A Buyer's Guide to 3D Printing Technologies for Dental Applications

stratasys

3D printing in dental laboratories is quickly becoming the industry standard, and labs that haven't embraced the technology may find themselves falling behind. As 3D printers become more established, many labs just entering the 3D-printing game are faced with the difficult decision of selecting which printer is best for their lab. After all, not all printers are created equal—it all depends on what you want to use them for.

"Each [3D printing] technology shines in specific areas," says Ron Ellenbogen, Director of Dental Products line. "Dental labs that have been printing for a while find that no one technology does it all. Ultimately, they pick and choose 3D-printing solutions based on the best fit for the lab and the applications they are seeking to produce."

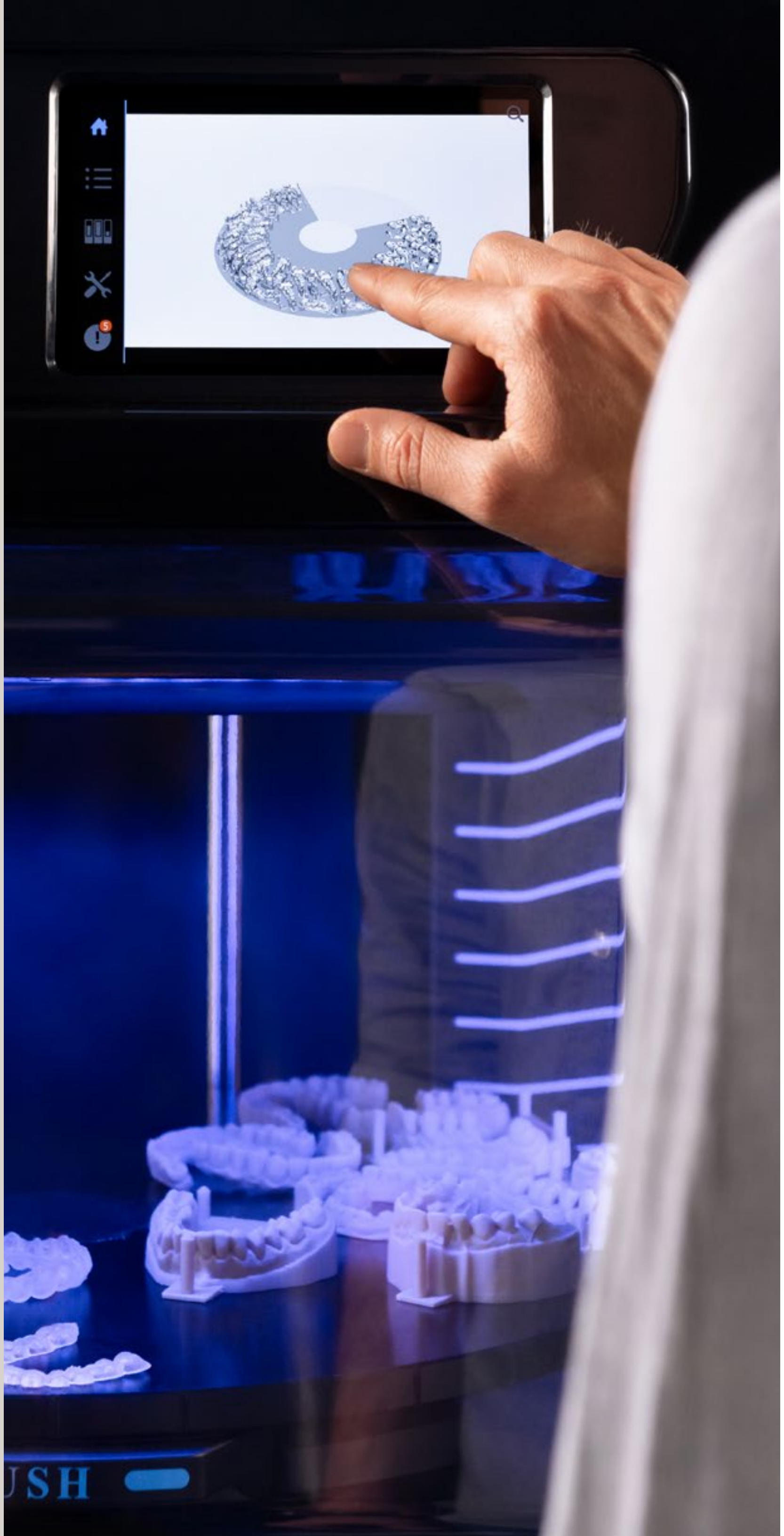
Understanding the dental applications for each technology can save labs time and money when it comes to production. So, what do labs need to consider before they invest?

