FORMLABS APPLICATION GUIDE:

3D Printing Splints with the Form 2

Dental LT Clear Resin is a long term biocompatible material formulated for manufacturing dental splints and retainers. As a rigid material, Dental LT Clear is most appropriate for printing hard splints. If soft or hard-soft splints are desired, the best method is to print the model and thermoform.

This application guide demonstrates each step for making 3D printed splints on Formlabs' Form 2 3D printer. Use the following workflow to ensure precise results.

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Essentials

Made by Formlabs

Form 2 (SLA) 3D Printer

Dental LT Clear Resin

PreForm Software (free)

Form Wash

Form Cure

Made by 3rd Parties

Dental Design Software (CAD)

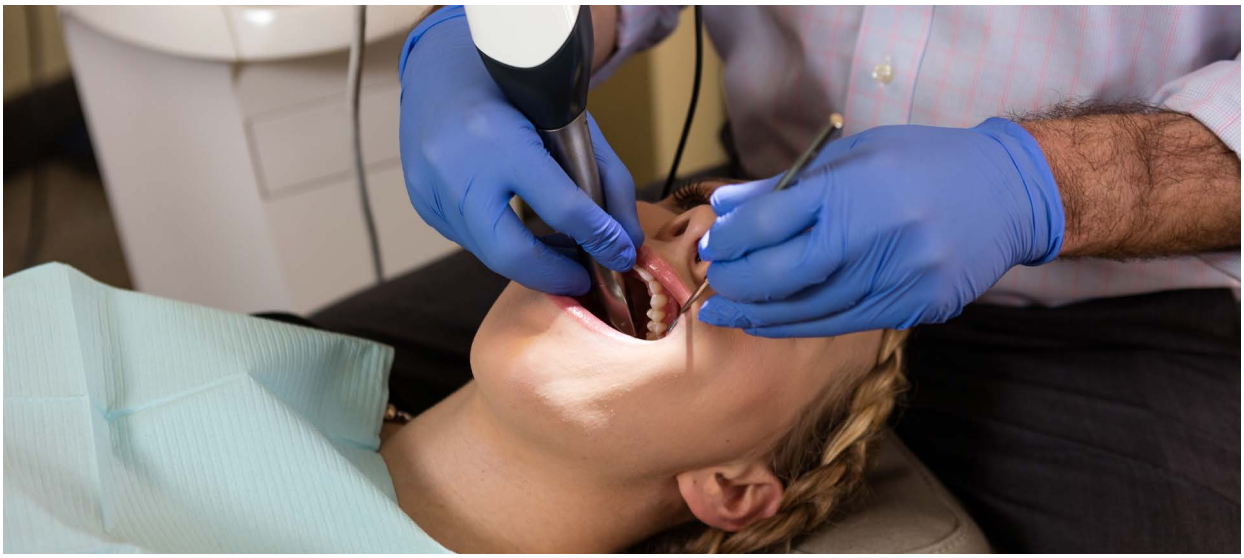
Intraoral or Desktop Optical Scanner

Alternative Post-Cure Chamber

Ultrasonic Bath

1. Scan

In order to 3D print a splint, use a scanner to collect anatomical data of the patient's dentition. Either scan the patient directly with an intraoral scanner, or use a desktop optical scanner to scan a polyvinyl siloxane (PVS) impression or stone model.



2. Design

To begin, design the splint in dental CAD software. Make sure to pick software that offers open STL file export. Design splints following the guidelines below to ensure that the parts have sufficient strength and durability.

Parameter	Recommended Values
Minimum side wall thickness	1.0 mm
Minimum bottom/occlusal surface thickness	1.5 mm
Offset (aka. "Block Out Undercuts Offset")	>= 0.1 mm

Additional block out settings, such as block out angle and retention, should be determined clinically by the doctor or the dental technician.

