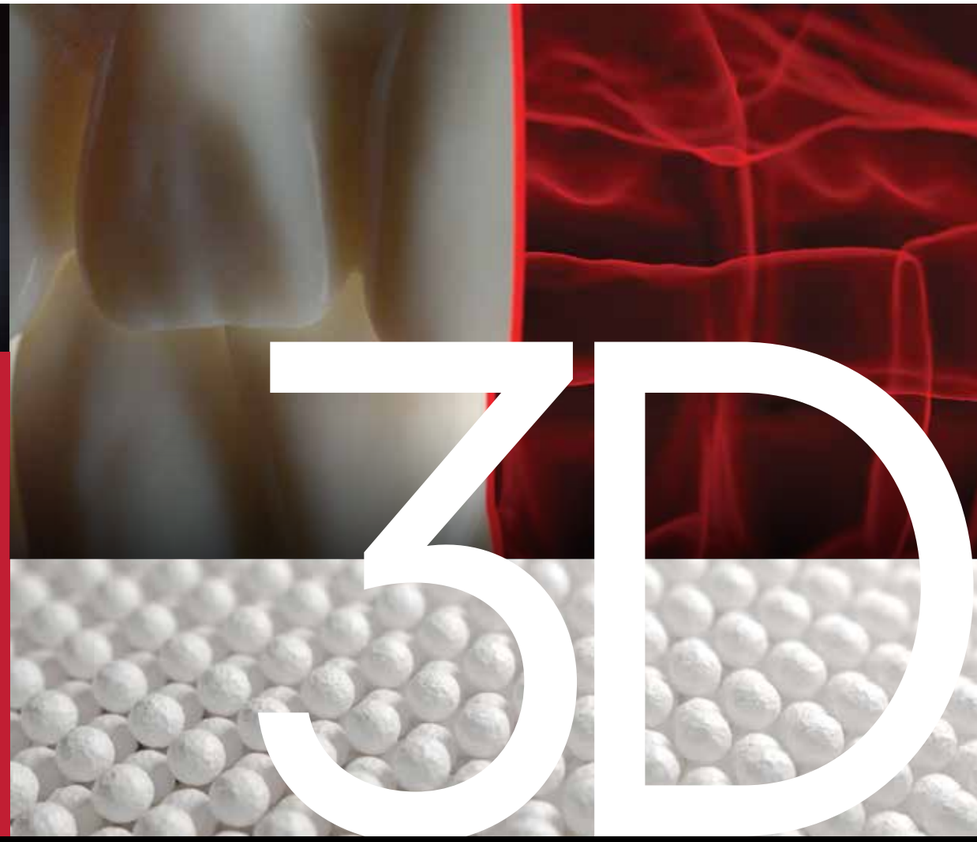
SprintRay

DENTAL 3D PRINTING: THE INTERSECTION OF ART AND SCIENCE



SECTION 1

Introduction to Dental 3D Printing

Say Hello to Dental 3D Printing

Thanks to recent advances in technology, design, and materials, the role of 3D printers in dentistry is rapidly expanding from dental labs to individual practices. As printing appears in more and more offices, we wanted to provide a comprehensive resource that compiles our industry and tech knowledge in a single place. Whether you're brand-new to 3D printing or have been at it for years, we hope you'll find something useful among these pages.

SprintRay was founded in 2014, believing that 3D printing should be made more accessible to dental professionals. We identified three major barriers to mass adoption: cost, user-friendliness, and support. We hope resources like this ebook help make 3D printing feel less strange or intimidating.

To help you find the content most relevant to your needs, we've broken our knowledge up into three separate ebooks:

We appreciate your interest in our approach to dental 3D printing and look forward to continuing to serve the unique needs of this wonderful, inspiring industry.

SCANNER DESIGN SERVICES PRO55 S 3D PRINTER PRO95 S 3D PRINTER PROCURE 2 PROWASH S CERAMIC CROWN RESIN AND KIT

The World of Dental 3D Printing

You may not realize it, but 3D printing has been part of dentistry for decades. Innovative companies such as Align Technology were among the first to capitalize on the benefits of additive manufacturing. They recognized that 3D printing was perfect for the unique needs of dentistry: low volume, highly custom, extremely accurate parts are the hallmark of the industry. If you've ever delivered a set of clear aligners to a patient, you've participated in the 3D printing revolution.

