Integrating three-dimensional digital technologies for comprehensive implant dentistry

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ABSTRACT

Background. The increase in the popularity of and the demand for the use of dental implants to replace teeth has encouraged advancement in clinical technology and materials to improve patients' acceptance and clinical outcomes. Recent advances such as three-dimensional dental radiography with cone-beam computed tomography (CBCT), precision dental implant planning software and clinical execution with guided surgery all play a role in the success of implant dentistry.

Methods. The author illustrates the technique of comprehensive implant dentistry planning through integration of computer-aided design/computer-aided manufacturing (CAD/CAM) and CBCT data. The technique includes clinical treatment with guided surgery, including the creation of a final restoration with a high-strength ceramic (IPS e.max CAD, Ivoclar Vivadent, Amherst, N.Y.). The author also introduces a technique involving CAD/CAM for fabricating custom implant abutments.

Results. The release of software integrating CEREC Acquisition Center with Bluecam (Sirona Dental Systems, Charlotte, N.C.) chairside CAD/CAM and Galileos CBCT imaging (Sirona Dental Systems) allows dentists to plan implant placement, perform implant dentistry with increased precision and provide predictable restorative results by using chairside IPS e.max CAD.

Conclusions. The precision of clinical treatment provided by the integration of CAD/CAM and CBCT allows dentists to plan for ideal surgical placement and the appropriate thickness of restorative modalities before placing implants.

Key Words. CAD/CAM; cone-beam computed tomography; implants; restorative dentistry; fixed prosthetics; guided implant surgery.

JADA 2010;141(6 suppl):20S-24S.

Dental computer-aided design/computer-aided manufacturing (CAD/CAM) technology is used in both dental laboratories and dental offices for multiple restorative applications. Chairside CAD/CAM systems for dental offices offer dentists the opportunity to design, mill and place ceramic restorations in a single appointment. As implants become the treatment of choice for fixed tooth replacement, dentists also are considering using chairside CAD/CAM systems as a restorative solution for implant prosthetics. A predictable CAD/CAM technique for dental implantology could satisfy patients' preference for convenience and dentists' desire for predictable, long-term restorations. Clinical research provides documentation of the success of ceramic restorations created using the CEREC system (Sirona Dental Systems, Charlotte, N.C.).[1-4] As the technology has evolved, it also has been used to restore dental implants.[5,6]

CAD/CAM TECHNOLOGY FOR DENTAL IMPLANTS

Initial attempts to fabricate implant restorations chairside with the CEREC system included the use of feldspathic and leucite-reinforced ceramic CAD/CAM blocks. These ceramics require adhesive bonding to be successful in restoring natural teeth. Adhesive bonding to implant abutments remains unpredictable and reduces the reliability of conventional all-ceramic materials. Reports of increasing the occlusal thickness of the restoration beyond the 1.5 millimeters recommended for conventional tooth preparations does not offset the fracture risk of adhesive glass ceramic CAD/CAM blocks used on implant abutments.[6,7] The results of the study by Wolf and colleagues[6] suggest that increasing the thickness of the crown to an unusual 5.5 mm in combination with shortening the abutment does not result in greater crown strength. To date, there have been no published clinical studies in which this type of ceramic material was used to restore dental implants. Despite this lack of published data, the introduction of a lithium disilicate glass ceramic with 360 megapascals of biaxial flexural strength (IPS e.max CAD, Ivoclar Vivadent, Amherst, N.Y.) provides dentists with the option to use either cementation or an adhesive bonding protocol. This material has the potential to be used for definitive implant restorations. The higher flexural strength of the

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material reduces the risk of fracture under normal masticatory load compared with that of conventional glass ceramic CAD blocks.[7-9] The results of the study by Wolf and colleagues[6] suggest that the interaction between abutment material and mode of cementation plays an important role in the viability of conventional glass ceramic CAD/CAM materials. They noted that the use of adhesive resin cement increased the overall fracture load of conventional CAD/CAM ceramic restorations compared with that of nonadhesive cements. With the recent availability of a high-strength ceramic material, a more favorable outcome for implant-supported restorations may occur.

