CAD/CAM technology: application to complete dentures

Mathew T. Kattadiyil, DDS, MDS, MS, and Charles J. Goodacre, DDS, MSD

Computer Aided Design – Computer Aided Manufacturing (CAD/CAM) technology has already made significant strides in the field of dentistry. CAD software renders the geometrical shape of an object, and the CAM software directs the fabrication process. Applications of CAD/CAM in dentistry include fabrication of inlays, crowns, fixed partial dentures, and implant abutments/prostheses.

Recently, CAD/CAM technology has become commercially available for fabrication of complete dentures through the introduction of AvaDent™ digital dentures by Global Dental Science, LLC. It is a system by which impressions, interocclusal records, and tooth selection can be completed in one appointment. The dentures are then fabricated using CAD/CAM technology and placed in the second appointment.

Describing early concepts and clinical methods used to acquire the necessary morphological data for CAD/CAM complete dentures, Goodacre et al. wrote, “[W]hen the CAD/CAM technology for fabricating complete dentures becomes commercially available, it will be possible to scan the denture base morphology and tooth positions recorded with this technique and import those data into a virtual tooth arrangement program where teeth can be articulated and then export the data to a milling device for the fabrication of the complete dentures.” With the introduction of commercially available CAD/CAM denture systems like AvaDent™ and Dentca, Inc., the era of digital complete dentures has arrived. The purpose of this article is to identify potential advantages of CAD/CAM complete dentures and describe the authors’ clinical experience with the AvaDent™ digital denture system.

The CAD/CAM process offers significant advantages to the dental practitioner and the patient. It is possible to record all the clinical data for complete dentures in one appointment (one to two hours). Clinical chair time is reduced considerably, thereby providing the opportunity for a more cost-effective set of appropriately accurate complete dentures. A repository of digital data remains available that allows for more rapid fabrication of a spare denture, a replacement denture, or even a radiographic or surgical template that aids in the planning and placement of dental implants in the future. Additionally, because the digital data are associated with a specific practitioner, it is more likely that patients will return to the dentist who fabricated their first digital denture when future treatment is needed. Because the denture base is fabricated by machining, polymerization shrinkage of the resin is eliminated, and the fit of the denture base is superior to that of conventionally fabricated denture bases. Due to the method of processing the acrylic resin for denture bases at fifty times the conventional processing pressure, there is less porosity; and initial research reveals that the AvaDent™ denture base material may have less C. Albicans adherence.

CLINICAL TECHNIQUE

Conventionally fabricated complete dentures frequently use a five-step appointment process:
1. Making preliminary impressions
2. Making final impressions
3. Recording jaw relation
4. Trial placement of wax denture pattern
5. Placement/insertion of complete dentures

The AvaDent™ digital denture process is designed to capture the necessary information for the fabrication of complete dentures in one appointment without compromising prosthesis quality. The entire digital CAD/CAM process consists of the following appointments:

1. Impressions, jaw relation records, occlusal plane orientation, tooth mold and shade selection, and maxillary anterior tooth positioning record
2. Placement of dentures

Appointment 1

Customizing stock trays

The procedure involves the fabrication of a putty cast formed by pressing mixed poly (vinyl siloxane)
putty into the intaglio surface of the patient’s existing dentures (Figure 1). If these dentures are unacceptable or unavailable, then diagnostic casts can be generated from a preliminary impression.

Figures 2 and 2a show the thermoplastic tray selection based on the arch size for the maxillary and mandibular cast respectively.

The tray is softened by immersion in a water bath set at $80^\circ C$ ($180^\circ F$) for approximately one minute and adapted to the putty cast by pressing the material into contact with the cast or stretching the material to cover required areas. The adapted trays can then be adjusted using acrylic resin burs or a sharp scalpel to remove overextended areas.

After the trays have been adapted on the putty cast, they are placed in the patient’s mouth to evaluate them for areas of overextension or underextension and adjustments made as needed. It is important that the maxillary tray extend posteriorly to cover the area of the vibrating line and the pterygomaxillary fissures (hamular notches) (Figure 3). It is also important that the mandibular tray cover the retromolar pads and available areas of the lateral throat form (retromylohyoid area). Coverage of these areas requires determining the location of the vibrating time by having the patient pronounce the word “Aah” or by coughing. Determining the extension of the mandibular tray into the retromylohyoid area requires placing the head of a dental mirror into this area and asking the patient to wet his/her lips with the tongue to determine the degree of displacement of the mirror by the tongue musculature.