With the decrease in price, size, and maintenance offered by high-resolution desktop 3D printers, clinicians today find technology more accessible than ever. 3D printing speeds up delivery times, improves efficiencies, and delights patients. But if you're new to the technology, where do you even start? In the following sections, we work through some fundamental questions of 3D printing in dentistry.

What is 3D Printing

And Why Is It Important to Dentistry?

3D File Prep **3D Printer** **Washing / Drying** **Curing**

In the last decade, the proliferation of digital imaging, CAD treatment planning software, and dental mills have improved the patient experience. Broadly conceived, imaging, CAD, and digital fabrication have paved the way for in-office dental 3D printing. Recent currents in dentistry have argued that 3D printers can further improve this paradigm, closing the loop by offering affordable fabrication localized to the individual dental practice. Though mills can provide rapid in-office production for certain applications, printers are less expensive, produce less waste, and are useful across a wider range of treatments.

3D printing allows clinicians to produce an output from their digital data and design locally without intermediary parties. This in-house production helps maximize existing investments in digital technologies, unlocking a new world of treatment control.

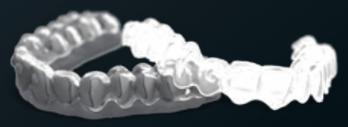
Additive manufacturing provides highly-customized production for small-batch parts at a significantly reduced cost compared to traditional methods. It also reduces the labor need while delivering greater reliability and repeatability. Because 3D printers can print a variety of indications and materials without retooling, they are ideal for the type of production required in dentistry.

Fabricating multiple copies of slightly different parts (such as models for clear aligners) or a single copy of a single part (such as a surgical guide) is a relatively expensive, labor-intensive process in traditional dental manufacturing. Pouring-up models in stone creates waste material and is highly technique sensitive. But 3D printing has the potential to make this process much faster and less expensive, creating an affordable path for dentists to manufacture what they need right in their offices without the intensive labor previously required.

3D Printed Appliances

With such a wide variety of uses from a single tool, 3D printing can provide a huge benefit to dental clinics of all varieties. It's difficult to think of other tools in a dental office that are as broadly productive as 3D printers.

Clear Aligners

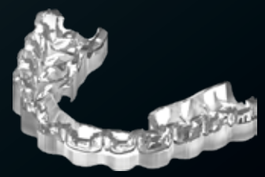


Retainers

Temporary Crowns

Try-ins

Night Guards

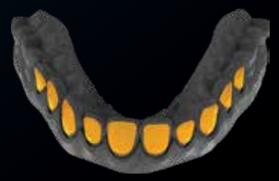


Indirect Bonding Trays

Veneers

Dentures

Surgical Guides



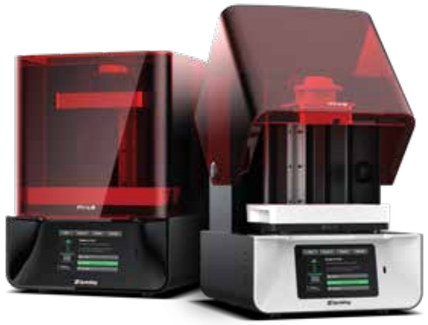
Bleaching Trays

Definitive Ceramic Crowns

Hybrid Dentures

Dental Models

The Right Sized Tool



Additive manufacturing is a vast market. 3D printers can cost anywhere from $500 to $100,000. And a single product is often marketed to multiple industries, which can sometimes make it difficult to find the information you need about dental-specific tools.

In the next decade, everything from consumer sneakers to professional-level race cars to jumbo jets will leverage 3D printing as part of their final production or development processes. With a technology that penetrates so many industries, it can be difficult to parse which features and technologies are needed in a dental clinic or lab.

A dental 3D printer needs certain characteristics, chiefly the ability to 3D print functional dental appliances with FDA-cleared materials for definitive and long-term use. This is crucial to the difference between how dental clinics will use 3D printers and how they're used in many other industries. FDA-cleared dental appliances are regulated medical devices and can be printed directly, with no significant intermediary steps before patient delivery.

Dental 3D printers have a specific, well-defined use case: the fabrication of FDA-cleared, functional dental appliances that will be placed intraorally and used long-term.