Evaluating Technology

The first step to integrating 3D printing is to identify the lab's 3D-printing goals. This includes evaluating everything from the purpose of the printer to the return on investment (ROI) of the technology. Ellenbogen recommends that labs consider the following questions before making a purchase:

- How many parts will you be printing daily?
- What are the important requirements for your business and customers?
- Does the printer support the materials and/or applications you want to print?
- Does the printer offer flexibility, printing multimaterials, etc?
- What are the additional costs beyond hardware that you need to consider?
- What kind of service and support will you get from the printer manufacturer or the reseller you purchase from?

"Labs should buy the printers that fit the needs of their business," Ellenbogen says. "Often, as you start marketing yourself as a lab that prints, you find more and more opportunities to make more of your lab's products on a printer. Then you should be evaluating [whether you] use what [you] have or buy a different printer based on the materials being offered, and whether you can grow that segment of the business."



The 3D Printing **Basics**

Before you can identify which printer to purchase, it's important you understand the basics and capabilities of 3D printers in general. With numerous printer options designed to manufacture a wide range of materials and end products, labs must decide what they want to print and what materials that will entail.

"The 3 most common applications in 3D printing are model printing, surgical guides, and end-use parts," Ellenbogen says. "End-use parts are quickly expanding from Class I devices, [such as] custom trays and IDB's for ortho, to Class II devices, [such as] permanent crowns and dentures."

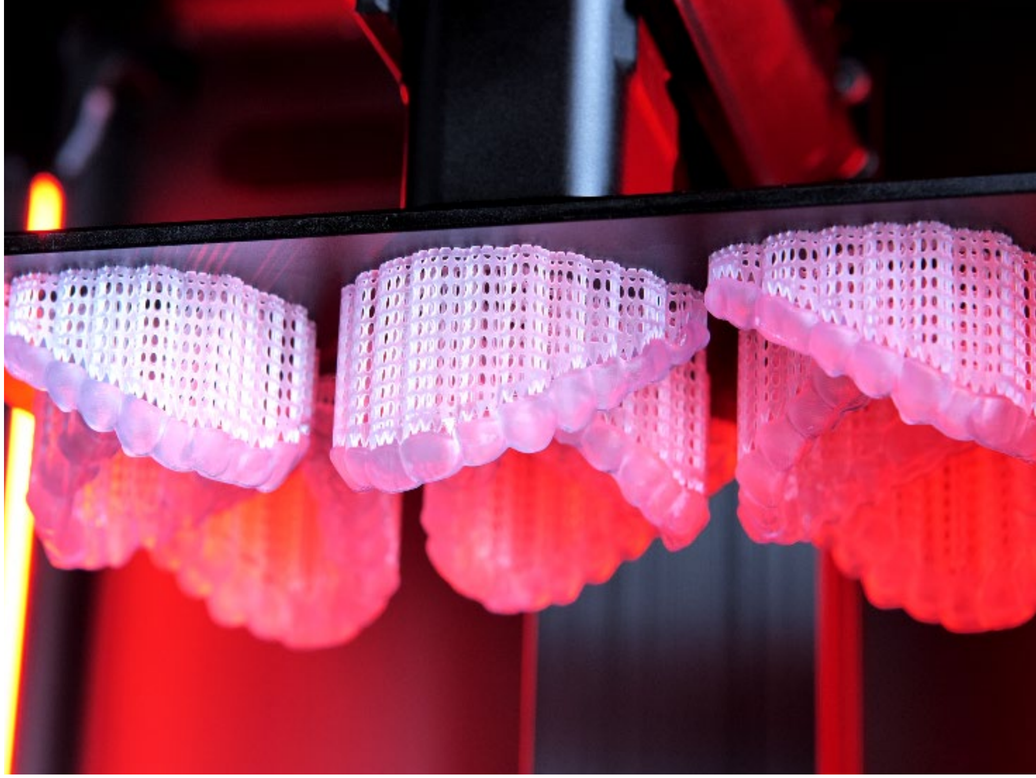
In addition to models and surgical guides, 3D printers are being used to create other end-use parts, such as bite splints, night guards and provisional restorations. With such a wide array of uses, 3D printers can manufacture just about any end product labs are looking for.

There are a wide variety of materials that can be utilized to create these finished products. Thermoplastics, thermosetting plastics, and biocompatible resins are used in different printing processes. Labs looking to invest in a printer should consider what type of material they will utilize most often, what brand of materials are out there, and what each brand or type excels at.