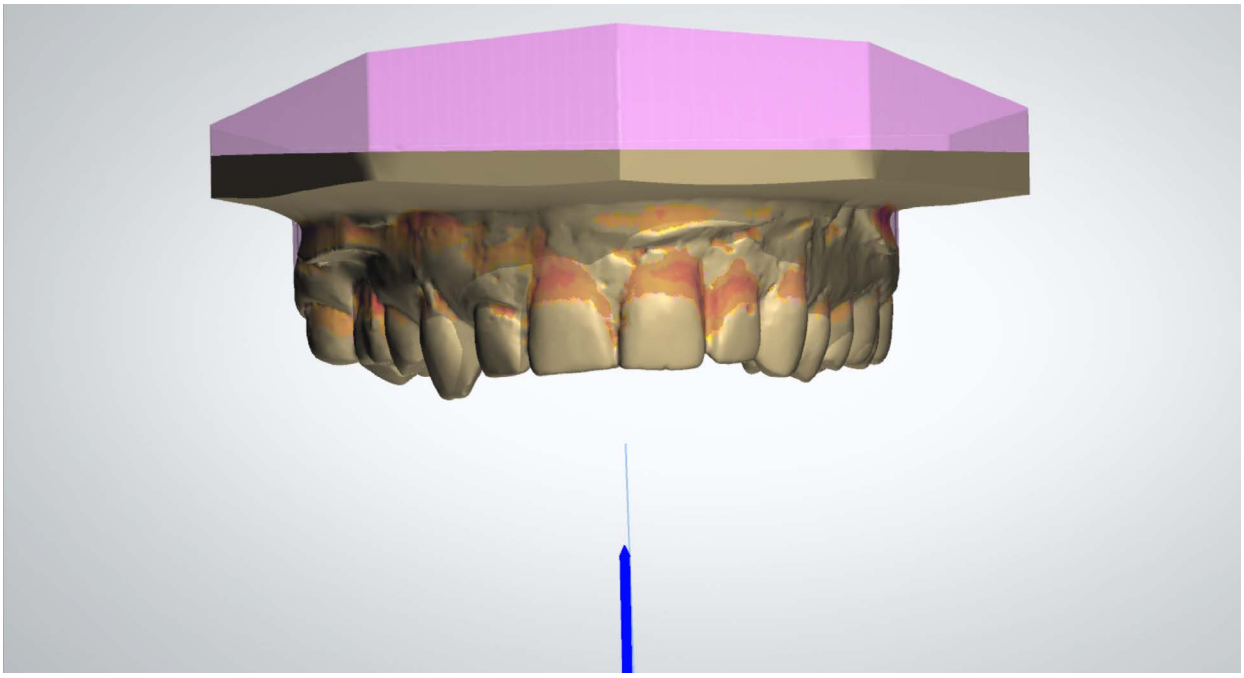
For detailed advice on designing splints, contact the manufacturer of the software of choice. A few major steps that are important to take into consideration for 3D printing are:

2.1 Import & trim scans—both preparation and antagonist

First, import the intraoral or desktop optical scans of the patient dentition into your preferred dental CAD software. Use line marking or area selection tools to remove erroneous scan data, and select only the portion of the dentition that will be printed.

2.2 Define insertion direction and block out undercuts

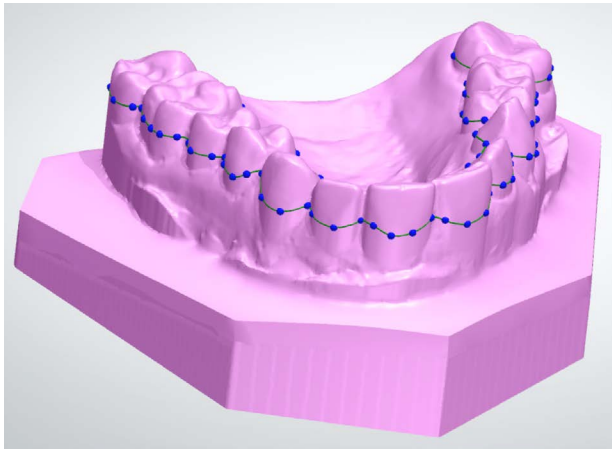
Ensure that the model is blocked out adequately where needed, depending on the specifics of the case. Block out undercuts directly to impact the retention of the splint.



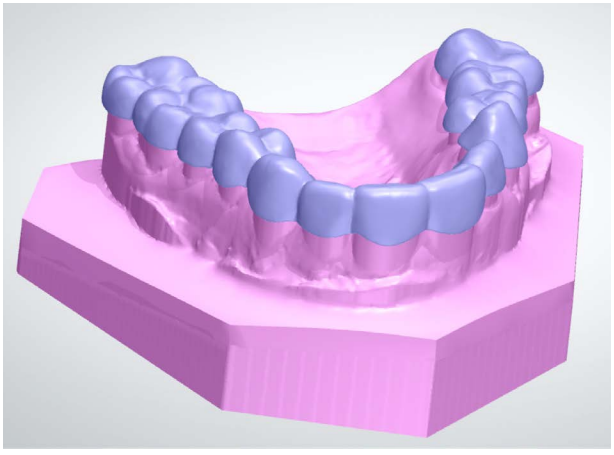
Undercuts blocked out after setting insertion direction and defining the desired block out parameters.

