CAD/CAM & DIGITAL SCANNING

Today's CAD/CAM: Flexible Digital Technologies Expanding Workflow Options

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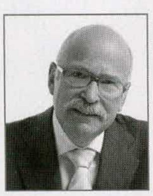
CAD/CAM and digital scanning technologies have become essential components of dentistry. Digital impression scanning, restoration design, and manufacturing techniques yield greater treatment predictability, high-level esthetics, and functional accuracy using a variety of materials.

Although first developed in the 1950s, computer-aided design/computer-aided manufacturing (CAD/CAM) wasn't introduced to dentistry until the 1980s. Following advancements and growth in this technology throughout the past 35 years, digital intraoral scanning and CAD/CAM systems are now commonplace in dental practices and laboratories alike. This recent increase in adoption can be attributed to several factors, including increased computational power, improved scanner technology, superior clinical outcomes, greater cost-effectiveness, and improved clinical and laboratory workflows.

Enhanced productivity, improved treatment planning, and consistent precision and accuracy in clinical outcomes have encouraged many dentists to integrate digital technology into their practices. Early CAD/CAM users utilized chairside units completely equipped with a digital intraoral scanner, design software, and in-house milling for single-visit procedures. However, these early technologies were "closed," requiring practices to use only the equipment and materials specifically developed for those systems.

Today, more flexible and interoperable digital technologies (ie, open systems) provide new equipment and workflow options, including laboratory CAD/CAM restoration design and manufacturing, outsourcing to milling centers, collaborative implant treatment planning, and more. In addition to enhancing workflow models, digital technologies can be utilized in almost any clinical situation, including facilitating treatment of complex cases requiring interdisciplinary collaboration.

The foundation of digitally designed restorations and treatment plans is the creation of a digital file of the patient's orofacial anatomy to provide a basis for diagnosis, restoration design, and manufacturing. Digital images obtained with an intraoral scanner dramatically enhance communication between the laboratory technician and dentist, as well as consultation with dental specialists, to improve treatment consistency and accuracy.



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Establishing the Digital Era

The introduction of CAD/CAM technology simultaneously initiated utilization of intraoral scanning devices. As CAD/CAM systems demonstrated an ability to provide faster, more economical, predictable, and consistent restorations,[1] the development of intraoral scanners also proliferated. Some of today's CAD/CAM systems (eg, CEREC®, Sirona Dental, www.sirona.com; Planmeca CAD/CAM Solution, Planmeca/E4D, www.planmeca.com) can be used for in-house milling and include their own system-specific intraoral scanners to work directly with their software and equipment for design and milling. Although both systems utilize manufacturer-specific software programs, they now offer the option to be used as individual digital impression systems.[2]

Unlike traditional impressions, digital intraoral scanning reduces chairtime, enhances the patient experience, and can improve the quality of the dental treatment.[2] Scanners eliminate such traditional impression-taking tasks as tray selection, dispensing and mixing materials, disinfection, shipment to the laboratory, and all the potential resultant inaccuracies. Additionally, the dentist receives instant feedback after capturing digital impressions, allowing him or her to review the image and modify the tooth preparation prior to submitting it to the laboratory, eliminating the need for retakes at another appointment.[3]

Digital intraoral scanners utilize a variety of technologies to produce accurate images. Blue light-emitting diode (LED) scanners (eg, CEREC Bluecam, Sirona Dental; Lava™ Chairside Oral Scanner COS, 3M ESPE, www.3MESPE.com) project shorter-wavelength intense blue light from blue LEDs, resulting in greater precision of the resultant optical image. Other scanners utilize laser technology to create digital images. Blue lasers (eg, PlanScan™, Planmeca) incorporate a shorter wavelength of 450 nm that, as a result of its refractive nature, creates sharp images and captures fine details. Parallel confocal imaging (eg, iTero® Align Technology, Inc., www.itero.com) also employs laser technology and optical scanning to capture the surface and contours of the teeth and soft-tissue structures. Scanning in accurate color and the ability to capture

HD images along with shade selection is a unique feature of the 3Shape Trios® (3Shape, www.3shape.com).

The various intraoral scanners require different techniques for achieving clear images. Some scanners utilize titanium-dioxide powder placed on intraoral structures in order for the camera to register all of the tissue details. Others scan each tooth individually, while some record video to capture the entire oral cavity. Scanners also vary in length and size, with smaller devices capturing detail more comfortably than larger scanners. Additionally, some scanners work as a component of in-house milling units, while others are completely independent devices. Regardless, all intraoral scanners can provide an almost instantaneous representation of a patient's intraoral situation without the need for impression materials.