"Not all materials are created equal, and within the same application group, you can find differences in printing quality, mechanical properties, surface finish, color, price, print speed, etc," Ellenbogen says. "To make sure you choose the correct materials, we recommend working with the printer manufacturer to make sure the materials are optimized for the printer, then validate that you are picking the best materials for your use case."

The Technologies

Which technology is the right investment for your lab? There are several different families of 3D printers that all come with their pros and cons, depending on your lab's priorities.



Origin One™ Dental - DLP (P3) Technology

Digital Light Processing

The most widely used technology across dental applications is digital light processing (DLP). This technology has numerous benefits, including broad material offerings, speed of printing, and accuracy. Although it is similar to SLA printing in that it uses vat polymerization, DLP printers create entire layers at 1 time using a digital projector, as opposed to SLA's point-by-point approach via laser. This reduces the print time and provides more accurate results.

"DLP is awesome in a production environment with flow technology or for parts that have stringent material and mechanical requirements, [such as] splints or permanent crowns," Ellenbogen says. "For Class I and II medical device end-use parts, evaluate that the resins, hardware, and software are all used to produce the parts your accounts want."

New advances in DLP technology are broadening the scope of DLP printing and accelerating production time. Programmable PhotoPolymerization P3™ technology from Stratasys allows for the mass production of functional end-use parts. A programmable, carefully orchestrated print process maximizes strength and production speed, and highperformance photopolymer materials result in optimal strength and precision. The Origin® One Dental 3D printer incorporates this technology to help labs scale up production of dental models, splints, and surgical guides.

Although DLP printers generally cost more than SLA printers, the quicker print times often offset the cost of equipment. "I once had a lab that tracked their costs across multiple printers that they operated. [They tracked] the cost of resin, the cost of consumables, the cost of spare parts, [and] the cost of service, then divided all those costs by the number of models each printer produced each month," Ellenbogen says. "Surprisingly, using this total cost of ownership model resulted in the most expensive printer having the lowest cost per model."

PolyJet™

A technology pioneered by Stratasys, jetting is ideal for producing multi-material mixed trays, full-color printing of realistic dental models or dental appliances such as dentures. These printers create models through a process similar to household inkjet printers. However, instead of jetting ink, PolyJet printers are loaded with resin cartridges which is jetted and cured on the build tray. Each resin is jetted and fully cured as it is applied in up to .018 micron layers, including a thin layer of support material that encapsulates each printed part. The technology can produce complex geometrics and intricate details, resulting in highly accurate parts. This makes it incredibly useful for printing applications that require high precision, such as crown and bridge models, implant models, and surgical guides.

PolyJet can also print thicker layers more quickly and by doing so increase throughput while achieving standard accuracy. This printing mode can be utilized for labs producing a high-volume of orthodontic appliances. “PolyJet is a great 3D printing solution for high volume output of parts in a large batch format,” Ellenbogen says. “Overnight, unattended printing allows for a much higher equipment and personnel utilization without costly automation add-ons [that are] found with some DLP systems.” Ellenbogen says one of the main advantages of the technology is that it prints using multiple materials simultaneously allows labs to print different applications all on the same build tray without sacrificing speed or accuracy. Multi-material printing capabilities can also be utilized to print full color parts using 5 basic colors (magenta, yellow, blue, white, and clear). This unique capability enables production of full-color, realistic dental models, or monolithic polychromatic dentures (TrueDent™).

“Of the multiple systems offered, labs [must] look at material offerings and print volumes relative to needed capacity,” Ellenbogen says. “Unlike the other vat-based systems, PolyJet is unique in that solvents [such as isopropyl alcohol] are not needed to clean parts, and the operator does not come in contact with uncured resin, making one of the safest platforms of the popular 3D printing technologies in dental labs”

Stereolithography

One of the most popular type of printers in the dental industry, stereolithography (SLA), is also one of the most established methods. SLA's vat polymerization technology works by producing thin sections of photosensitive liquid resin in a vat that is cured with UV light into layers in a point-by-point manner. The liquid material is selectively exposed to the light so it is solidified in specific areas to form the correct shape. The self-adhesive properties of the polymers allow the layers to adhere to one another to form a cohesive model.

SLA exclusively utilizes a variety of resins, with varying thermal and mechanical properties to match a range of applications. Standard resins provide a smooth surface finish and are good for concept models and looks-like prototypes, whereas clear resins polish to practically optical transparency. For labs looking for speed, draft resins are one of the fastest 3D printing materials available, as they print up to 4 times faster than standard resins. Other varieties of durable resins, high-temp resins, and biocompatible resins are available to meet the differing needs of wear-and-tear prototypes, molds, dental appliances, surgical guides, and prosthetics.

