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BUSINESS STRATEGIES FOR DENTAL LABORATORY DECISION MAKERS

Just as 3D printing technology revolutionized the hearing aid industry—95% of hearing aids are now printed—it's poised to transform fabrication processes in our profession. LMT shares experiences, challenges and advice from early-adopter lab owners and managers who've successfully implemented printing into their workflows.

By Kelly Fessel Carr, Associate Publisher/Editor, and Laurel Carbonneau, Associate Editor

"Printing has revolutionized my manufacturing process," says Michael Smith, BBA, CDT, Owner, Sierra Dental Arts/Sierra Milling in Dayton, TN. "I'm excited the industry is embracing printing because it's a much more environmentally friendly and cost-effective process than milling and conventional fabrication. When used in conjunction with intraoral scanning, everything stays digital, from start to finish."

3D printing is touted for eliminating waxing and model pouring, increasing efficiency and completing the fully digital workflow, and reducing material usage, production and turnaround times. "We can load an entire batch of copings and frameworks before we leave and when we arrive in the morning, everything is ready to sprue up and cast or press," says Randy Blackburn, President, Blackburn Dental Laboratory, a 45-person lab in Pearl, MS. "The accuracy of our printed copings is such a big step above hand waxed or milled ones."

Lab owners are also excited about printing because it's opening the door to offering new services. "Since buying our MoonRay printer [from SprintRay] six months ago, we've brought aligners in house and added a removable department. I had no interest in doing traditional removables but now we can print try-ins and denture bases and then mill the denture teeth. Also, our dentists started asking us to print study models for them so we've started offering that as a new service; that was a surprise," says Darin Throndson, President, Innovative Dental Technologies, a full service, three-person lab in Memphis, TN.

Orthodontic laboratory owners have been especially quick to embrace printing technology, largely because their orthodontic clients have been quicker than the general dentist population to adopt intraoral scanning. For example, Kevin Mader, President, Provident Laboratory Services, a three-person orthodontic lab in Omaha, NE, has been printing models on his Stratasys Objet30 Orthodesk for four years. Prompted to get a printer by one of his clients who bought an intraoral scanner, he says the combination of intraoral scans and printing offers numerous advantages, including more accurate impressions and final results, ability to save the digital file rather than store models and easily print a new model and make a replacement retainer without having the patient return to the dental office for a new impression. "Plus, it shows patients that the orthodontist is keeping up with the latest technology and you can send a 3D model home with the kids, which they always think is cool," says Mader.

Looking to get in on this hot trend? Here are key considerations:

Where Do I Start?

Printing models is step one for most labs getting involved in the technology. Similar to implementing CAD/CAM technology, many start by outsourcing model fabrication to another lab or manufacturer. Then they purchase a printer if they want more control over the fabrication process and/or determine it's more cost effective to own than outsource. "I look for an 18-month ROI on my equipment. So, once I started spending $350 per month on outsourcing my printed models, I knew it was time to buy a printer and that I could break even in 18 months," says Throndson.

For others, however, staying on the cutting-edge of technology is more important than ROI. "We looked at implementing printing as a long-term growth strategy for our lab. We were making an investment in learning digital and gaining experience so that when our

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clients were ready to go digital, we'd be ready for them," says Michael Wright, CDT, President, Orthodent Laboratory (ODL), a 30-person orthodontic laboratory in Williamsville, NY; he has purchased two heavy-duty EnvisionTEC Vectors in the past two years and is now printing about 150 to 200 models per day.

Which Printer is Right for Me?

3D printing technology was first developed in the 1980s and has been available to laboratories for less than a decade (see *3D Printing Through the Decades* on page 18 for related coverage). Recently, there has been an influx of new printers on the market, giving laboratory owners a lot of options from which to choose (also see LMT's comprehensive *Product Focus: 3D Printers and Materials* starting on page 25).

Here are some important shopping tips:

Determine Your Needs. Do you want to print models and/or surgical guides? Do you want to print 100 models or 25 higher-accuracy models per day?

"Don't buy a printer that's only good for one thing and expect it to do everything. Buy the printer that's best for the work you're looking to do," recommends Danny Ulaszek, Vice President, Artistic Dental Laboratories, a full service, 85-person laboratory in Bolingbrook, IL.

Knowing what you want to print will help you determine the level of accuracy you need from a printer. For instance, Throndson offers this advice:

- If you're going to print and then cast the unit, 25-micron accuracy is required.
- For C&B models to check margins and occlusion, the 50-micron range is acceptable.
- For dentures, models for aligners, surgical guides and occlusal rims, you need 100-micron accuracy.

Cost: Printers range in price from around $4,000 to well over $100,000. Chris Roman, Owner, Oak View Dental Laboratory, a four-person C&B lab in Washington, PA, has a Formlabs printer and selected it because of the $4,000 price tag. "It's a good entry-level printer and an easy, affordable way to get into printing," he says. He's printing models and surgical guides and uses Formlab materials.

