Dental laboratories today are truly valued partners and an integral part of the dental team. We possess a wealth of information for our dental clients, from providing material properties and correct indications for use to being on the forefront of how technology is used to manufacture custom patient specific medical devices. We are at the intersection of art, material science, manufacturing and technology. In the current climate of our industry, it is more crucial than ever as their most valued resource to provide our clients with a diverse range of products and services so their patients can receive the highest level of care.

One example of such a service and the product it yields is CBCT guided implant surgical planning and CAD/CAM based surgical guides for implant placement. CBCT stands for cone beam computed tomography, also referred to as C-arm CT, cone beam volume CT, or flat panel CT. This is a medical imaging technique consisting of X-ray computed tomography where the X-rays are divergent, forming a cone. Surgical guides and templates for implant cases have been around for many years and there are ways to fabricate them without the use of CBCT and CAD/CAM software, however, CAD/CAM based surgical guides are quicker and less expensive to fabricate with guided surgical software in the lab than ever before, making them a great way for a lab to diversify its product offerings and bolster value added services for our clients. In this article the author will present a CBCT guided surgery case from surgical consultation and implant placement planning with the clinician utilizing coDiagnostiX surgical planning software (codiagnostix.com), to the design and fabrication of the CAD/CAM based surgical guide in the laboratory using a Carbon M1 3D printer (carbon3d.com), as well as the implant placement surgery using the CAD/CAM based surgical guide.

CAD/CAM based surgical guides allow a general dentist or surgeon to place an implant or multiple implants in a pre-determined location and use implant specific integrated drill guide sleeves that control the angle and depth at which the implant is placed. CBCT guided surgical software uses a DICOM file from a patient's cone beam scan which provides crucial data about the patient's anatomy (bone density, nerve location, soft tissue, etc.) combined with data showing the patient's existing dentition and occlusion via an .stl file from an intra-oral scanner (or a stone model from a traditional PVS impression scanned in a lab scanner) to plan the implant placement.

Most guided surgical software on the market includes a digital wax-up feature allowing a technician
to take into account the desired shape and position of the final restoration so the implant can be placed optimally for the best esthetic and functional outcome (Fig. 1). CBCT guided surgery also expedites and streamlines the restorative process because an immediate temporary restoration and/or custom healing abutment can be designed, fabricated and delivered with the CAD/CAM based surgical guide. An added benefit to immediate custom temporization is this; since the emergence, shape and contour data is saved digitally by the lab, the clinician can simply take a final impression after the healing process concludes and replace the healing abutment with the final abutment and restoration with confidence that they will match the healing abutment’s emergence and be an exact match to the healed tissue contour.

It is possible for implants to be placed successfully without the use of surgical guides and many clinicians have surgical planning protocol in place that allows them to deliver a high standard of care for their patients without utilizing guides. Planning the placement of an implant with the use of a CAD/CAM based surgical guide, however, adds a technological tool to the surgeon’s arsenal and allows the clinician and lab to collaborate more effectively, building synergy and consistency. In the author’s experience, the use of CAD/CAM based surgical guides is equally beneficial for a single unit implant restoration as for more complex multi-unit restorative scenarios because the position, angle, and depth at which an implant is placed can affect the esthetic and/or biomechanical (functional) result. A case that is poorly planned can result in implant placement in a site with inadequate osseous support creating an osseointegration issue and subsequent implant failure, or in some cases, nerve damage can occur if an implant is placed too close. These are more serious consequences of a poorly placed implant but in the author’s experience a compromised esthetic result is much more common and results in an unsatisfactory outcome, often requiring a re-make. Studies show CAD/CAM based surgical guides yield a more predictable outcome than basic guides and templates (which only offer a suggested implant placement based on the proposed final restoration contour in relation to the selected implant site) because they offer 3D views of the bony morphology and anatomical structures and because the CAD/CAM based guide design software allows the technician and clinician to fabricate a guide which limits the angulation and depth at which the implant is placed.¹

For a single unit implant case with a restoration cemented to a custom abutment, correcting an
angulation/positioning issue is often achieved effectively with the custom abutment design and/or by using a custom abutment with an angled screw channel. On multi-unit implant cases, screw-retained cases and implant retained denture cases, however, poorly placed implants with spacing or angulation issues often means the screw access will exit the buccal surface, and in some cases as the example shown here, the poor outcome can be dramatic (Fig. 2). Just as treatment planning with diagnostic wax-ups and the newer digital smile design software allows dental professionals to achieve better results for non-implant restorative cases with all-ceramic crowns and veneers, CBCT guided surgical software and CAD/CAM based surgical guides allow implant surgery to be performed with precision, yielding very predictable outcomes for dentists and their patients.