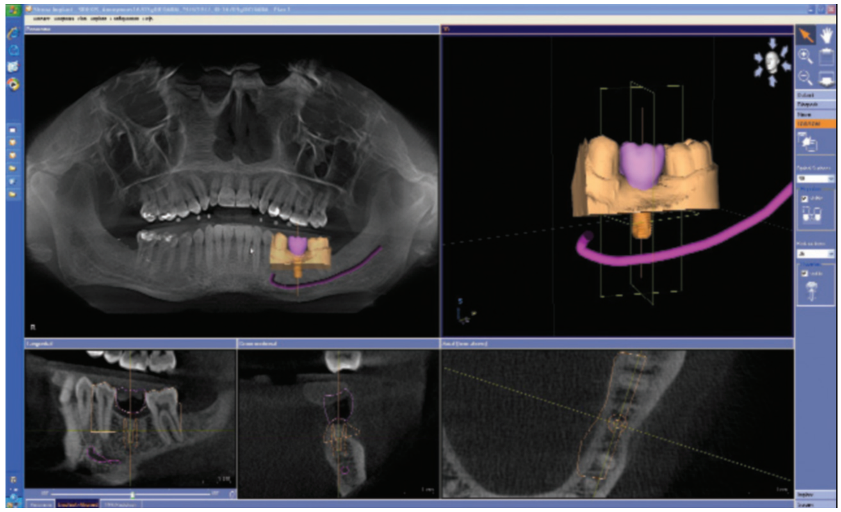

Figure 1. Sidexis and Galileos implant software (Sirona Dental Systems, Charlotte, N.C.) provides tools such as nerve mapping and implant planning. Galileos CEREC (Sirona Dental Systems) integration allows for computer-aided design/computer-aided manufacturing data to be imported into software to create virtual prosthetics, giving dentists the opportunity to plan comprehensive restorative treatment in a single visit. Image of Galileos Sidexis software reproduced with permission of Sirona Dental Systems, Charlotte, N.C.

INTEGRATION OF CONE-BEAM COMPUTED TOMOGRAPHY AND CAD/CAM

The primary emphasis in a surgery-focused approach to implant placement is on the anatomy, bone physiology and surgical success. The restorative demands of the case may be secondary when determining the placement of the implant fixture. During the restorative phase, compensation for deviations in implant fixture location involves the use of complex custom prosthetics components. A technique that requires custom prosthetics designed after surgical placement of the endosseous dental implant does not allow for the implant to be restored in a single visit because of the required laboratory fabrication process.

Dentists need to consider the restorative goal and surgical requirements to plan optimally for the surgical placement of implants. This process requires a plan for the final restoration's optimal function, esthetics and biomechanics before making the surgical plan. The traditional technique for such planning begins with using diagnostic casts, impressions and clinical records. Using the diagnostic casts, the dentist or laboratory technician produces a wax-up to simulate the desired restorative outcome. A stone duplication of the wax-up is necessary for processing either a laboratory surgical guide to help with traditional implant placement or a radiographic scanning appliance for subsequent diagnostic implant planning. This work flow involves multiple patient appointments and separate laboratory procedures involving the clinician and the laboratory technician before the implant can be placed. Because of procedural complexity, the clinician may favor a surgically focused technique for implant placement and treat the restorative process as secondary.

Sirona Dental Systems introduced a combination of three-dimensional (3-D) radiographic imaging and 3-D planning by integrating CEREC Acquisition Center (AC) design with Galileos (Sirona Dental Systems) cone-beam computed tomographic (CBCT) imaging to facilitate comprehensive implant treatment. Galileos CEREC integration (GCI) simplifies restorative-focused implant placements through the use of intraoral surface data (the digital impression) and radiographic data (Figure 1). The GCI technique gives dentists the opportunity to plan optimum prosthetic and surgical outcomes for implants during the diagnostic and planning phases of treatment while minimizing the number of procedures and increasing work-flow efficiency.

By using GCI software, the clinician can identify the restorative requirements virtually, including proper restorative material thickness around the long axis of the planned implant, depth of restorative interface and emergence profile. Such information may help the dentist decide whether to use

ABBREVIATION KEY. AC: Acquisition Center. **CAD/CAM:** Computer-aided design/computer-aided manufacturing. **CBCT:** Cone-beam computed tomography/tomographic. **GCI:** Galileos CEREC integration. **3-D:** Three-dimensional.