2.3 Generate initial splint shell and apply

To design the splint, use spline tools to mark the margin of the splint along the perimeter of the arch. Generate an initial splint design, using a minimum thickness of 1.0 mm and an offset of 0.1 mm. Adjust the design manually using standard sculpting tools if necessary.



Left: Splint boundaries defined using spline tools.

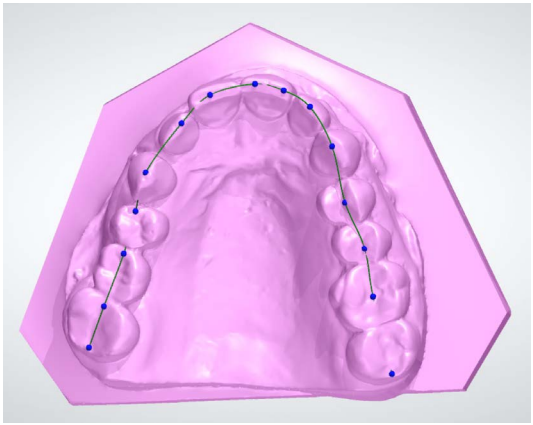


Right: Automatically generated initial splint mesh.

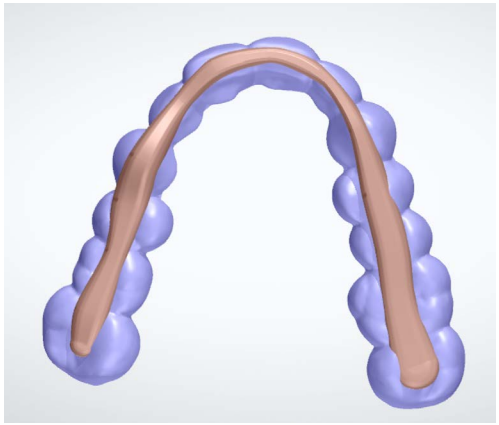
2.4 Generate splint bar

In splint design software that offers the option, use the spline tools to generate a bar and combine it with the splint design. Ensure that the total initial thickness of the bar and shell are at an initial minimum of 3.0 mm, to allow space for antagonist adaptation.

When using splint design software that does not allow for the generation of a bar, ensure that the bottom surfaces of the splint are at least 1.5 mm thick.



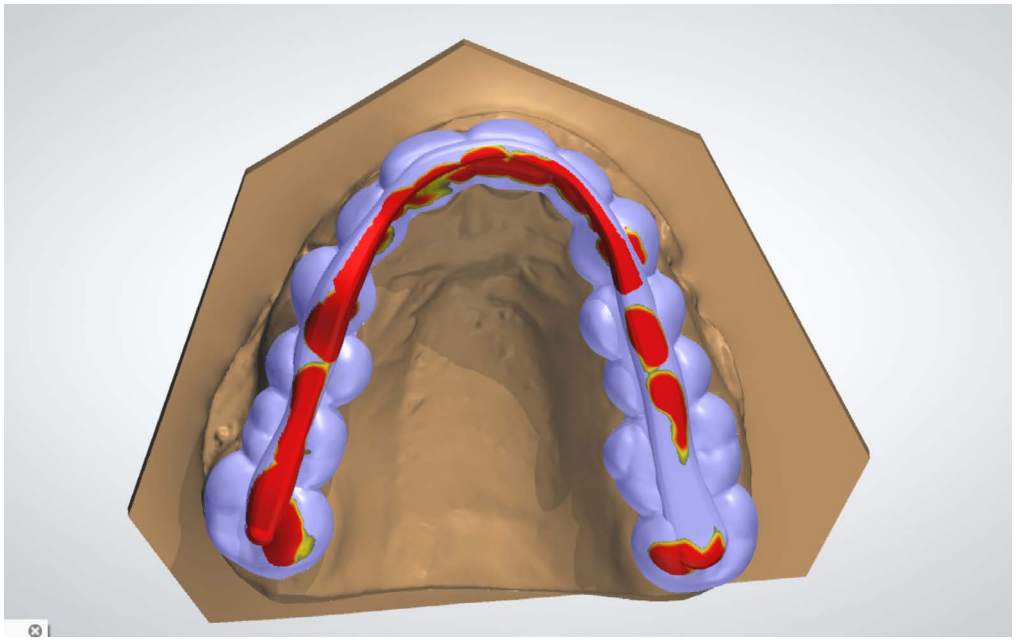
Left: Splint bar path defined using spline tools.



