APPLICATION NOTE

LuxaPrint Ortho

Validated workflow with DMG DentaMile

DMG

Application Note: LuxaPrint Ortho

LuxaPrint Ortho is a light-curing 3D printer resin for the production of individual drilling templates with the highest level of precision and is certified as a class I medical device.

Precise drilling holes and an exact fit. Especially for drilling sleeves. LuxaPrint Ortho, a highly transparent premium resin, provides you with reliable support in this area. The excellent flow property and printing parameters designed for dimensional stability ensure optimum shaping. The demand for sterility is no challenge for this material: it meets the high demands of an implant in every particular.

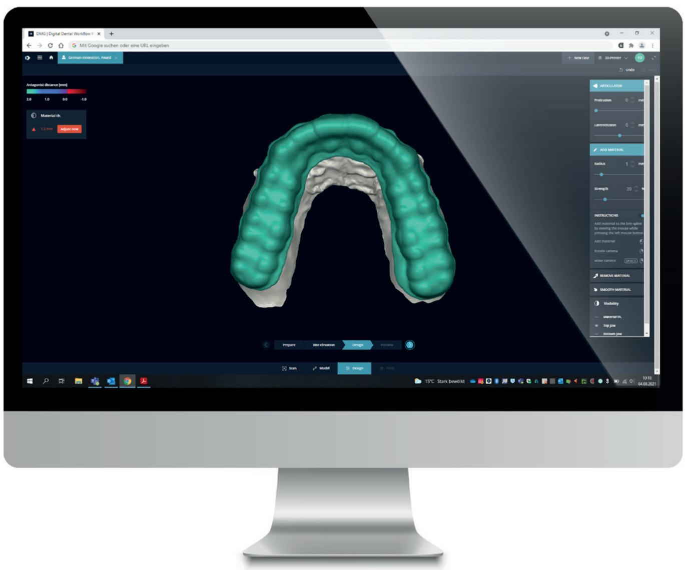
LuxaPrint Ortho is also characterised by its extremely high transparency:
99 % transparency ensures the clearest view of your work area and full control.

Short printing times and low material requirements have the added benefit of making the production in the lab pleasantly economical.

Validated workflow with DMG DentaMile

In this application guide, we present our validated DentaMile workflow, which you can use to easily and reliably achieve a result that meets the high requirements of dental users in terms of biocompatibility, stability and precision.

The DentaMile workflow was developed at DMG according to strict criteria, and carefully tested in our digital application centre. Please follow the below procedure exactly. You can be sure that you will always deliver work of the highest quality.



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Required equipment and resources

SCAN

- Intraoral scanner or optical desktop scanner
- Optional: Volume topography (DVT) scan of the patient's bone structure

DESIGN

- Dental design software (CAD) for fabricating drilling templates (e.g. 3Shape)

PRINT

- Slicing program to suit the 3D printer (Autodesk Netfabb for **DMG 3Demax DMG 3Delite** (DMG), D10+ / D20II / D20+ / D30II / D30+ D40II (RapidShape) and P10+ / P20+ (Straumann); Asiga Composer for Asiga printer)
- **DMG LuxaPrint Ortho** Resin
- **DMG 3Demax** 3D printer, **DMG 3Delite 3D printer**, D10+ / D20II / D20+ / D30II / D30+ D40II (RapidShape), P10+ /P20+ (Straumann) or Asiga 3D printer (e.g. Asiga MAX UV)
- **DMG 3Dewash** / RS wash / P wash or ultrasonic bath and cleaning fluid (isopropyl alcohol, ≥ 99% or ethanol, ≥ 96%)
- **DMG 3Decure** / RS cure / P cure post-curing device or xenon flash lamp device (Otoflash G171 or Heraflash/HiLite Power 3D)

1. Scanning

The fabrication of the digital drilling template first requires digital patient data to be generated. This can be done at the dental practice with an intraoral scanner or in the dental laboratory with a laboratory scanner. Depending on the version, impressions of the patient's teeth or plaster models can be scanned directly with the laboratory scanner.

The fabrication of complete guided drilling templates also requires DVT (digital volume tomography) scans of the patient’s bone structure.

2. Designing

Based on the digital data of the patient's teeth, the drilling template can now be constructed using an appropriate program.

