Incorporating Three-Dimensional Printing in Orthodontics

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The progression from gypsum laboratory to three-dimensional printing constitutes a paradigm shift in orthodontics. Physical impressions and poured stone casts have given way to intraoral digital scans and printed resin models. Computer workstations with computer-aided design and manufacturing (CAD/CAM) software and 3D printers are replacing much of our conventional orthodontic laboratory equipment. With this new technology comes a new workflow for the orthodontic office.

This article, the fourth in our series, describes the advantages of converting to a digital laboratory process. We will also review the steps needed to incorporate 3D printing in the orthodontic practice.

Advantages of Digital Printing

The most notable benefits of printed digital models are their precision and durability. Digital models can be repaired or altered accurately using CAD/CAM software prior to printing. The software can also be used to digitally remove brackets and appliances. Thus, an orthodontist can deliver a transpalatal arch on the day an expander is removed or retainers immediately after debonding. When patients lose their retainers, the printed resin models are sturdy enough to be reused for making replacements.

There are also numerous advantages to converting to a fully digital workflow, including fewer appointments that are shorter and more consistent in length; enhanced patient comfort; avoidance of impression redundancy and the need for band fitting; elimination of shipping expenses, delays, and model breakage; shorter laboratory turnaround time; improved office cleanliness; and better communication with the laboratory technician. Simply stated, the digital workflow promotes both patient comfort and practice efficiency.

The primary disadvantages of a digital office lab are the cost and maintenance of the 3D printer, the annual cost of a CAD/CAM software subscription, and the expense of a laser welder if metal...
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appliances are made in the office. Laser welding is preferable to soldering because the precise placement of the energy spot and low heat application reduce the chance of model distortion, so that the printed model does not need to be replicated in gypsum (Fig. 1). Another disadvantage is the increased time required to prepare and print a digital model in comparison to pouring a gypsum cast.

Building a Digital Laboratory

The space requirements for a digital laboratory differ from those of a gypsum laboratory. There is no need for a stone dispenser, investment vibrator, model trimmer, large sink with plaster trap, or designated countertop space for poured casts. On the other hand, a digital lab does require space for a designated computer workstation, the 3D printers and resin cartridges, and the post-processing procedures (Fig. 2).

The computer workstation contains the CAD/CAM software used for digital model preparation and serves as the primary storage unit for the digital model files. To ensure adequate system performance, the computer should have at least an i5 or i7 processor, 16GB of RAM, and 500GB of hard-drive storage. Dual monitors will be helpful, considering the time required for model repair operations.

The digital lab should be free of dust and
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Disturbances, because particles and vibrations can cause print failures and long-term issues with 3D printers. Compressed air is needed to operate a thermoforming machine and is useful in cleaning newly printed models. An adequate ventilation system to expel resin fumes is recommended.

Because the best layout for the work area will depend on the type of printer, all phases of the print operation must be considered when designing a digital laboratory. For example, while PolyJet® photopolymerization (PPP) and stereolithographic (SLA) printers both use photopolymerization (solidification of resin by ultraviolet light), their printing techniques differ (Fig. 3). A PPP printer works like an inkjet printer, jetting liquid resin layer by layer; an SLA printer “pulls” the model out of a vat of resin as it cures. Unsurprisingly, their post-processing phases are also different. A PPP printer requires a WaterJet® washing station to remove the model’s gelatinous support material after printing (Fig. 4). In contrast, an SLA printer uses an alcohol wash to clean the model, followed by exposure in an ultraviolet light box for complete curing (Fig. 5).

Submitting a Case Digitally

Orthodontists who want to incorporate digital model printing may still prefer to send out

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**Stratasys Ltd., Eden Prairie, MN; www.stratasys.com.


****Motor City Lab Works, Birmingham, MI; www.motorcitylabworks.com.
their laboratory cases. Most regional orthodontic laboratories have “open connections” that can receive STL files, but they may have limited 3D printing capabilities. Two laboratories more dedicated to digital workflows are New England Orthodontic Laboratory, which offers a full range of appliances made from printed models, and Motor City Lab Works, which focuses exclusively on printed models and thermoformed appliances (Fig. 6).
The first step in submitting a case is to connect the intraoral scanner to the preferred destination laboratory, usually during the initial scanner setup. A new laboratory can be added later through the scanner settings or by contacting a customer-support representative. Once added, the new laboratory will be displayed in the scanner’s drop-down menu.

If the technician selects the destination before scanning, the STL file will be automatically transferred to the laboratory when the scan is finished. If a laboratory is not chosen, the STL file will need to be exported manually. STL files created by iTero scanners are exported through myalignitech.com; files created by Trios scanners are exported to OrthoAnalyzer, a CAD/CAM software program.

Once the STL file is sent to a laboratory, the next step is to complete the prescription online. RxWizard and EasyRx are popular laboratory-prescription software programs. EasyRx currently integrates with Cloud 9, Dolphin, Oasys, OrthoTrac, and topsOrtho practice-management software. In addition to managing laboratory prescriptions, EasyRx can also create bases and label digital models for 3D printing. Photographs or handwritten prescription forms with sketches of the appliances to be made can be uploaded in these programs.
**New Scheduling Protocol**

A digital workflow reduces the number of appointments needed to deliver an appliance. Making a metal appliance from a gypsum cast requires four appointments: initial separators, impressions, second separators, and delivery. In contrast, only two appointments are needed for digital case submission, the first for scanning and separators and the second for appliance delivery. If a maxillary expander is prescribed, for example, the patient will first come in for a digital scan including the palate. The orthodontist does not need to seat the bands because the laboratory will fit them indirectly on the printed model (Fig. 7). The separators are placed immediately after the scan, and the patient is scheduled to return in one or two weeks to receive the appliance.

A clinical tip: an iTero scanner owner can use the Treatment Simulator feature after scanning to help motivate an anxious or undecided patient regarding the potential benefits of orthodontic treatment. This feature does require that both arches be scanned.

The scheduling benefits of a digital workflow are most apparent in retainer-delivery appointments. For initial retainers, the patient is scanned at the visit before debonding. The laboratory removes the brackets from the digital models, fits any bonded lingual retainers, and fabricates one or more pairs of overlay plastic retainers to be delivered immediately after fixed appliances are removed. The patient is also given the printed models, which can be reused at a later date to make replacement retainers. If the patient loses both the retainers and the printed models, the models can be reprinted to fabricate new retainers without the patient returning for a chairtime appointment. This is particularly beneficial when a patient does not live nearby.

If a retention patient develops a minor relapse, the teeth can be realigned with a series of thermoformed appliances fabricated from digital models. Malpositioned teeth are corrected on the digital models using CAD/CAM software such as OrthoAnalyzer, Orchestrate 3D, Orchestrate 3D, or Suresmile elemetrix.

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**Conclusion**

The incorporation of intraoral scanners and 3D printers enables an orthodontic office to transition to a completely digital laboratory workflow—a system that is not only more comfortable for the patient, but also more efficient for the practice. In the future, as 3D printing technology improves, orthodontists may be able to prescribe, design, and manufacture orthodontic products right in their offices.

**REFERENCES**


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