Right: Automatically generated bar mesh applied to the splint mesh.

2.5 Adapt splint design to antagonist

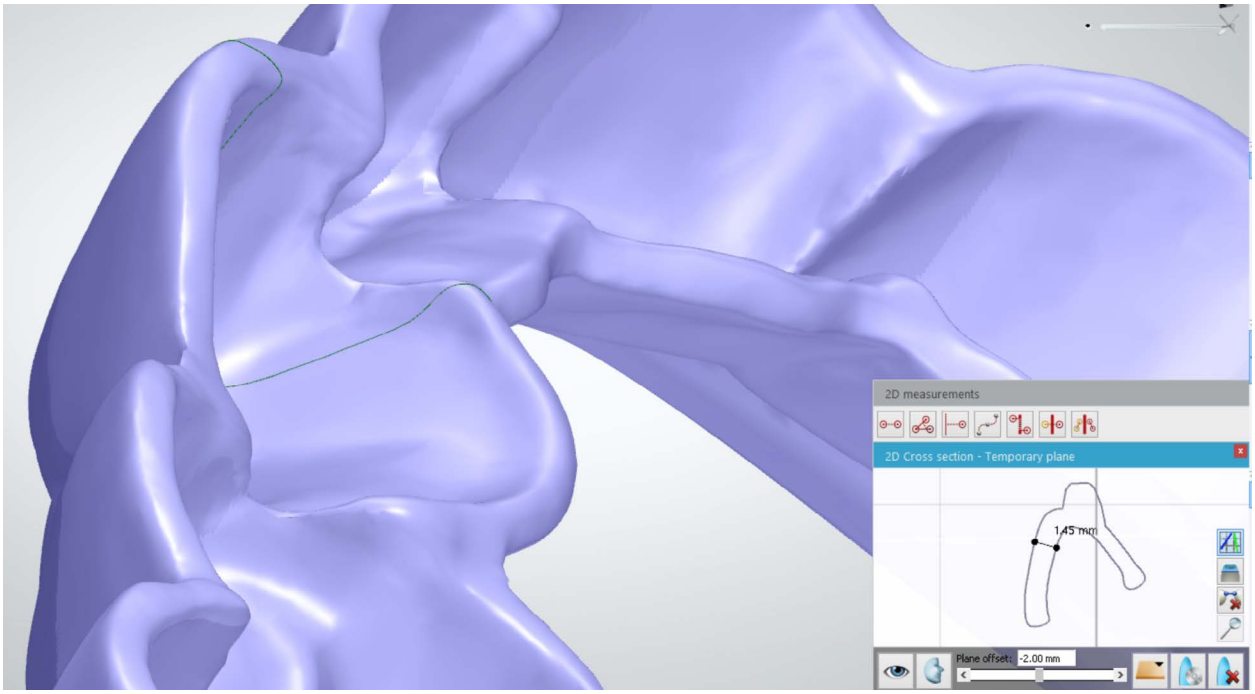
Remove material on the underside of the splint to adapt the design to the antagonist. Use static occlusion or dynamic occlusion via a virtual articulator, depending on the CAD software.



Splint with areas highlighted for adaptation due to dynamic occlusion with the antagonist.

2.6 Check design and make final adjustments

Inspect the model to ensure that the part is not thinner than 1.5 mm at any point in the occlusion or 1.0 mm in the side wall. Adjust the design manually using standard sculpting tools if necessary. Finalize the design by double checking the occlusion and articulation of the model and splint.



Using inspection tools to ensure that side wall thicknesses are greater than 1.0 mm and bottom surfaces are thicker than 1.5 mm.

2.7 Export

Once the design is created, export a digital model of the part in STL or OBJ file format.

3. Print

3.1 Select material

Open PreForm. Select “LT Clear” from the Material menu.