If you use 3Shape Implant Studio, you can choose the material parameters saved by the system for DMG LuxaPrint Ortho as the starting point for your design. If you are working with a different program, you can use the following settings as starting values:

Table 1: Recommended settings for the drilling template design

	Minimum value	**Recommended basic setting**	Maximum value
Material thickness	1.5 mm	**1.5 mm**	7 mm
Spacing to the teeth	0 mm	**0.02 mm**	0.15 mm
Retention	0 mm	**0.01 mm**	0.10 mm
Spacing to the sleeve	0 mm	**0.08 mm**	–

Depending on the program used, the type of drilling sleeve and geometry of the patient's teeth, it may be necessary to change the recommended basic settings here to achieve a safe and precise design with an optimal fit.

How to proceed with the treatment planning and the design of the drilling templates may vary depending on the program used. For detailed instructions on how to design the drilling templates, please contact your program developer.

3. Preparing the print

After the design process, the digitally designed drilling template must now be imported into the printer program in order to prepare it for printing.

In this step, the drilling templates are oriented in the build area of the 3D printer and provided with support structures.

PRACTICAL TIP

Please always ensure that the correct machine and material parameters are used. Selecting the wrong settings can result in misprints and drilling templates with a poor fit as well as inadequate mechanical properties and lack of biocompatibility.

3.1. Autodesk Netfabb for DMG 3Demax and 3Delite (and RapidShape D-series)

3.1.1. Selecting material and machine

Open Autodesk Netfabb and select your machine environment (e.g. DMG 3Demax).

The DMG workflow area appears on the right-hand side of the screen (marked by the blue DMG logo). Here, you will be guided through all the relevant steps of the software from start to finish.

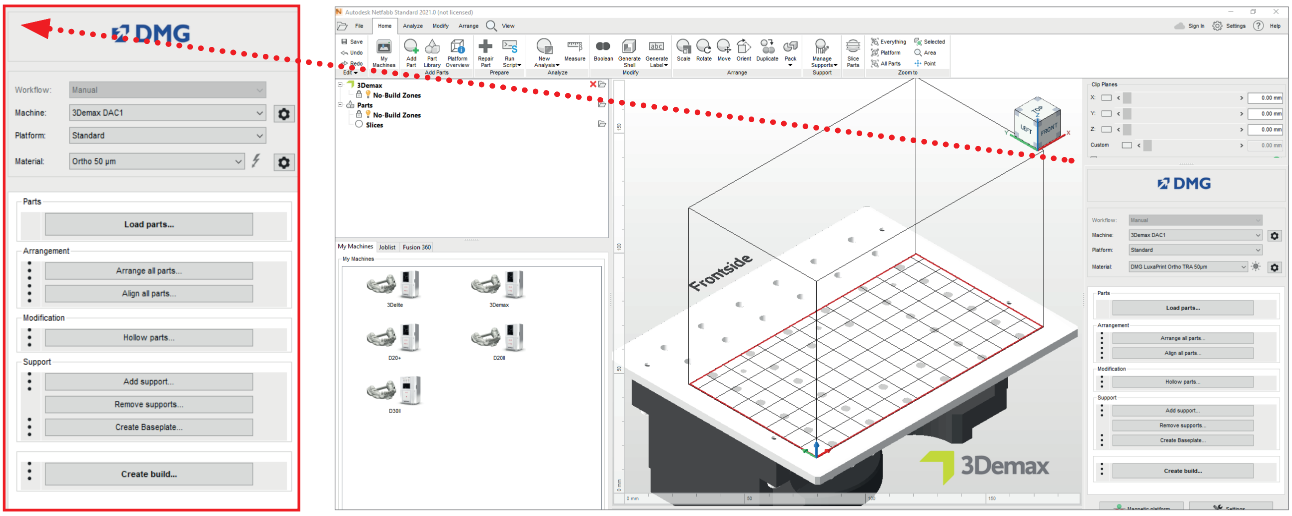


Figure 1:
Selection of machine
and material parameters

First select your printer and the material »DMG LuxaPrint Ortho« as well as the desired layer thickness. If you have never worked with the material, you may have to use the setting wheel next to the material line to create it (see 3Demax/3Delite operating instructions, point 6.7).

All available layer thicknesses have been checked in our digital application centre and deliver an exact and reliable printed object. A lower layer thickness leads to a finer surface structure, higher accuracy and longer printing time. Choose the correct layer thickness depending on your specifications at the time available and the desired surface quality.

3.1.2. Importing the drilling template

Import the previously created drilling template design into the Netfabb program. To do this, simply drag your file into the program's 3D view or select the »Load Pieces...« item in the DMG workflow area and navigate to your design.

