Figs 20 to 23). Now that the decision is made, a converting process is followed to fabricate the definitive complete denture, including internal staining (Fig 24) to create a natural appearance (Figs 25 to 27).
Fig 10  Digital image of first teeth setup: bold maxillary lateral incisors and minor mandibular incisor crowding.
Fig 11  Digital image of completed denture after festooning (first setup).
Fig 12  Try-in denture (first setup).
Fig 13  Teeth alignment (first setup).
Fig 14  Teeth alignment in denture (first setup).

Fig 15  Digital image of second teeth setup: soft maxillary lateral incisors and moderate mandibular incisor crowding.
Fig 16  Digital image of completed denture after festooning (second setup).
Fig 17  Try-in denture (second setup).
Fig 18  Teeth alignment (second setup).
Fig 19  Teeth alignment in denture (second setup).
Fig 20 Patient’s evaluation of first try-in denture in mouth.
Fig 21 Patient’s evaluation of second try-in denture in mouth.
Fig 22 Patient’s smile with second try-in denture.
Fig 23 Patient with chosen try-in denture (second setup) in mouth.
Fig 24a Cutback for internal staining and enamel layer.
Fig 24b After application of internal stain.

Figs 25a to 25c Completed CAD/CAM denture.
Fig 26 Patient’s smile with definitive CAD/CAM complete denture.
Fig 27 Patient’s natural-looking appearance with the CAD/CAM denture.
CONCLUSIONS

CAD/CAM technology for fabrication of complete dentures represents a new benchmark for the clinician’s armamentarium. CAD/CAM dentures provide reliable and predictable oral rehabilitation of edentulous patients with superior performance when compared to traditional methods of denture fabrication.

REFERENCES