Beyond the functional requirements, a good dental 3D printer should have a small footprint that can coexist with other equipment in limited space. It must be reliable for production, not just prototyping. This means achieving consistent, accurate results that are easily repeatable. It must be affordable – upfront and over time – for a typical dental practice. User-friendliness is critical, with a good support system to help clinicians and their staff take full advantage of all that 3D printing offers.

There are many desktop 3D printers on the market today that are capable of fabricating beautiful-looking parts. Many OEMs feature printed dental models on their websites to showcase their dental chops. Many of these, especially those with extremely low prices, claim to be valuable for dentistry but lack the materials certifications to create FDA-cleared, definitive printed dental appliances.

Comparing Dental Workflows – Traditional Process

1. Prepare impression material

2. Load impression tray

3. Insert impression in patients mouth and let set

4. Remove impression from patients mouth

5. Disinfect impression and prepare to make stone model

6. Mix stone model

7. Load tray with stone

8. Load tray with stone

9. Allow stone model to set up

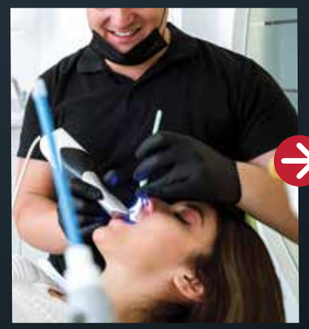
10. Remove stone model

11. Trim/grind off excess material

12. Brush and rinse stone model

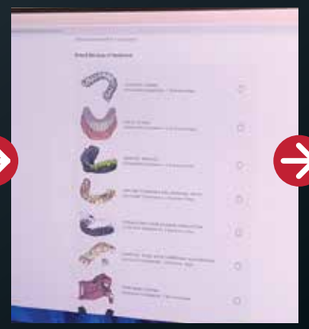
Finished stone model

Comparing Dental Workflows – 3D Printing Digital Process



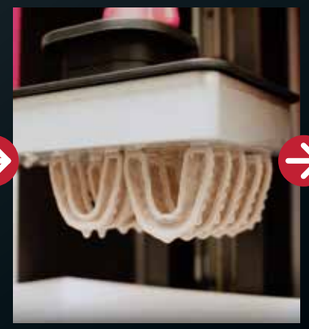
Data Capture

Capture the patient data using an intra-oral scanner.



File Prep

Send data from IOS to SprintRay Cloud Design Services or Rayware Cloud for data to be prepared for printing.



3D Print

Fill resin tank select job in queue and select print.

Clean

Once printing is complete, move parts on platform to SprintRay ProWash S to clean and dry.

Cure

Remove from wash unit, take parts off of build platform, and remove supports. Place parts in cure unit and select cure.

Finishing

Grind off any support nubs and polish.

Deliver

Finished part ready to deliver to the patient

The Three Pillars of Dental 3D Printing

The adoption of dental 3D printers is driven by innovation in three major categories:

1 BIOCOMPATIBLE MATERIALS

2 ACCURACY AND REPEATABILITY

3 EASE OF USE AND ROBUST SUPPORT

Biocompatible Materials

Dental 3D printers reached an inflection point in their acceptance when biocompatible materials became widely available for desktop machines. These FDA-compliant resins make 3D-printed parts safe for intraoral use and offer great mechanical properties, fast production, and low cost, propelling desktop 3D printers into dental practices worldwide.

Materials innovation continues to drive the adoption and usage of 3D printing in dentistry. Today's manufacturing needs go beyond the simple production of dental models to include definitive prosthetics across restorative dentistry and beyond. Because the available resins drive the indications affected by 3D printing, it pays to consider the materials that are being developed for the 3D printer you choose.

Since the introduction of biocompatible materials for 3D printing in dentistry, there has been an emphasis on improving mechanical properties to provide printed intraoral parts with great strength and high resistance to wear. Because materials innovations can come from anywhere, it's important to choose a 3D printer that offers support for third-party materials where necessary – though the use of SprintRay resins by SprintRay 3D printers assures optimal, seamless results.