You can buy or lease most printers. However, one company, Carbon, offers a different option: you pay a three-year subscription fee that includes all maintenance and upgrades; you never actually own the printer and after the subscription expires, you can upgrade to a new printer or renew your subscription.

Blackburn, who recently subscribed to Carbon M1, says he did so "because the reliability of my previous printers wasn't great; they were breaking down a lot. For us, Carbon makes sense because the $25,000 per year subscription includes maintenance so it seems more cost effective and efficient; we're not going to get hit with a huge bill and I won't get stuck with technology that will become outdated."

Another consideration is the size of the build plate on the printer; it determines the amount of work you can print at one time and, depending on how you position the part, it can impact the printing speed, too. For example, if the build plate is too small to lay a model flat, you may have to stand it up which means it will take longer to print.

Material Options: The race is on to expand printing material options, get them FDA approved for long-term use in the mouth as well as develop new materials. Right now, there are materials for printing C&B and orthodontic models; indirect bonding trays; gingival masks; surgical guides; splints; nightguards; castable copings, frameworks and partial dentures; and denture bases and teeth.

Many printers work hand-in-hand with the manufacturer's printing resins, giving you the convenience and efficiency of getting the company's technical support for both the machine and materials.

However, some printing systems offer the flexibility to use materials from other sources. For example, Dane Barlow, Owner, Smiles Inc., a three-person, C&B lab in Boise, ID, purchased a non-dental-specific printer, the Uniz Slash+. "Uniz offers resins but after much experimentation and testing of different resins and shrinkage rates, I decided to use a third-party resin for my models: Fun To Do resins; I use their snow white resin and Castable Blend," he says.

Likewise, one of the reasons Throndson purchased his MoonRay printers is because of the open source option for materials. "I don't like being locked into one company's materials," he says. "Plus, being a DLP printer, it's fast and efficient." (See *SLA, DLP, CLIP: What's the Difference?* on page 22.)

Training and Support. Users agree that the company behind the printer and its technical support are very important factors when choosing a printer.

"Who are you going to call when things go wrong? It's inevitable that the machine is going to go down. You need to know you have someone to call," says Ulaszek, who purchased two Asiga Pro 2 printers because of his great relationship with Whip Mix, the U.S. distributor of Asiga, as well as the accuracy and simplicity of the machine.

Smith agrees. "Support is the number one thing you need," he says. As one of the first EvoDent customers in the U.S., Smith is part of a Facebook group that offers support and assistance to other lab owners who are just buying EvoDent printers.

What are Some of the Challenges?

Learning Curve: Users agree there's no one plug-and-play system so some experimentation and patience are required. "Don't get frustrated initially. It will take a few print runs to get dialed in," says Lonni Thompson, CDT, President and Owner, Image Gallery, a six-person C&B lab in Dublin, OH.

Roman agrees. "3D printing is vastly different than waxing and milling. The biggest thing we've run into was inconsistent models. We had to find the correct build angle and orientation that gave us the repeatability we were looking for. Finding the settings that worked best for us was a trial-and-error process of printing the same model in different positions then eliminating them based on fit until we found the best settings to use."

Post Processing to remove support structures, clean and/or cure the printed part varies depending on the printer. For example, the Stratasys Objet30 Orthodesk requires blasting off the support material with a pressure washer and then a 20-minute soak in a diluted lye solution; the parts are completely cured during the printing process.

Other printers, however,

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require a two-step post process: a wash in a 99% alcohol bath in an ultrasonic cleaner and then light curing. The length of time for the wash and light curing varies depending on the printer and the type of part being printed.

Some printing companies also sell washing and curing units, offering convenient accessories for post processing. It's important to note that surgical guides and any other printed parts that are going in the mouth must be cleaned in a separate alcohol bath to avoid cross contamination.

To save money, Darin Throndson has taken the DIY approach to his washing and curing units:

- He made his own washing station using a 2,000-ml beaker for the alcohol with a 2" metal pellet in the bottom. He positions it on a magnetic plate which spins the metal pellet around, creating a tornado effect in the beaker; printed units go into a basket that's set into the beaker.
- "For the curing box, I bought two U-shaped light-cure boxes like you see in nail salons, put them together, then replaced the lights with LED bulbs which don't lose their strength or generate heat. So, for $160 we have a custom-made curing box," he explains.

Switching from Plaster to Plastic: Getting used to working with a plastic model rather than a plaster one requires some time and training. "The plaster model, being porous, has surface tension whereas on the 3D resin model, the wire slides while adapting. The printed model also requires adequate blockout of undercuts because it doesn't have the same give as plaster. It took several weeks to get the feel of the resin model," says Mader, noting that one nice feature of a resin model is that there are no air bubbles that get introduced to the acrylic and therefore no presoak time prior to the acrylic process.

Preparing the STL Files: If you're accepting digital impressions, you'll also need to prepare the files prior to printing. "The files don't come in clean. You have to add a base if you're printing a model, clean up artifacts and stray data and remesh the file to make it print ready," says Wright. "Doctors just send their scans; they expect you to know what you're doing to generate a good output."

