The digital domain

Brenda Baker and **David Reaney** look at how to make the most of the opportunities provided by the brave new world of digital dentistry

The advent of digital technology has had an impact on almost every facet of dental practise.

Modern dentistry uses computerised radiographs, practice management software with computerised databases, and even allows practices to scan documents to create digital records. Other technologies that provide information to clinical practise include digital cameras, intraoral cameras, digital impression units, caries detection units and tooth colourimetric devices.

Digital technology (photography, email, digital models and collaborative software) empowers dentists and technicians to achieve excellence. Decisions can be made quickly and concisely when digital technologies are used before, during and after treatment.

Computer-aided design (CAD) and computer-aided manufacturing (CAM), more generally referred to as CAD/CAM, has grown in popularity over the last two decades (Fasbinder DJ, 2012). The technology is used both in the dental laboratory and in the surgery and can be applied to the fabrication of simple to complex prosthodontics, depending on which system in used.

Dental CAD/CAM technology was developed to address three challenges:

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Education aims and objectives

The aim of this article is to explain how the disparate elements of digital processes in dentistry work, fit together, and benefit the practioner and parient alike.

Expected outcomes

Correctly answering the questions on page 50, worth one hour of verifiable CPD, will demonstrate that the reader understands key terminology and functionality of the digital dental workflow.

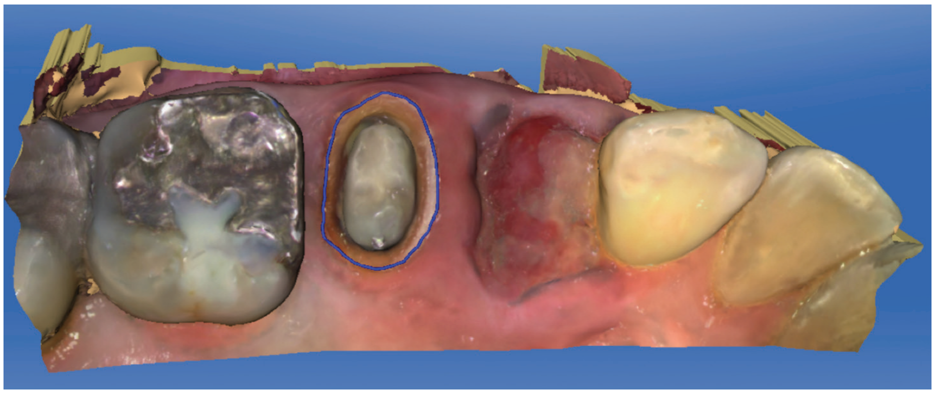

Figure 1: Margin marking is a feature of digital systems

- Ensuring adequate restoration strength, especially in the posterior
- The creation of natural and aesthetic restorations. Demographics combined with increased demand for aesthetic dentistry has resulted in a rise in the number of fixed restorations being provided
- Facilitating production of restorations to be easier, quicker and more accurate.

There are three components to the CAD/CAM system: scanning, designing and milling.

This article will focus on the dentist-laboratory digital communication channels that ultimately improve workflow and dentists' clinical involvement and responsibility so that quality restorative dentistry can be provided.

Digital systems

There are a number of ways in which dentists and laboratories can work with new technology:

- The dentist can take a digital impression and send this to the laboratory. There are several examples of digital impression units (stand-alone configurations), which include the Cadent Itero, the True Definition scanner (3M Espe), the Cerec AC Connect (Sirona), E4D Sky (Planmeca), the Fastscan (Ios Technology) and the Trios (3shape).
- The dentist can use their own computer-aided design and mill in-house. Chairside CAD/CAM systems have manufacturer-specific software programs that permit the production of single tooth ceramic or composite inlays, onlays, veneers and crowns. However, these in-house units have finite capabilities in terms of their material and dimensional span limitations. Complex and larger restorations, particularly for customised zirconia and metal abutments, implant-supported crowns, bridges and overdentures require laboratory manufacturing.

There are two prevailing available chairside CAD/CAM systems that consist of a handheld scanner, a cart that houses a personal computer with a monitor and a milling machine. These are the Cerec Acquisition Centre and E4D Dentist system.