Proprietary, biocompatible specialty and model resins developed and tested for market-leading performance in digital dentistry

Die & Model 2
Study Model 2
Gingiva Mask

Night Guard Flex
Surgical Guide 3
IDB 2

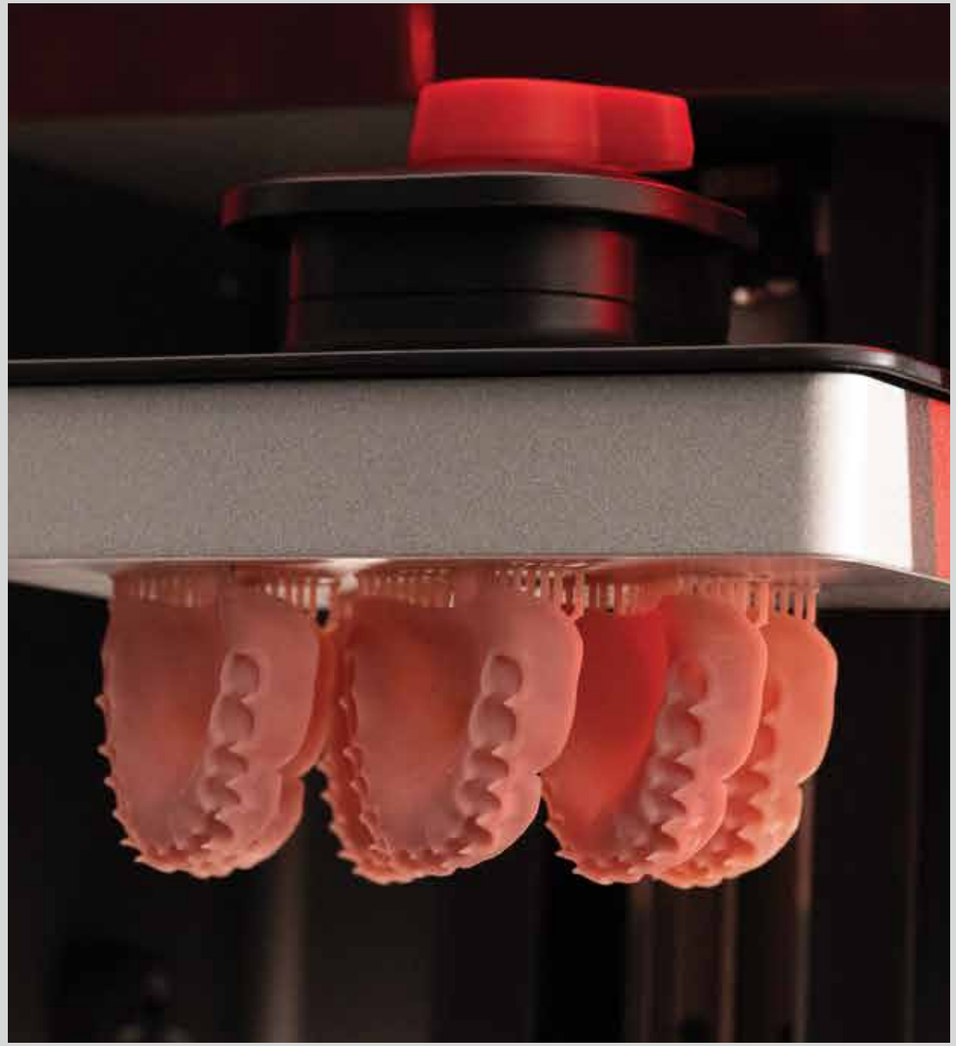
SprintRay Crown
SprintRay EU High Impact Denture Base
SprintRay EU Temporary Crown & Teeth

2

Accuracy and Repeatability

Accuracy and repeatability are essential qualities for a 3D printer that will be used in dentistry. To provide the highest standard of care, high accuracy is a non-negotiable feature and the ability to duplicate these outcomes at each iteration maximizes the advantages. Recent advancements in materials and printing technology have supercharged the accuracy of 3D printers such as SprintRay Pro S, propelling them beyond what was originally thought possible.

Bringing the manufacturing of models and other appliances in-office is worth the investment only if the technology can consistently provide the tight tolerances required for fitted parts. It isn't enough for a single print to provide good results; they must be repeatable over time and across different environments. Printers can be easily bucketed into categories based on operating characteristics, but these classifications rarely tell the full story. We will cover accuracy in-depth later in this book.



3. Ease of Use and Robust Support

To keep pace with a busy office, a good dental 3D printer should offer a full ecosystem, including software and hardware. Each workflow piece should be easy to use and connected with the other elements. Ultimately, it's important to consider who will be responsible for the printer workflow and ensure that person understands their role.