3.2 Import model files into PreForm

Import the STL or OBJ file into PreForm.

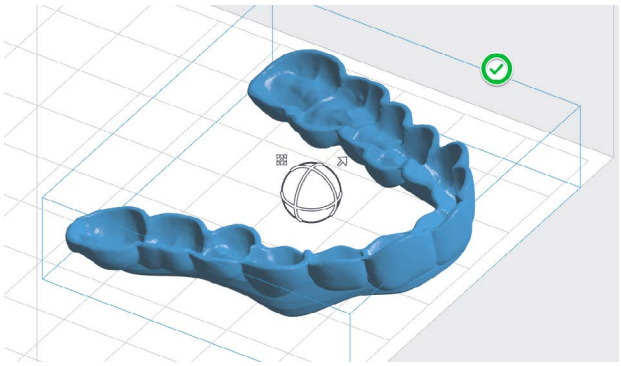
3.3 Orient models

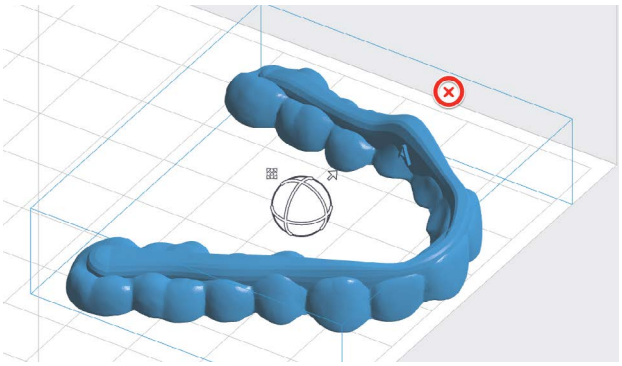
Orient parts with the intaglio surfaces facing away from the build platform, to ensure that supports will not be generated on these surfaces.

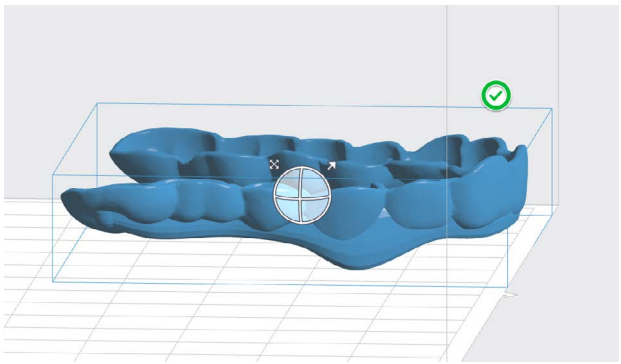
Ensure that parts are oriented at an angle of 30° or less. Orienting parts upright or at angles more than 30° will compromise precision and lead to poorly fitting parts.

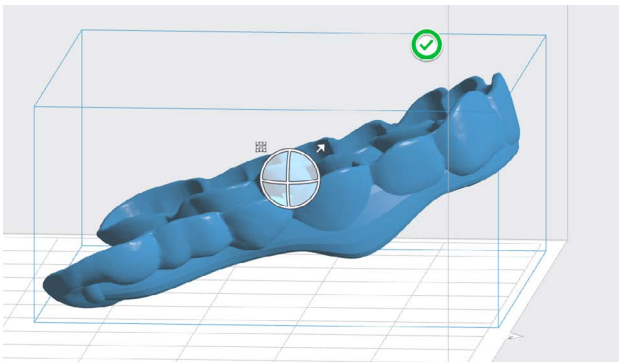
When angling the model in PreForm rotate the anterior portion upward and away from the build platform so that the posterior ends remain closer to the build platform.

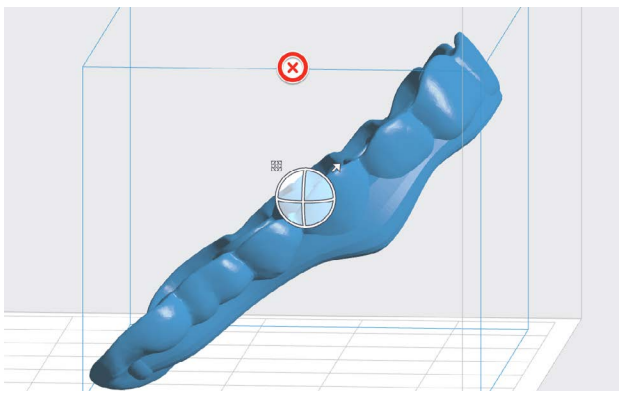
> **Warning!** Printing at greater than 30° angles will result in poorly fitting splints. As the angle of inclination of the part increases above 30 degrees, interproximal surfaces will print less accurately, which may result in a poor fit.

