1/2 point CDT documented scientific credit. See Page 36.

By Robert Kreyer, CDT and Kathleen Catanzaro, CDT

Digital Denture Solutions

Conventional Complete Prosthetic History

In 1914, The Dentist Supply Company of New York, now Dentsply Sirona, incorporated the research work of Drs. Leon Williams and Alfred Gysi into the development of the Trubyte® System. This was the first complete prosthetic method for selecting denture teeth based on the shape of a patient's face and replicating natural tooth form with a functional denture occlusion.

Dr. Leon Williams, a U.S. dentist, found that a harmony existed between the shape of a person's face and their anterior tooth form. Dr. Williams had become increasingly dissatisfied with the shapes of artificial anterior teeth so he started to develop tooth forms that would aesthetically match the patient's facial form. About the same time, Dr. Alfred Gysi, a skilled researcher and dentist from Zurich, Switzerland made similar observations with posterior teeth. Gysi designed artificial teeth such as Anatoline posteriors to function in a similar fashion to the characteristics of the human mouth. He had three goals in the development of posterior teeth: (1) anatomical similarity to its natural counterpart (2) better efficiency in the mastication of grainy and fibrous foodstuff, and (3) functional incorporation of the determinates of a cusp-fossa occlusion into the pathways of mandibular motion during chewing.

Conventional Meets Digital

Now one hundred years later, through the publications of Gysi and Williams plus other dental professionals these basic prosthetic principles of complete dentures are integrated into the Dentsply-Sirona Digital Dentures Engineered by Avadent using Computer Aided Engineering (CAE) which is a mathematical solution for correctly applying prosthetic principles. These mathematical models use rules formed from basic prosthetic principles such as the complete denture publications of Gysi, Williams and others over the last 100 years.

AvaDent's computer aided engineering (CAE) is complemented by computer-aided design (CAD) and computer-aided machining (CAM). CAE is the analytical intelligence that drives CAD through the digital workflow process into CAM. Having a digital workflow process that uses CAE, CAD and CAM is what defines a true digital denture.

A digital denture workflow should be a seamless transition from conventional to digital. The clinical workflow such as impressions and record relationships remain the same. The clinician still must capture all necessary anatomical landmarks with excellent impressions and accurate maxillo-mandibular records. Technical workflows have evolved according to advancements in computer-aided technologies although the basic complete prosthetic principles remain the same. While the edentulous patients' desires, denture space and oral environments biologic condition still dictate treatment there are many more clinical and technical options by extending conventional removable prosthetic product lines with digital workflows.

There are several digital denture workflow processes that have been developed by leading dental manufacturers. These digital denture workflows are differentiated with an ability to set in all occlusal classifications and schemes, additive or subtractive technologies, availability of mold selection, bonded or fully milled, systematic approach to digital denture diagnostics and design.

In the coming years, the total denture market is projected to grow with partial dentures growing at a faster pace to traditional dentures as patient retention of natural dentition improves. This growth coupled with the following factors increase the market need for digital denture work flow solutions. (1): 1. U.S. population >65 continues to grow thus driving a growing demand for dentures (full and partial). 2. Dentists and dental technicians knowledgeable in complete dentures are retiring and not being replaced at the same rate 3. Dentists entering the workforce today are more knowledgeable in digital dentistry however they have less education and practice in dentures.

The combined impact of these market factors will result in an increasing rate of adoption of digital denture solutions. According to a market outlook prepared by Dentsply Sirona, up to 45% of dentures could be produced digitally by 2024.

Bonded Digital Denture Workflow

In this article a digital workflow process for a difficult maxillary and mandibular denture with a unique biologic condition will be presented. Dr. M.M. House created a system to classify the biologic conditions as they are clinically observed. Dr. House's classifications systems include; muscles of mastication, arch form, ridge relationship, soft tissue, peripheral

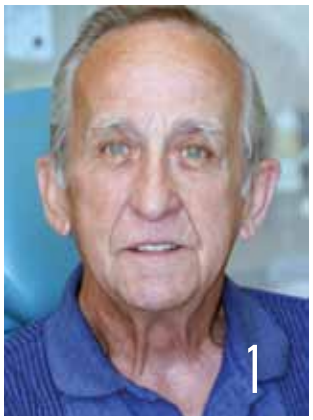


Figure 1
The patient's desires are to improve esthetics and have a complete denture that fits better than existing prosthesis.

Figure 2
The patient presents with a compromised maxillary and mandibular edentulous situation. Mandible was edentulated two months prior to impressions.