**Making maxillary and mandibular final impressions**

After customizing the impression trays and confirming appropriate coverage and adaptation in the patient’s mouth, tissue stops should be added to the trays. After applying the appropriate adhesive, AvaDent™ registration or a fast setting interocclusal record material is applied as four dabs to distributed areas on the maxillary tray and three areas of the mandibular tray. The trays are then seated in the patient’s mouth and oriented so that the trays are not pressed into contact with the soft tissue, thereby leaving space for the subsequent border molding and wash impression material. The AvaDent™ border molding impression material, or a medium body poly (vinyl siloxane) impression material, is then used to border mold the maxillary and mandibular trays employing the method used with conventional custom trays.
The border molded trays are inspected. If there are areas where the tray has contacted the mucosa, these areas are removed using an acrylic resin bur. If there are defects in the border molding, adhesive is applied to these areas and additional border molding material applied so that the border molding can be repeated in those areas.

Final impressions of the maxillary and mandibular arches are made using either the AvaDent™ impression material or a light-body poly (vinyl siloxane) impression material (Figures 4 and 5). The area of the posterior palatal seal is identified by marking the vibrating line and the areas located anteriorly where the seal can be positioned based on the areas of compressibility and the depth to which the tissue can be compressed in these areas. The areas are marked and then transferred to the impression. The traditional method of scoring the definitive maxillary cast to establish the posterior palatal seal area is not used with CAD/CAM maxillary dentures because there is no physical cast. It is suggested that wax be applied to the appropriate areas of the impression at a height that corresponds to the desired depth of the compressible tissue. Because there is no polymerization shrinkage of the base due to its being milled from pre-polymerized resin, posterior palatal seals are not always needed, unless there is considerable moveable tissue present in the posterior palate and over the edentulous
ridges. When needed, it is proposed that the posterior palatal seal be such that it is one-half or less of the tissue compressibility depth.

**Jaw relation records**

The AvaDent™ denture technique uses an Anatomical Measuring Device (AMD) that can be adjusted to the desired occlusal vertical dimension and then used to maintain that dimension while centric relation is recorded using the incorporated gothic arch tracing plate and stylus. The AMD is also used to determine the correct amount of upper lip support, the position of the maxillary six anterior teeth, and the desired mediolateral orientation of the occlusal plane. The AMD consists of a maxillary tray with a centrally located adjustable stylus and an adjustable lip support flange (Figure 6) and a mandibular tray with a flat occlusal tracing plate (Figure 7). In addition, there is an occlusal plane orientation ruler that can be inserted into the maxillary AMD and used to record the alignment

of the maxillary AMD with the interpupillary line to make it possible for the computer program to align the maxillary teeth with the interpupillary line.

The maxillary AMD is filled with AvaDent™ registration material (Figure 8) and seated to record the ridge morphology of the maxillary arch as well as the portion of the palate covered by the AMD. There should be sufficient material to stabilize the tray, or the process should be repeated.

The mandibular tray with the recording plate is then filled with the recording material and used to stabilize the tray in the patient’s mouth. Care should be taken so that the maxillary and mandibular AMDS are positioned to be fairly parallel to each other and the maxillary stylus is located over the anterior aspect of the mandibular AMD tracing plate (Figure 9), or the process should be repeated.
The occlusal vertical dimension is determined. If the existing dentures provide an appropriate occlusal vertical dimension, they can be used to record the distance between marks on the face when the dentures are in occlusal contact. If not, conventional methods should be used to determine the desired dimension. The rest vertical dimension, tonicity of the musculature, facial proportions, and biofeedback can then be used to confirm appropriate occlusal vertical dimension (Figures 10, 10a). The adjustable screw in the maxillary tray is turned clockwise to extend the stylus, or counterclockwise to retract the stylus so that it contacts the mandibular tracing plate at the appropriate vertical dimension (Figure 10). Once the vertical dimension has been established, the adjustable screw in the maxillary AMD (Figure 11) is used to extend or retract the upper lip support flange so that it provides adequate lip support. The patient is given an opportunity to assess the adjustments by viewing his/her lips in a mirror.