Benefits of Digital Intraoral Scanning

Cost remains a major deterrent and explains why some professionals have refrained from integrating digital scanners, as purchasing a CAD/CAM system or intraoral scanner is an investment in technology and training. However, digital intraoral scanners continue to demonstrate benefits for the dental practice, clinician, and patient.

Digital scans save physical office space since they are stored on hard drives indefinitely. They also avoid complications associated with conventional models that can chip or break over time. With no need for physical shipments, digital scans reduce the possibility of remakes due to inaccurate analog impressions. By simplifying the impression-taking process and providing instant feedback, computer-aided impressions benefit dental practices in creating a more efficient workflow.[4]

Similarly, dental laboratories also benefit from switching to digital impressions, as technicians can avoid pouring base and pin molds, cutting and trimming dies, and articulating casts. With margin-defining software, technicians can create precise and accurate restorations without a physical model. In a study comparing crowns from intraoral scans and from silicone impressions, the intraoral scanned crowns demonstrated better marginal fit and interproximal contact area quality.[5]

Innovation is rapidly taking place in the arena of CAD/CAM dentistry. For example, the integration of 3-dimensional radiography with intraoral scanning is an exciting new development that has enormous implication for redefining workflows in implant dentistry. The ability to accurately merge cone-beam CT files with intraoral scan files enables the surgeon, restorative dentist, and dental laboratory technician to accurately plan ideal implant position and pre-plan the final restoration in a collaborative manner that was never before possible.

What the Future Holds

Alongside CAD/CAM technology, application and utilization of digital intraoral scanning will increasingly shift the paradigm of traditional dental workflow models. Similar to having an x-ray machine in each treatment room, dental offices of the future will likely include a scanner in each operatory, and every new patient appointment will include a digital scan as part of the patient's initial evaluation. Digital scans will facilitate diagnosis (eg, oral lesions, pathology, etc.), maintain baseline patient information for future reference (eg, fractured teeth, lost teeth, etc.), and enhance interdisciplinary treatment planning. Scanning technology will also be fundamental for color matching (ie, photospectrometers), assessing wear, measuring tooth shifting, and monitoring occlusal changes (ie, computerized occlusal analysis) over time.

Additionally, concurrent with in-office and laboratory manufacturing, laboratories could increasingly outsource their manufacturing to milling centers, enabling technicians to focus their skills on more artistically sensitive fabrication tasks. Empowered by digital files, scans, and information transfer between dental practices, laboratories, and the milling centers themselves, this workflow model will enhance efficiency in restoration fabrication and reduce laboratory overhead, including costs associated with material inventories. It will also help maintain on-time productivity when overflow occurs. Technicians can then focus on quality assurance while still delivering completed restorations to dental practices. These new workflow options will continue to lower costs for patients, dentists, and laboratories while enabling more predictable and consistent treatments than traditional "handmade" or "hands-on" processes.

In the author's opinion, open architecture is critical for the future development and widespread implementation of CAD/CAM dentistry. As in the computer industry or digital photography, closed systems will ultimately disappear from dentistry, allowing the CAD/CAM user to choose the scanner, design software, manufacturing technique, and dental material of his or her choice. For this to become a reality, file formats will need to be standardized and devices will need to easily communicate in a true "plug-and-play" fashion.

Conclusion

Since CAD/CAM has the potential to reduce many of the variables associated with analog dentistry (eg, human error, material deformation, geographic location limitations), and research is proving the efficacy of digital dental processes, technology will continue to gain significance and prominence. The ongoing enhanced development of CAD/CAM software and manufacturing units, along with intraoral scanners, will provide the impetus for a continued shift in how dental professionals work and collaborate to deliver consistently high-quality treatment outcomes. As more dentists and laboratories invest in digital technologies, digital intraoral scanners and CAD/CAM systems will continue to improve workflow, reduce costs, and contribute to more streamlined procedures.

REFERENCES

1. Child PL. Digital dentistry: Is this the future of dentistry? *Dental Economics*. 2011;101(10). http://www.dentaleconomics.com/articles/print/volume-101/issue-10/features/digital-dentistry-is-this-the-future-of-dentistry.html. Accessed January 30, 2015.
2. Fasbinder D. Using digital technology to enhance restorative dentistry. *Compend Contin Educ Dent*. 2012;33(9):666-672.
3. Olitsky J. Digital impressioning on its way to becoming mainstream. *Compend Contin Educ Dent*. 2012;33(9):692-693.
4. Patzelt SB, Lamprinos C, Stampf S, Att W. The time efficiency of intraoral scanners: an in vitro comparative study. *J Am Dent Assoc*. 2014;145(6):542-551.
5. Syrek A, Reich G, Ranftl D, et al. Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. *J Dent*. 2010;38(7):553-559.