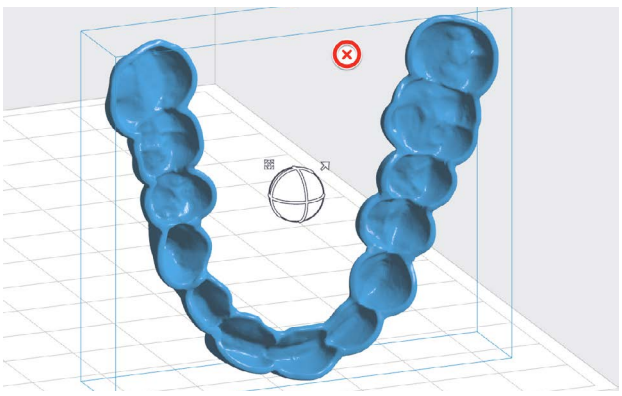






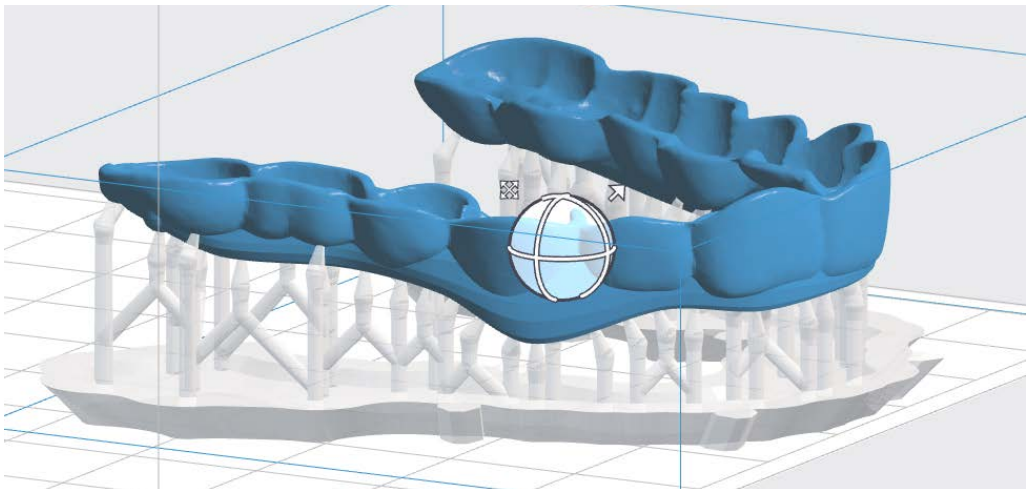






3.4 Generate Supports

Generate supports using PreForm's auto-generation feature. Inspect the part to ensure there are no support touchpoints on intaglio surfaces. Use the manual support editing feature to add or remove supports, if needed.



3.5 Upload the print

3.6 Prepare the printer and resin

Insert a resin tank, resin cartridge, and build platform into the printer. Thoroughly agitate the resin cartridge before inserting, by shaking and rotating it several times.

Warning! For full compliance and biocompatibility, Dental LT Clear requires a dedicated resin tank, build platform, and finishing kit, which should only be used with other Formlabs biocompatible resins, such as Dental SG.

Using Standard Resin Tanks vs. Resin Tank LT

For the highest accuracy and precision, Resin Tank LT is recommended for printing with Dental LT Clear. Testing of Dental LT Clear on Resin Tank LT revealed no degradation of accuracy or precision over the lifetime of the tank.

If using the standard resin tanks, laser exposure forms white, clouded marks on the surface of the resin tank's silicone layer. This clouding eventually becomes extreme enough to affect accuracy. Testing revealed that splint accuracy began decreasing after 2,000 layers were printed in a given position on the tank. In testing a worst-case scenario of printing an identical splint in the same position in a resin tank multiple times, splints still fit accurately after 25 consecutive prints.

To avoid fit issues due to tank clouding, switch to a new standard resin tank after 25 consecutive prints, or with every new cartridge of resin, whichever comes earlier.