Recording centric relation is accomplished by making an intraoral gothic arch recording. While the stylus on the maxillary AMD can produce markings on the mandibular plate when jaw movements are made, it may be helpful to place a marking medium on the tracing plate by spraying the plate with an aerosol marking medium or by rubbing articulating paper over the plate and transferring the pigment from the paper to the plate. The gothic arch tracing is made by instructing the patient to move the lower jaw forward and backward while maintaining the maxillary stylus and mandibular AMD tracing plate in contact. The patient is then instructed to move the jaw to one side, making a lateral excursive movement from the centric relation position, and then to the contralateral side. The stylus on the maxillary tray scribes lines on the mandibular recording plate, and if the process is done correctly, an arrow point or gothic arch recording should be clearly seen (Figure 12). The apex of the recording denotes the centric relation position. A recess is then made in the tracing plate that approximates the tip diameter of the stylus at the apex of the gothic arch arrowpoint using an appropriately sized round bur or acrylic resin bur, and the mandibular tray is reinserted in the patient’s mouth. The patient can then move his/her mandible or be guided to the position where the maxillary stylus engages the recess and maintain the centric relation position (Figure 13).

Occlusal Plane Orientation, Maxillary Anterior Mold and Shade Selection, and Maxillary Anterior Tooth Positioning

To record the occlusal plane orientation, the AvaDent™ ruler is inserted in the maxillary AMD (Figure 13a) and the anterior adjustable portion moved until it is aligned parallel to the imaginary interpupillary line connecting the centers of the pupils of the eyes (Figure 13b). The angle is noted and recorded on the laboratory work authorization form. This will assist the manufacturer in orienting the
mediolateral occlusal plane to parallel the interpupillary line.

The next procedure in this first appointment is to mark the midline on the lip support flange as well as the smile line for the maxillary anterior teeth based on the curvature of the lower lip during smiling. The size of the maxillary anterior teeth is determined by overlaying the three available tooth size templates on the teeth in the existing denture, assuming the existing denture tooth size is desirable to the patient (Figures 14 & 14a). If not, the tooth template is selected that matches the patient’s desired tooth size. Also, by overlaying the maxillary tooth templates on the existing denture, the position of the pink denture base resin around the necks of the teeth can be selected from the locations present on the tooth template. To serve as a guide during denture fabrication, flowable composite resin is applied to the inside of the selected tooth mold template. The tooth mold template is then positioned carefully over the midline and smile line markings and placed in the exact location where the denture teeth should be arranged. The resin is then light polymerized to affix the template in position (Figure 14b).
AvaDent™ registration material (or another interocclusal record material) is injected into the space between the maxillary and mandibular arches, with the jaw stabilized in centric relation (Figure 15). It is important that a generous amount of material be used so that it flows around the tracing plate and stylus and firmly attaches the maxillary and mandibular AMDs together. The interocclusal record assembly is then removed and inspected to confirm that the stylus is in the centric relation recess and that the AMDs are firmly interlocked (Figure 15a). After following normal disinfection protocol, the final impressions and connected AMDs (along with the completed laboratory authorization form) are mailed to the Global Dental Science, LLC, producer of AvaDent™ digital dentures, along with any special instructions.

The company processes the impression and the AMD so that they can be more easily recorded during the laser scanning process. The laser scans of the impressions and connected AMDs are made and the morphologic data merged so as to establish the occlusal relationship of the complete arch data obtained from the complete arch impressions. The denture borders are identified and marked using the computer software (Figure 16), teeth are set virtually so that they occlude properly and have the desired occlusal plane orientation (Figure 17), and the morphology of the denture base is established. Once the denture has been designed virtually, the denture base is milled with recesses that accurately fit each denture tooth (Figures 18 and 18a), and the teeth are bonded with a proprietary...
bonding mechanism. The denture base can be fabricated from different choices of base material, and different options are available for the denture teeth.

Appointment 2

Placement

The placement and post-placement adjustments of CAD/CAM complete dentures are similar to the placement of conventional dentures. Because the denture base is made from a traditional resin material, implant attachments, if any, as in the patient situation illustrated, can be picked up intraorally using conventional techniques. Figure 19 shows the frontal smile view of a patient wearing a maxillary complete denture and a mandibular implant overdenture fabricated by the AvaDent™ digital denture system. The patient is seen as needed for routine follow-up and maintenance appointments.

CONCLUSIONS

The use of CAD/CAM technology to fabricate complete dentures has positive benefits for both the patient and practitioner. The ability to reduce the time required to provide patients with dentures and the potential to reduce the cost of care for patients while still providing quality dentures using state of the art dental materials is promising. The clinical records can be obtained in one appointment so that definitive prostheses are available at a second appointment.

References