Typically, dentists are not primarily responsible for the printer's maintenance and daily use, so the ecosystem's usability is key for staff members who will interact with the product. Staff turnover at practices tends to be quite high, so the person who does the implementation may not always be there to operate it smoothly. This means that training and support are essential to a sustained printing workflow.

When things don't go to plan, or when it's time to expand to new indications with the printer, it's key to have a robust support system. A comprehensive

knowledge base and training center is key, and not just when you're first implementing the workflow. The staying power of a 3D printer often hinges on individual members of your staff taking ownership and solving problems on their own.

Being able to pick up the phone or speak to someone via live chat can make the difference between workflow success and failure. Many companies offload their support to third parties or distributors, making it difficult to track down reliable information about the product. A good dental 3D printer is backed up by a first-party support system and staffed with knowledgeable members that are easy to contact.

Are 3D Printers Accurate Enough for Dentistry ?

One of the concerns holding back the adoption of dental 3D printing is the question of accuracy. Anxiety around materials, speed, and price is often underpinned by the lingering suspicion that the output of a desktop 3D printer might not stand up to the accuracy demands of real-life clinical use. If the ceramic crown doesn't have perfect marginal fit, then the whole enterprise of in-office 3D printing is a bust. Fortunately, clinicians and universities the world over have found that, given the right hardware and materials, this reservation has no bearing.

In the intervening years since 3D printing landed in dental offices, accuracy has been the center of much deliberation. Intrepid clinicians and labs, undaunted by skepticism, marched forward in their private practices, demonstrating that the technology could be useful in a clinical environment.

As the technology has become a more mainstream option for in-office manufacturing, dental universities have begun releasing their findings about accuracy, and the verdict is clear: printing is highly accurate, often exceeding the accuracy of other digital tools often used today such as mills.

Taking Stock of the Accuracy Landscape

When 3D printer manufacturers publish claims about final print accuracy, they are often the results of internal testing. While internal tests can be a helpful metric, it's important to remember that the results are not impartial, not verified by an independent third party, and therefore not necessarily repeatable. Even if the results are genuine, the test may be designed specifically to play to the strengths of a given product.

When seeking accuracy numbers, it's best to find data published by reputable universities or dental journals. As with any dental product, 3D printer manufacturer claims should always be supplemented by corroborating evidence from dental schools and other credible sites.

Thankfully, a recent windfall of studies has confirmed what many clinicians already knew: professional-grade 3D printing is extremely accurate, especially when rendering complex geometries. When taken as a part of a fully digital workflow alongside scanning and CAD design, the accuracy of a 3D printing workflow is outstanding.

Measuring Dental 3D Printer Accuracy

- **Methodologies for determining the accuracy of 3D printers vary, but the foundational principles remain similar:**
- **Establish a physical model to use as a baseline**
- **Digitize the baseline model using a digital scanner**
- **Use a 3D printer to fabricate a replica of the baseline model from the digital scan**
- **Digitize the newly-fabricated replica using a digital scanner**
- **Utilize CAD software to measure the difference in dimensional accuracy of the second scan (3D printed model) against the first scan (original model)**
- **Repeat with additional test groups until a statistically significant sample size is reached**

Accuracy vs. XY Resolution

Depending on the software and particular methods used, this demanding process can measure hundreds of thousands of individual data points on each scanned model. The numbers are added, and an average is reached. This average, a difference usually expressed in microns, represents the printer's dimensional accuracy. Using this method, a printer with a higher average deviation from the original data set (in this case, the scan of the first physical model) scores a lower overall dimensional accuracy.

Defining XY Resolution

XY resolution refers to the smallest single point of light that a 3D printer can deliver. This number is worthy of attention for a few reasons. First, XY resolution tells us something about how smooth the final surface texture of printed parts may be, though recent software technologies have proven that it is a flawed number in predicting surface smoothness.

A smaller XY resolution value means that a light projection onto paper in perfect conditions could show finer detail, but mechanical and optical imprecision will often invalidate these claims. This is especially true among budget printers, which frequently use off-the-shelf parts and resins that are white-labeled rather than bespoke or specially designed materials and industrial construction. Despite a perceived convenience to many manufacturers, XY resolution is not a shortcut to accuracy.