Both chairside CAD/CAM systems also offer the option to be used as purely digital impression systems. The Cerec Connect system for the Cerec AC unit and the E4D Sky Network for the E4D Dentist system are options to allow electronic transmission of the digital file to

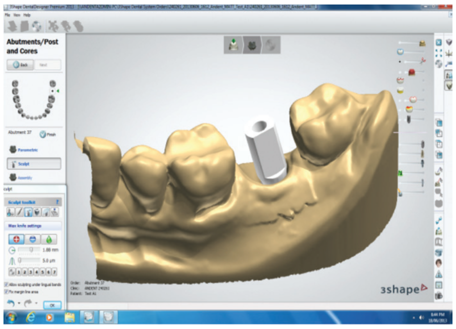

Figure 5: Digital technology is used to fabricate abutment

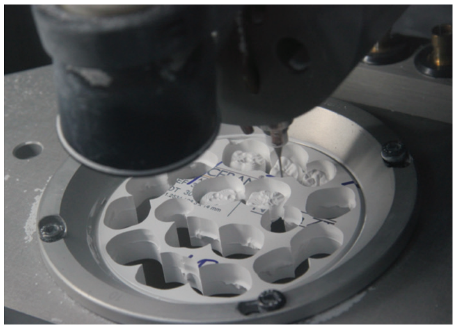

Figure 6: Multiaxis machining is a manufacturing process where computer numerically controlled tools are used to manufacture parts out of metal or other materials

• Dental scanners and dental design software

• Dental design software and manufacturing devices.

Another initiative to standardise design software occurred in 2011, when three companies – Dental Wings, 3M Espe and Straumann – united to create an open global standard software platform to use across a range of applications in dentistry. The software is independent of scanning and manufacturing solutions.

3M Espe and Straumann have embraced DWOS, the software platform of Dental Wings, as the basic operating solution in their CAD/CAM systems.

A technician could design a customised CAD abutment and coping and multi-unit prosthesis to be made in a milling centre with one software solution. The whole design of the multi-unit prosthesis is designed by the technician in any virtual environment.

DWOS has well-established interfaces to the leading intraoral and laboratory scanners, milling devices and three-dimensional printers belonging to different suppliers. This means that DWOS has open interfaces at both ends so it can import scan files from different scanners and scanning technologies and export generic Surface Tessellation Language or Stereolithography (STL) files that can be used for production using any machine with open interfaces. An STL file describes only the surface geometry of a three-dimensional object without any representation of colour or texture (Figure 4).

Software scope

DWOS aims to provide an interface to connect open architecture devices along with a well-defined and secure connection with leading scanning and manufacturing processes, thereby guaranteeing the final quality of the end product.

There are five icons in the menu bar of DWOS that show the basic workflow and which can be summarised as:

Prosthetic design: this contains information about the dentist and the patient

Scan import application: the scanner can either be present near the design station or the scan data can be imported as a file from a scanner located anywhere

CAD engine: this provides automatic proposals based on requirements in the order and scan information

CAD application: this allows changing or optimising the automatic proposal

Production management: DWOS software contains five modules, which can be used independently or as an integrated suite. These modules are:

• The DWOS crown and bridge module is the cornerstone of prosthesis design and permits designs from coping to full contour, from a simple unit to a full arch design. The framework designs are actively adjusted to the shape of the full restoration to allow the most desirable porcelain support. The operator has several editing tools – axis modification, virtual wax knife and contacts between adjacent and opposing teeth. Rotations can occur buccolingually and mesiodistally. Simultaneous designs of upper and lower arches, wax-ups and virtual articulator capabilities are possible in the latest version of the software. Flexibility exists to change the design at any time without losing valuable information

• The implant custom abutment: strategic designing of this module means that one-step planning of custom abutments can be done that considers the clinical situation. The topography of the patient's implant site is automatically computed to fit the designed implant abutment. DWOS features an integrated implant library so the accurate interface geometry is achieved. The framework design is actively adjusted to the shape of the prosthesis. One session dedicated to design means that a custom abutment, framework and the full contour design can be obtained. A workable scanned model from a physical impression that uses a scan body for implant hex position and height is shown in Figure 5

• Partial frameworks: this module allows automated functions such as undercut measurement and block-out and unrestricted design tools that transfer technical information to a digital environment

• Virtual model builder: the aim of this function is to generate a virtual model that can be produced with the preferred manufacturing solution

• Manufacturing modules: there are two manufacturing modules, called DWOS-

Veneer
- ≥0.6mm labial and cervical reduction (do depth cuts)
- ≥0.7mm incisal reduction
- Incisal preparation margins must avoid areas of static or dynamic contact
- Bevel the incisal one third back to the lingual incisal edge
- Lingual preparation is not needed on all veneers. It can be used on the lingual aspect of the cuspid to re-establish canine rise.

Maryland bridge
- 0.5-0.7mm lingual reduction for metal
- 0.8-1.2mm for zirconia or nano ceramic (a non-CAD/CAM zirconium silicate which is reinforced with mesh) and higher clearance required
- Preparation should be enamel instead of dentine
- Use of retentive element is recommended – either a groove, a ridge or a pinhole
- Retentive element must have a minimum radius of 0.5mm
- Circular/island preparation of wings is not possible.