Figure 3
Analysis of existing prosthesis to understand occlusal forces and functional wear patterns. Note the left side has a reverse curve of Wilson due to opposing natural teeth and right side has no wear due to opposing no dentition.

border attachments, retromolar pads and throat form. In this case the maxillae is a House Class 3 palatal throat form. Class 3 throat forms usually accompany a small maxillae with a V shaped hard palate. The "curtain" of the soft palate turns down abruptly 3 to 5 mm. anterior to a line drawn across the palate at the distal edge of the tuberosities. Such maxillae usually have very small or no tuberosities compared with a House Class 1 Throat Form that is large and normal in form. It has a relatively immovable resilient band of tissue 5 to 12mm distal to a line drawn across the palate at distal edge of tuberosities. A digital denture workflow enables the technician and clinician to view this palatal throat form and relationship to teeth in a perspective that is not possible with a conventional workflow. The advantage is an ability to visualize the negative space between palatal ridge and teeth to improve prosthetic stability.

It's critical to successful conventional or digital outcomes that a clinician understands the edentulous patients' biologic condition plus desires and expectations during examination of oral environment and analysis of existing complete removable prosthesis (**Figs. 1-3**). Conventional border molded maxillary and mandibular impressions are then taken followed

by the creation of stone master casts for fabrication of baseplates and occlusal rims (**Fig. 4**). At the patient's second appointment wax occlusal rims were contoured followed by the establishment of vertical dimension of occlusion and centric relationship records (**Figs. 5-6**).

The relationship records plus border molded impressions were then scanned to create the master STL files for designing the digital dentures (**Figs. 7-9**).

This clinician desired the ability to modify anterior tooth arrangement clinically so a workflow that included the Wagner Try-in (WTI) was selected. The Wagner Try-in has the advantages of a processed base with anterior teeth set in wax and posterior occlusal rims for indexing record. In the maxillary, a second pre-molar was missing which enabled the clinician to move the anterior teeth and first bicuspids into desired position. The mandibular anterior teeth

Figure 4
Impressions of maxillary and mandibular edentulous arch were taken with a VPS border molding technique and wash.

Figure 5
Maxillary occlusal rim is contoured for lip support, smile line and buccal corridor with midline and high lip line markings.

Figure 6
After the occlusal rims have been contoured vertical dimension of occlusion is re-established. A wash impression is taken in maxillary and mandibular baseplates to provide stability when recording centric relation record.

Figure 7
Impressions or master casts plus washed baseplates with occlusal records are then scanned creating STL reference file of impressions and records.

Figure 8
Maxillary and mandibular teeth are set according to reference record in brown.

Figure 9
The final base building design for Wagner Try-in is finished then ready for milling.

were milled in a block enabling this segment to be placed into desired position. The mandibular posterior was used for an occlusal rim or Aluwax record index. The clinician could adjust intaglio of base if necessary then capture modifications of this surface when scanning WTI records.

The Wagner Try-in enabled the clinician to verify midline, incisal edge position, reconfirm records (**Figs. 10-11**). At the third clinical appointment, the Wagner Try-in was used to establish anterior esthetics and relationship records (**Fig. 12**).

After this clinical try-in, the Wagner Try-in was scanned for creating a final design STL file for the definitive digital denture (**Fig. 13**).

The Wagner Try-in was now a reference in the design file for final set-up and arrangement of the Portrait®IPN® Denture Teeth (**Fig. 14**). Teeth were arranged to the reference and a final base was built before the design file was sent to customer for

Figure 10
Final QC photos of maxillary Wagner Try-in, note the milled maxillary anteriors and first pre-molars are set in wax according to design matrix.

Figure 11
Final QC photo of mandibular Wagner Try-in, note the milled anterior block teeth are set in wax with a posterior wax occlusal rim for establishing records.

Figure 12
The maxillary and mandibular Wagner Try-in is placed in patient's mouth to verify anterior tooth placement and establish VDO/CR with and Aluwax bite record.

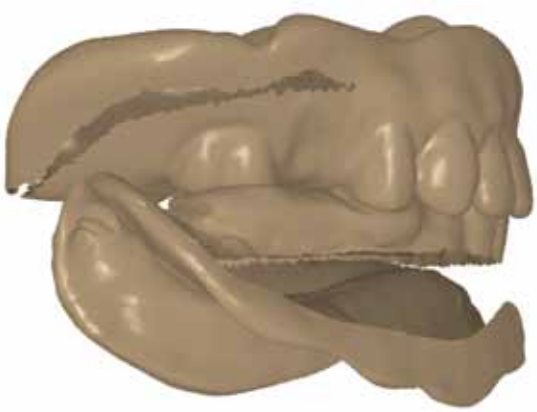


Figure 13
Wagner Try-ins with records are scanned and reference STL file is created.