Wright also cautions that it can be a challenge to get dentists to pay the higher fee for a printed model. "I charge an extra $12 for a digital model and that can be a hard pill for some dentists to swallow. It required a lot of training and explaining that the cost is offset by the benefits: a more accurate model, no impression material expense, no gagging patients in the chair and less chairtime," he says.

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What's on the Horizon?

In addition to the wealth of new printers on the market, there's also a move to automate the printing process. For instance, Structo recently announced a new desktop printer, the Velox, that has a rotating carousel that moves the case through printing, washing and curing, allowing users to go from STL file to final printed appliance with one machine.

Users are also enthusiastic about the potential printing materials in development. In addition to removable prosthetic materials, "the holy grails are a printable ceramic approved for use in the mouth that dentists could code as an all-ceramic crown for insurance purposes and a printable aligner material," says Throndson. "The aligner material is especially challenging because it has to be really thin for comfort, strong, flexible and crystal clear."

Many lab owners believe the technology will become the definitive manufacturing process in the lab. "3D printing will replace milling once the accuracy and materials get better. Look at milling now versus 10 years ago; it's a completely different world. The same thing will happen with printing in the next 10 years," says Roman.

Smith agrees, saying, "I don't think we've scratched the surface as to how we'll use printing in the laboratory in the future." LMT

SLA, DLP, CLIP: What's the Difference?

There are several types of printing technologies and their capacity, accuracy, speed and prices vary. These are some of the most common technologies used in the laboratory:

SLA (Stereolithography)— widely recognized as the first 3D printing process to be developed—is a laser-based process. A photopolymer resin is put into a vat with a movable platform inside. A laser beam is directed in the X-Y axes across the surface of the resin according to the STL file and hardens the resin precisely where it hits the platform. Once a layer is complete, the platform drops down by a fraction, the subsequent layer is traced by the laser; this continues until the entire object is completed and the platform is removed from the vat.

DLP (digital light processing) works in a similar manner except it uses a more conventional light source, such as an arc lamp, with a liquid crystal display panel or a deformable mirror device, which is applied to the entire surface of the vat of resin in a single pass, generally making it faster than SLA.

A few months ago, Michael Smith, BBA, CDT, Owner, Sierra Dental Arts/Sierra Milling, Dayton, TN, switched from an SLA printer to an EvoDent Series 1 DLP printer. "Once we dove into DLP, which has a higher resolution, we saw the accuracy and detail of our models improve dramatically," he says.

MSLA (Liquid Crystal Mask Stereolithography): Developed by Structo, this proprietary technology uses a panel light source array and a liquid crystal film mask to control which regions of the printing plane are illuminated by the light source. Wherever it allows light to pass through, the light strikes photocurable resin, causing it to solidify to form a layer of the printed object. This process repeats itself until the entire object is printed.

CLIP (Continuous Liquid Interface Production) is unique to Carbon's M1 and M2 printers. Rather than repeated layering, the company's printers "grow" parts from a pool of resin using digital light projection and oxygen permeable optics.

One of the reasons Jamey Schropp, Owner, Midwest Dental Arts, Swisher, IA, has a Carbon printer is speed. "It's nearly three times as fast as other printers with the same accuracy," he says.

Extrusion, also known as Fused Deposition Modelling (FDM) or Freeform Fabrication (FFF): This process works by melting plastic filament—which is deposited via a heated extruder one layer at a time—onto a build platform according to the STL file. Each layer hardens as it's deposited and bonds to the previous layer.

Material Jetting uses a printhead—similar to those used for standard inkjet printing for paper—to dispense droplets of a photosensitive material that solidifies under ultraviolet (UV) light, building a part layer-by-layer.

SLS/SLM (Selective Laser Sintering/Selective Laser Melting) features a laser that sinters particles of powdered materials including alloys. This is the type of technology that Argen Digital uses to print copings and bars and 3DRPD uses to print partial denture frameworks.

Sources: 3dprintingindustry.com, aniwaa.com and 3dhubs.com*

***Editor's Note:** Aniwaa.com calls itself the "IMDB [Internet Movie Database] of 3D Printing." Created by two childhood friends from France, their website is a robust database of 3D printers, scanners and filaments; the site currently boasts a catalog of 1,250 printers. One helpful feature for a prospective 3D printer buyer: a comparison tool that allows you to filter printers by print technology, price, material, manufacturer and more. LMT

3D Printing and FDA Regulations

Here are some guidelines regarding FDA regulations and printing from Safelink Consulting:

- **Surgical guides:** If you're printing surgical guides, you need to register with the FDA and make sure the software in the printer has a 510(K) that shows it's validated for printing those devices.
- **Bite guards or splints:** Class II materials used for these appliances must have a 510(K). A laboratory doesn't have to register with FDA unless you're marketing a splint to treat migraines, TMJ, etc.

For more information, visit FDA.gov.