Since the building platform is submerged in the vat, SLA printers can only print 1 material at a time. However, SLA is compatible with the aforementioned wide range of resin materials. To switch materials, labs just need to swap out the tank and cartridge. SLA build platforms are fairly small, which prevents simultaneous fabrication of multiple models or restorations. However, it makes them ideal for labs looking for a printer with a small footprint.

"This can be a great entry-level option for many users," Ellenbogen says. "But be sure the materials offered perform up to your standards and that print times and build plate volumes meet your capacity needs."

Fused Deposition Modeling

Fused deposition modeling (FDM) is a material extrusion type of printing that can process polymers or plastic materials. In this type of printer, coils of thermoplastic material are heated to their melting point, pushed through a nozzle, and deposited in layers, which eventually, layer-by-layer, build up into the model.

The most common FDM 3D printing materials are acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), and various blends. ABS has the benefit of being durable and tough, as well as heat and impact resistant, and is ideal for functional prototypes. PLA, the easiest FDM material to print, is strong and rigid, although it tends to be brittle. It is less resistant to heat and chemicals and is often used for concept models or looks-like prototypes. Other FDM printing materials include nylon, which is ideal for functional prototypes and wear-resistant components; polyethylene terephthalate glycol, which requires lower printing temperatures, resulting in faster production of snap-fit components and waterproof applications; and thermoplastic polyurethane, which is stretchable and impact resistant, resulting in quality flexible prototypes.

While FDM initial printing is fairly accurate, the material must cool after printing and the risk of warping is higher than other printing techniques. This can be problematic when it comes to producing accurate models

Although the lower price on these machines can be incredibly attractive and may be appropriate for certain applications, FDM may not always be the best choice for dental because of its low speed, poor resolution, difficulty scaling, and limited dental material options.

Powder Bed Fusion

One of the most common 3D printing techniques used for additive manufacturing across the board is powder bed fusion printing. This technique uses a powder rather than a liquid. Selective laser sintering (SLS) is the most widely used form of powder bed fusion printing used for dental applications. This process uses powdered polymers (generally thermoplastics) that are spread across the build area and are selectively melted using a laser, sintering the powder into the desired shape. This technique uses a bed of powder to support the design, resulting in no need for additional supports, which reduces postprocessing.

The most common material used for SLS is nylon, although ceramics can also be processed. Nylon is a thermoplastic with strong mechanical properties, making it ideal for products that need to be sturdy, durable, and impact resistant. However, the durability comes at the expense of esthetics, and finished products can often be porous or rough.

“This is typically only used for high-volume thermoforming by true power users,” Ellenbogen says. “There are very limited material offerings, and prints have a rough surface finish.”

Taking the **Plunge**

Once you've identified what and how you want to print, it's time to create a short list of printers that could get the job done. Ellenbogen recommends reaching out to the companies to ask for printed benchmark parts—preferably a part you have designed. This gives labs the opportunity to learn from the printer company, with feedback on what you've designed. This interaction also gives you the opportunity to see how the company collaborates with you. Identifying whether a company is simply transactional or whether they will be your partner in integrating 3D printers into your workflow can save headaches down the road. A good company should be eager to help you succeed and be willing to provide support and education as you go.

"Dental labs do not need to become technical experts in 3D printing," Ellenbogen says. "But working with a strategic partner that offers multiple solutions and a deep understanding of the industry and the competitive landscape can be beneficial in helping labs find the right printer match between technologies and applications."

It's also important to ensure the partner you work with can provide you with the necessary service support. Although evaluating cost per part is important for ROI, it's important to recognize that poor service can also affect your bottom line. Ellenbogen says savvy lab owners will do their homework to ensure that printer problems will be taken care of quickly, minimizing disruption to their business. After all, suffering a lengthy downtime on a key piece of equipment will cause labs to miss production deadlines and lose money.

"Software, hardware, and materials are all evolving at a rapid rate, and it's important to become a lifelong learner or leverage a relationship with a strategic partner," Ellenbogen says. "Know [whether] you want to be on the bleeding edge, leading edge, or in a safety zone. Each has its merits, but you [must] know where you are comfortable. Stratasys is working with both software and hardware partners to improve the pre- and postprinting processes, knowing that every minute counts [for dental labs]."

Stratasys Headquarters

7665 Commerce Way,
Eden Prairie, MN 55344
+1 800 801 6491 (US Toll Free)
+1 952 937-3000 (Intl)
+1 952 937-0070 (Fax)

1 Holtzman St., Science Park,
PO Box 2496
Rehovot 76124, Israel
+972 74 745 4000
+972 74 745 5000 (Fax)

stratasys.com

ISO 9001:2015 Certified