Figure 14
Maxillary and mandibular teeth are digitally set according to WTI reference

Figure 15
Maxillary and mandibular digital setup with reference is reviewed with transparency to visualize relationship of teeth to ridges. Note the high vaulted palate in transparency view.

Figure 16
Maxillary and mandibular final digital setup and base build before digital preview is sent to customer for design approval.

Figure 17
AvaDent Digital Design Preview is sent to customer for evaluation of complete denture set up and base build. Customer can navigate through preview to analyze design in various perspectives and transparencies. Relationship of teeth to residual ridges is shown above.

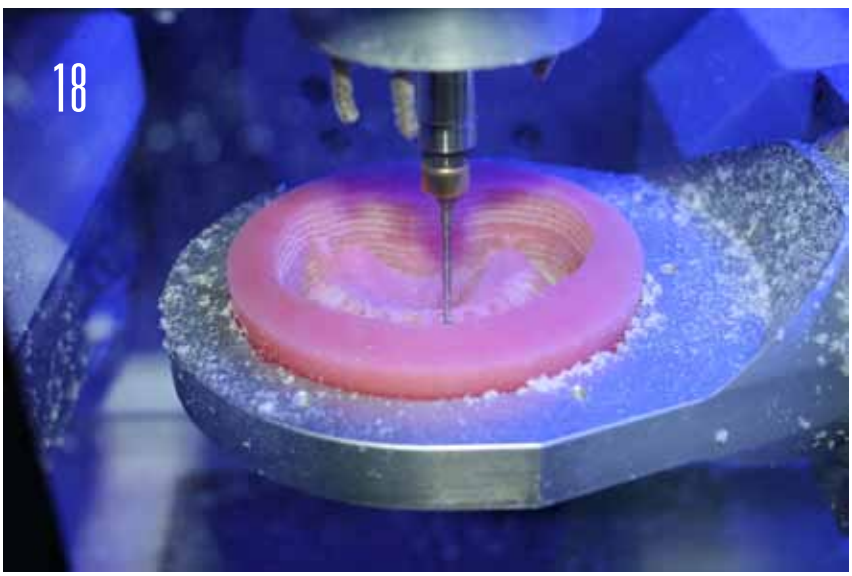
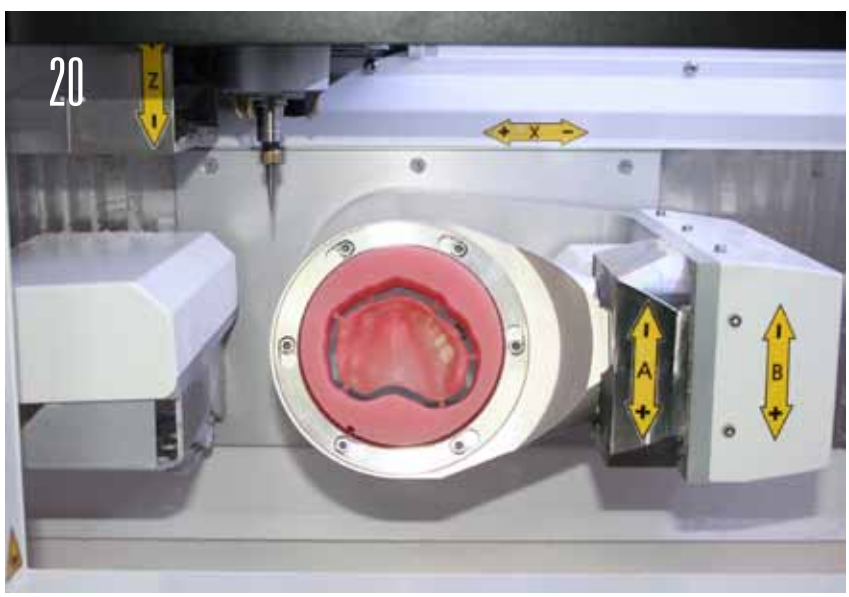


Figure 18
After the Digital Preview is approved by customer files are exported for milling. Pockets for bonding maxillary teeth are being milled.

Figure 19
Portrait IPN Denture Teeth are bonded into milled pockets.

Figure 20
Maxillary puck is placed back into holder for the final intaglio milling pass. Shown final mill of intaglio surface of maxillary complete digital denture.