A decade ago, CAD/CAM based surgical guides for single unit implant cases were not commonly utilized. Most were fabricated only for complex cases, and only a handful of dental laboratories were providing them to their clients; the chief reason being the surgical software available on the market was limited and very expensive, meaning that only large labs or large surgical practices could afford to purchase it. The number of implant platforms and

Figure 4
The DICOM file from the patient’s cone beam scan is imported into the CoDiagnostix (www.CoDiagnostix.com) surgical software

Figure 5
The patient’s study model is scanned and the .stl file is imported into the surgical software and combined with the DICOM file

Figure 6
The guided surgery consult is performed via WebEx and the dentist selects and places the implant digitally in the CoDiagnostix software with the Ziemek surgical specialist. The implants are Biohorizons Mount Free Tapered, 3.8mm x 15mm. (www.Biohorizons.com)
implant companies participating in the process was limited, meaning guides could not be fabricated for every implant platform. The fabrication of CAD/CAM based guides was also an issue, with milling as the primary fabrication method. Exacerbated further by limited materials available for milling and compatibility issues with the types of files exported by the software, fabrication was limited to just a handful of milling machines meaning the cost of the surgical guides was very high and the time required to produce was usually weeks.

Today there are many more CBCT guided surgical software options on the market. These options span different price points and offer varied levels of lab participation, from outsourcing fabrication of guides to third parties, to providing the implant placement consultation and fabricating CAD/CAM based guides in the lab. Examples of some software options available today are Simplant (dentsplysirona.com),

Figure 7
The surgical software is utilized to design the surgical guide with the collected data

Figures 8a - 8b
The guide is printed from Whip Mix Surgical Guide Resin (www.whipmix.com) on a Carbon M1 3D Printer (www.carbon3d.com)

Figures 9a - 9b
The guide is removed from the Carbon M1 3D Printer and post processed by a combination of cleaning in isopropyl alcohol and curing with UV light in a curing unit by Dreve (www.print.dreve-america.com)
Fabrication of CAD/CAM based surgical guides is achieved by milling and 3D printing, with milling being the primary method used in past years, but with the evolution of 3D printing technology and available materials, printing is now a very common method of fabrication which has lowered the price of production per guide and the speed at which they can be produced. General dentists and specialists are now designing and fabricating their own CAD/CAM based surgical guides in-office with desktop printers like Formlabs (formlabs.com) and MoonRay (sprintray.com) or chairside milling units like the CEREC MC XL/MC X (dentsplysirona.com). Labs that are fabricating CAD/CAM based surgical guides with 3D printers are using machines from Carbon (carbon3d.com), Formlabs (formlabs.com), Envisiontec (envisiontec.com), Stratasys (stratasys.com), 3D Systems (3dsystems.com), and more.

CAD/CAM based, 3D printed surgical guides are designated as a Class 1 exempt device by the FDA. To be in full compliance and legally protected from liability, it is important to note that the lab technician cannot make clinical decisions and needs to require the surgical clinician to approve the final planned implant placement.

At the time of publication the patient featured in this article was still healing from the implant surgery and the final custom abutments and restorations were not yet fabricated, however the article serves to illustrate the process of CBCT guided implant surgical planning and CAD/CAM based surgical guide fabrication in the lab leading up to the custom abutment and final restoration fabrication. In conclusion, labs and clinicians now have many more options when looking to add CBCT software guided surgery and CAD/CAM based implant surgical guides to their list of products and services. The evolution of dental materials and technology will continue to improve processes and shape the direction of our industry’s future.  

**Figure 10**
The drill guide sleeves are placed in the surgical guide

**Figures 11 - 12**
Day of surgery, the guide is placed in the patient’s mouth and the implant surgery is performed.
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References

About the Author
Jamie Stover, CDT is the Chief Operations Officer Ziemek Laboratories, DAMAS, Olympia, Wash. Jamie utilizes over 20 years of experience at the bench as a dental lab technician to manage and oversee all daily operations at Ziemek Laboratories. Jamie has written dozens of articles for national dental publications and he lectures regularly on a myriad of topics for dental professionals. Jamie is a member of the Dental Technician Alliance of the American College of Prosthodontists, a member of the Straumann Speaker Bureau, he is on the team of professional contributors at Dentalcompare.com, is an Align Dental XP Lecturer, and is a Special Section Editor at Inside Dental Assisting.

Figures 13 - 14
The x-ray image showing the implant post-op* and healing caps in place.

*Image courtesy of Dr. Steve Russell DDS, Olympia, Wash.