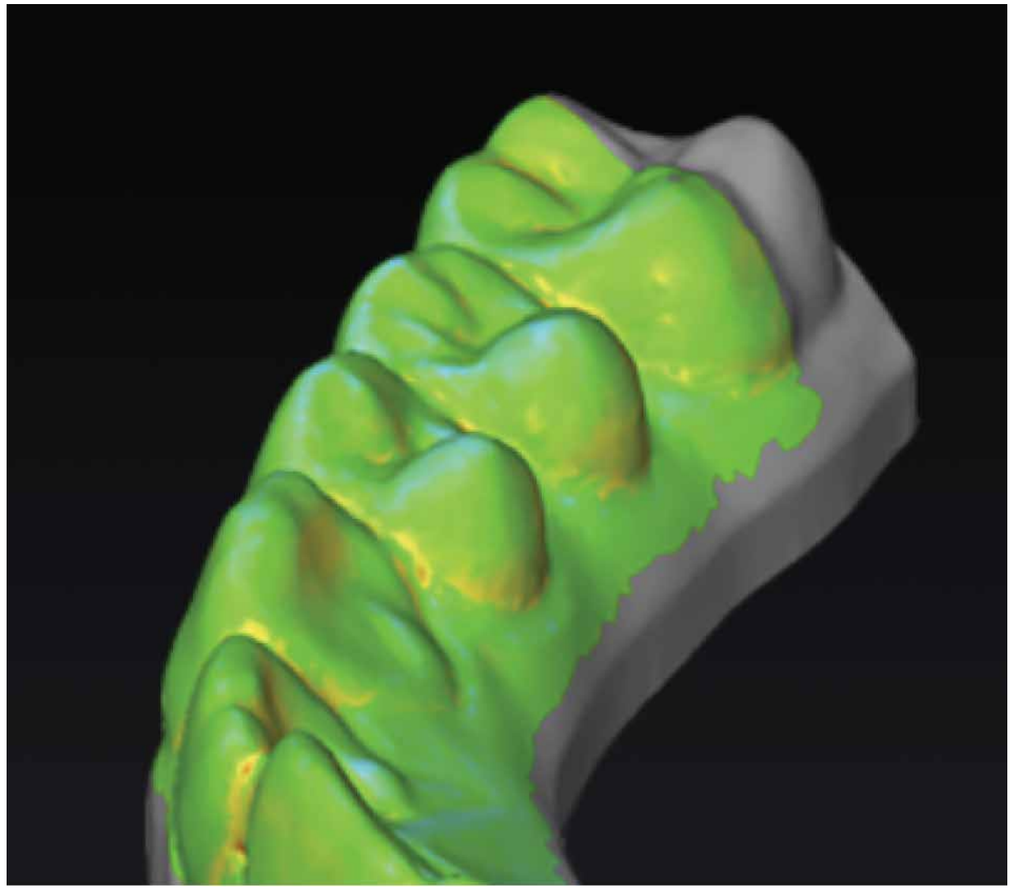
Traditional Alginate

3D Printed Model

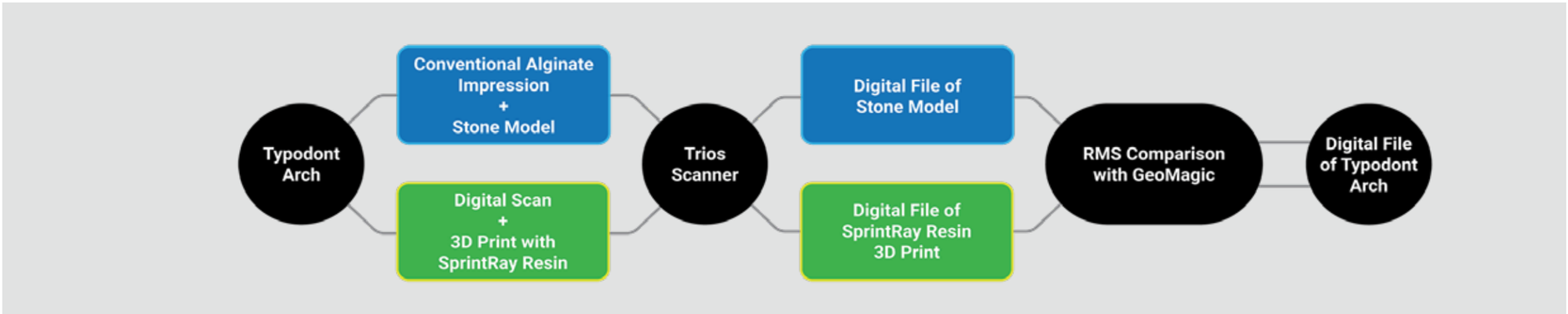
Defining Accuracy

Accuracy is the measurement of a 3D printer's real-world ability to create parts that are true to the exact dimensions of the digital blueprint. Parts with a smooth surface finish aren't useful if they don't accurately represent a patient's dentition, particularly in the case of fitted parts. Imagine a single unit crown printed three times, and in each print the marginal integrity was compromised in a different way. Even very small variations in accuracy can have adverse effects on clinical outcomes.