Inlay/onlay
- ≥1.5mm preparation depth
- ≥1.5mm isthmus width
- 6^0 sidewall taper
- Proximal box should be diverging walls
- [Inlay bridge] – contraindicated.

Ideal preparation for all-ceramic restorations

Table 4: Choosing the correct cement

Clinical situation	Type of cement
Tooth-coloured inlays, onlays, leucite-and lithium disilicate-based, hybrid ceramic crowns	Self-etching resin cement or resin cement with prior application of separate self-etching bonding agent
Ceramic veneers and leucite- and lithium disilicate-based crowns, hybrid ceramic crowns demanding optimal aesthetics	Resin cement used after total etch of enamel and a subsequently applied self-etch of dentine.
Crowns and bridges that have repeatedly come loose during service	Resin cement with a pre-cementation application of self-etching bonding agent, applied after both the fitting surface of the restoration and the tooth preparation have been roughened to increase retention
All-metal, PFM, hybrid ceramic crowns, alumina and zirconium-based crowns and bridges 1. With good or adequate retention 2. With minimal or reduced retention	RMGI (useful because of fluoride release) Resin cement with prior application of separate self-etching bonding agent

CAM and DWOS-RPM, which form the interface between the design and production environments. DWOS-CAM handles digital processes such as compensation for shrinkage, calculation of tool paths and paths and curves for milling. DWOS-RPM provides automatic generation – for example, support for rapid prototyping.

Dental networks have evolved as a result of the need to allow dental professionals to connect. The DHS (Dental Hub System) is one such network, which is connected to DWOS software. Many milling centres employ it for the collection of dental design files from clients.

The dynamics of this system means that all scanners used in laboratories in combination with DWOS are connected to DHS and the order requirements, file transportation and order tracking are catered to with this system.

The DHS facilitates a global synergistic platform for technical support people and service centres to access real-time accountability and traceability. All DWOS users are DHS enabled and have connectivity to an ever-growing open dental forum.

Computer-aided manufacturing hardware

When laboratories receive a digital impression, they can create a printed/milled model from the data, either to fabricate a restoration traditionally or to check a digitally produced restoration. Alternatively, the laboratory can do all of the design work directly on the computer based on the images received.

Some digital machines use CAD/CAM resin (polyurethane) models, which are not subject to voids, shrinkage or expansion of materials or defects. The models are strong and durable with excellent marginal adaptation and resistant to abrasion and chipping. Other systems use stereolithography (SLA), which provides a solid model and a working model.

The production of the desired restoration obtained from CAD can be done at either the dental laboratory or at an off-site milling centre. The actual fabrication can be achieved with either a subtractive or an additive technique.

The subtractive technique, which is most commonly used, involves cutting the coping or framework from a solid block. The milling time and type of milling instruments used depends on the block type (green-stage, pre-sintered or fully sintered).

The milling size of the coping or framework depends on material shrinkage during sintering. Sintering is needed to achieve strength for green stage and pre-sintered blocks.

The additive technique involves building a coping or framework by adding material to a die. Selective laser sintering or melting is another way to produce metal frameworks. Laser sintering collects CAD data to create a three-dimensional freeform object. Thin layers of a heat-fusing powder are fused with a scanning laser beam to create a single coping or framework.

The most sophisticated machines are 5- to 9-axis simultaneous milling machines with multi-tool changers, tool sensors and breaker detectors (Figure 6).

With these, dry or wet milling is achievable. This type of machine is unparalleled for milling complex implant situations.

Conclusion

Digital technology has totally altered the capability of the dental team to communicate without the constraints of time or geography, thus producing easily accessible and transmittable records. Lab-side CAD-CAM technologies – increasingly involved in the production of prosthodontics (including implants) and removables – are set to permanently change the face of dentistry and, in many cases, clinical outcomes.

Care to comment? @AesDenToday

References

Fasbinder DJ (2012). Chairside CAD/CAM: An overview of restorative material options. Inside Dentistry 8(5)

Lops D, Mosca D, Casentini P et al (2012). Prognosis of zirconia ceramic fixed partial dentures: a 7-year prospective study. Int J Prosthodont 25: 21-3

McLaren EA, Schoenbaum T (2011). Digital Photography Enhances Diagnostics, Communication and Documentation. Compend Contin Educ Dent 32 Special No 4: 36-38

Fahl N Jr, McLaren EA, Margeas RC (2014). Monolithic vs. layered restorations: considerations for achieving the optimum result. Compend Contin Educ Dent 35(2): 78-9

Pianykh OS (2012). Digital imaging and communications in medicine (DICOM). Springer publishing

Raigrodski AJ, Hillstead MB, Meng GK, Chung KH, (2012). Survival and complications of zirconia-based fixed dental prostheses: a systematic review. J Prosthet Dent 107(3): 170-7