3.6 Print

4. Post-processing printed splints

Post-processing 3D printed splints primarily involves five steps: rinsing, drying, post-curing, removing supports, and polishing.

4.1a Wash parts with Form Wash

Place the build platform, with surgical guides still attached, into a Form Wash filled with isopropyl alcohol (IPA, 96% or higher). Set Form Wash for 5 minutes, which will clean the parts and remove liquid resin before post-curing.

Leave parts to air dry completely, or use a compressed air hose to blow IPA away from parts' surfaces. Inspect parts closely to ensure all uncured resin has been removed. Repeat wash if necessary, but do not leave parts in IPA for more than 10 minutes, as this may reduce mechanical performance and cause defects in the printed parts.

Remove parts from the build platform with the part removal tool.

4.1b Wash parts with an ultrasonic bath

Remove parts from the build platform with the part removal tool.

Rinse parts in isopropyl alcohol (IPA, 96% or higher) for two minutes in an ultrasonic bath to dissolve any uncured or excess resin. Transfer parts to a new bath of clean alcohol solution and rinse them for an additional three minutes in an ultrasonic bath.

Leave parts to air dry completely, or use a compressed air hose to blow IPA away from parts' surfaces. Inspect parts closely to ensure all uncured resin has been removed. Repeat wash if necessary, but do not leave parts in alcohol for more than 10 minutes as this may cause reduced mechanical performance and defects in the printed parts.

4.2a Post-cure parts with Form Cure

Printed splints must be exposed to light and heat to achieve biocompatibility and optimal mechanical properties. Place the printed parts into a Form Cure. Post-cure for 20 minutes at 80 °C.

Warning! Post-curing outside of the recommended settings can lead to extreme discoloration of the parts. Post-curing at too high a temperature, for too long a duration, or with too high intensity of light can cause yellowing. In addition, improper post-curing steps can also lead to sub-optimal mechanical and biocompatibility properties.

Post-cure only in accordance with official recommendations from Formlabs for the clearest and best possible results.

4.2b Post-cure parts with an alternative post-cure chamber

Printed splints must be exposed to light and heat to achieve biocompatibility and optimal mechanical properties. Post-cure time depends on the light intensity and the internal temperature of the post-curing device. One acceptable method for post-curing is exposure for 10 minutes to 72 watts of Blue UV-A (315–400 nm) in a heated environment at 60 °C (140 °F). One acceptable lighting setup is four 18W/78 lamps (Dulux blue UV-A).