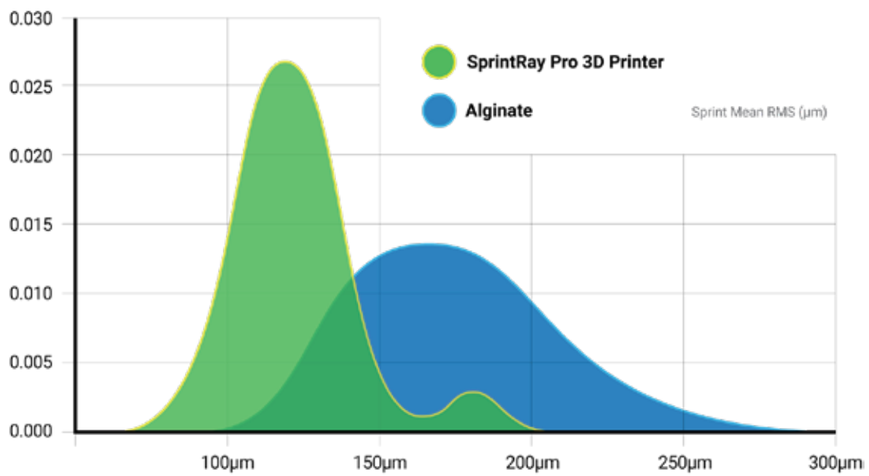
Though accuracy is more difficult to measure than XY resolution, it is an excellent way to express a 3D printer's output. Build quality and components, such as chassis construction, Z-axis motor quality, tank materials, build platform surface material, heat, resin calibration, and many more factors can and do affect dimensional accuracy. The light delivery method, typically a choice made between DLP, Laser-SLA, and LCD, also plays a substantial role in accuracy. The best way to determine a printer's clinical accuracy is by recording measurements through impartial, third-party testing.



University Study: Dental 3D Printer Accuracy



A recent study performed by a major university of dental medicine measured the accuracy of SprintRay Pro and compared it to the accuracy of a model poured up in stone from an alginate impression. The findings concluded that SprintRay Pro, using SprintRay Die & Model Tan resin, created models that were more accurate than their conventional counterparts.



For clinicians and dental professionals concerned about accuracy, SprintRay Pro S presents a highly-flexible manufacturing package that is more accurate than stone. Alginate impressions and models have long been considered clinically acceptable for their applications. But SprintRay Pro S improves the accuracy of model creation compared to traditional methods while offering increased speed and flexibility. Though performance and efficiency are often at odds, highly accurate 3D printing is one place in which they operate in harmony.

The study data shows SprintRay Pro demonstrated higher accuracy values and more consistent results. Printed models will be more accurate, resulting in better-fitting parts for better clinical outcomes. This is fantastic news for clinicians, who can have complete confidence in the accuracy of their SprintRay 3D printers.

Here to Stay

3D printing has come to dentistry in a big way. In the last five years, the technology has matured from high-end mass manufacturing enterprises to an accessible way for dental professionals to bring chairside production into their clinics. While spec sheets for other printers suggest an evolving convergence in capabilities across the industry, SprintRay Pro S 3D printers stand apart in their ability to do more than serve dental clinics' accuracy, speed, and usability requirements.

The importance of quality hardware cannot be overstated. That said, a printer’s materials ecosystem often separates the truly great, essential printers from the merely useful. Advancements in software, such as using artificial intelligence to provide touch-free designs for common treatments, will further drive home the value of a clinical 3D printing ecosystem.

SprintRay is on the cutting edge of software, hardware, and materials, providing groundbreaking workflow solutions that enable clinicians to deliver better care to more patients.

Schedule a Full Demo

Request a 3D Printed Sample

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