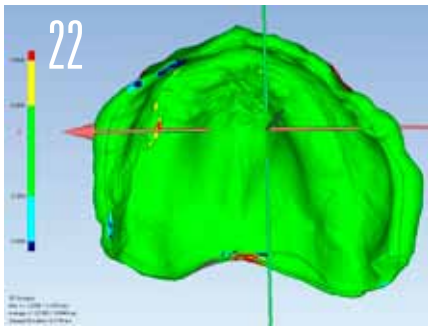
Figure 21
Finished Maxillary milled bonded Denture in puck.



approval (**Figs. 15-16**). After the digital design preview of set-up and base build was approved by customer, the definitive design file was exported to milling (**Fig. 17**). The external of the base was milled with pockets for bonding (**Fig. 18**). The puck was removed and the dental technician bonded the Portrait®IPN® denture teeth to the Lucitone 199® milled denture base (**Fig. 19**). After curing the teeth in pockets, the puck was returned to mill for final pass of intaglio denture surface (**Fig. 20**). The puck was removed from the mill and inspected visually before removing the milled denture from puck for scanning to register milled denture with design file (**Fig. 21**). The intaglio and teeth were digitally registered with the design file to verify the final milled denture was in the same position as the design file that included impression and records (**Figs. 22-23**).

Dentures were then traditionally finished and polished by the dental technician and prepared for delivery to the clinical customer (**Fig. 24**).

At the fourth clinical appointment the definitive set of digital bonded dentures was delivered to patient. As with traditional dentures,



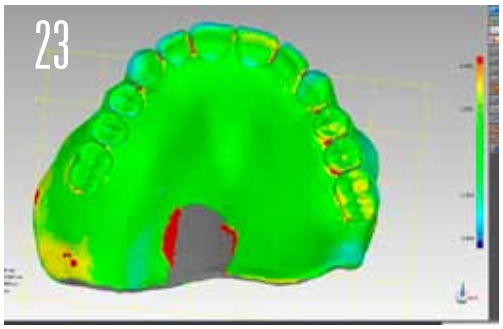


Figure 22
Milled and bonded dentures are removed from puck then scanned for a color map analysis of intaglio tissue surface to master impression.

Figure 23
Color map analysis of maxillary teeth in relation to digital setup.

Figure 24
Final QC photo of finished maxillary and mandibular dentures.

they were verified for retention, stability and functional occlusion. The patient was the final judge of satisfaction with this digital treatment in regards to fit, function and appearance (**Fig. 25**).

Conclusion

The digital denture workflow presented had four clinical appointments. Clinical workflows for two and three appointments have been very successful; these digital workflow options are selected according to variables involved combined with desires and expectations.

Removable complete denture prosthetics is currently in a state of convergence between conventional and digital workflow processes. Digital dentures are evolving rapidly. As these digital workflow processes evolve the advantages to improve communication and collaboration between the clinician and technician become evident. Creating a denture design that is based on rules of geometry while enabling one to precisely measure, analyze and then visualize prosthetic design images in digital perspectives is a main factor that differentiates the digital denture process from conventional. **JDT**

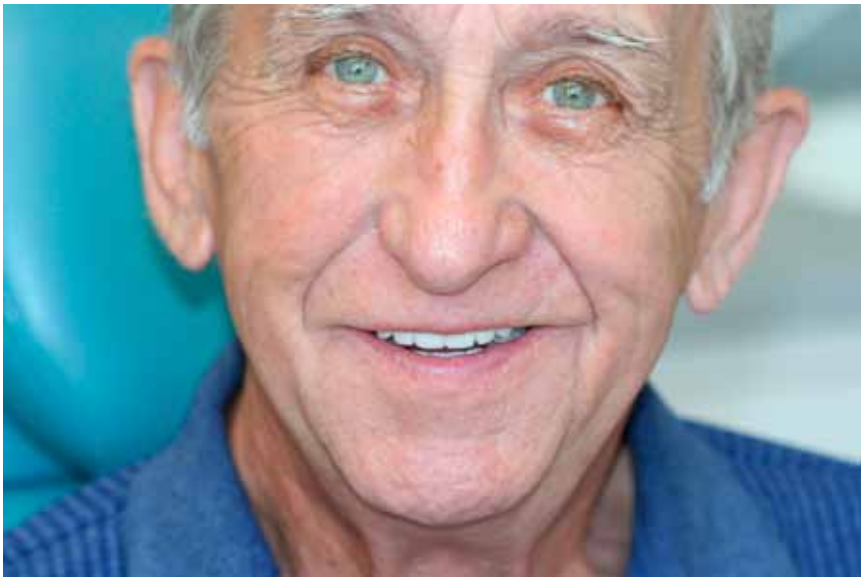


Figure 25
Delivery of a natural, esthetic denture to the patient produced with Lucitone 199® and Portrait®IPN® teeth to the patient.

QUIZ

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