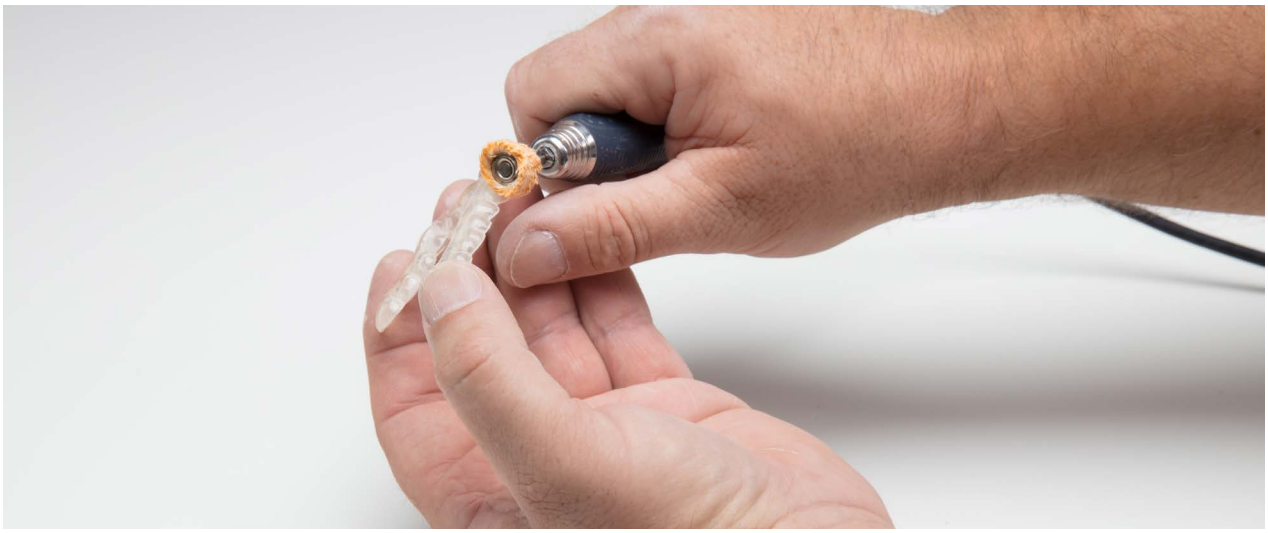
4.3 Remove supports

Use the flush cutters included in the Formlabs Standard Finish Kit to carefully cut the supports at the points where they attach to the part. Use caution when cutting the supports, as the post-cured material may be brittle. Supports can also be removed using other specialized appliances, such as cutting disks or round cutting instruments like carbide burs.

Warning! Remove supports only after post-curing to ensure that parts do not warp.

4.4 Polish parts

For a glossy surface finish, polish parts using a rag wheel and pumice at low speeds. After initial rough polishing, switch to a dry cloth polish. Finish with a high-grit acrylic buffing paste, such as Hi-Shine, at high speeds.



4.5 Check fit

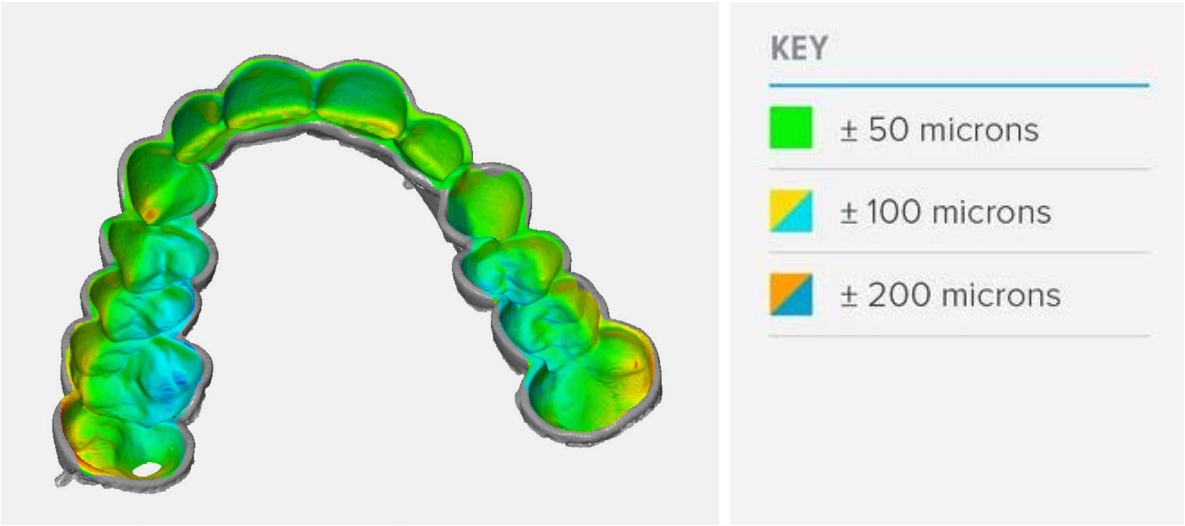
To check fit, print a solid model of the patient's dentition, and place the splint on the model. Make adjustments to the 3D model or the post-processed parts if necessary. For printing orthodontic models we recommend Standard White or Grey Resin. For higher accuracy, use Dental Model Resin.

5. Cleaning and disinfecting

Use an ethanol solution to disinfect parts before use.

Accuracy Study

An in-depth accuracy study of 80 Dental LT Clear printed splints showed that intaglio surfaces of Form 2 printed splints were dimensionally accurate within ± 100 microns over 80 percent of the intaglio surfaces, and within ± 125 microns over 90 percent of the surfaces. This was found to provide a precise fit on both models and patients.



Biocompatibility

Dental LT Clear is a Class IIa biocompatible resin that is in conformity with the essential requirements and provisions of the Council Directive 93/42/EEC concerning medical devices as amended by Directive 2007/47/EC, and is in conformity with the following standards:

EN ISO 1641:2009
EN-ISO 10993-3:2009
EN 908:2008
EN-ISO 10993-1:2009/AC:2010
EN-ISO 10993-5:2009

EC Declaration of Conformity

Contact sales to learn more

Contact Formlabs to learn how desktop SLA 3D printing can simplify dental workflows and get a free sample for your specific application.

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