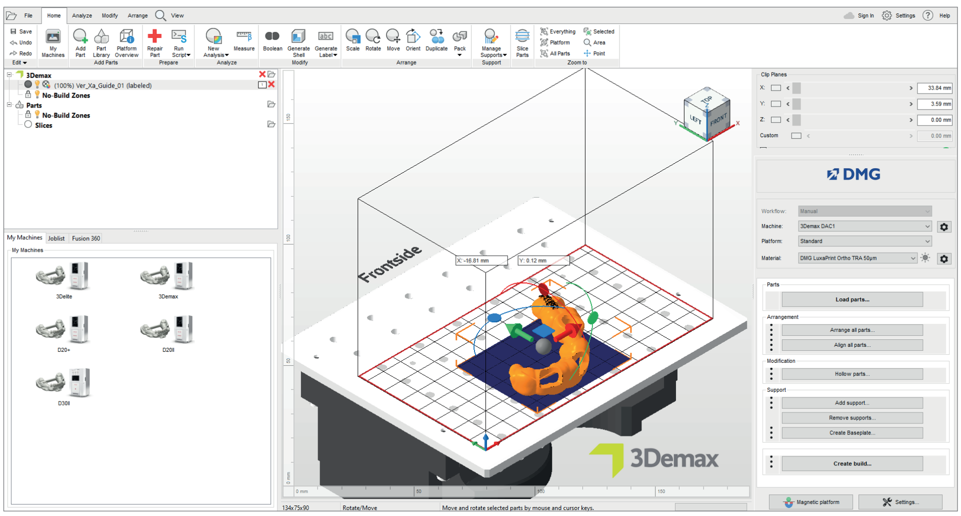


Figure 2:
Import of the digital
drilling template into Netfabb

3.1.3. Alignment of the drilling templates in the build area

Always align the drilling templates so that the inside of the template, relevant to the fit, faces away from the building plate. This achieves the highest level of accuracy and ensures that no support structures are generated on these surfaces.

The holder(s) for the drilling sleeve(s) should also always be as flat and parallel to the building plate as possible (so that the hole for the drilling sleeve is pointing in the Z direction or upwards) so that the drilling sleeve has an exact fit.

In the event of several drilling sleeves in one drilling template, all holders for drilling sleeves should be positioned as flat as possible and in a similar angle. For angles greater than 10°, it may be necessary to adjust the parameters specified in table 1.

Background / Further information

One reason for the lower reproduction accuracy at larger orientation angles is the overcuring in the Z direction, which is necessary to connect the individual layers to one another. Overcuring only occurs in the case of undercuts and holes or cavities in the object; namely whenever no object structure prevents hardening in the liquid resin in the Z direction (beam path of the light rays from bottom to top or from the tub towards the building plate). In case of a horizontal alignment, the fitting surface of the drilling templates (inside) typically lies in the direction of the material tray so that no overcuring phenomena occur here. This is especially important for the reception of the drilling sleeves. To ensure an exact fit of the sleeve, the hole of the receptacle should be perpendicular to the building plate.

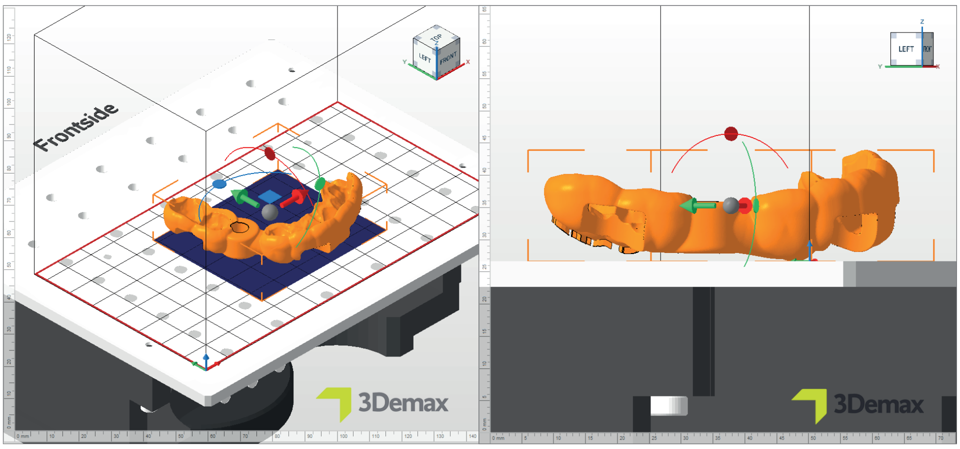
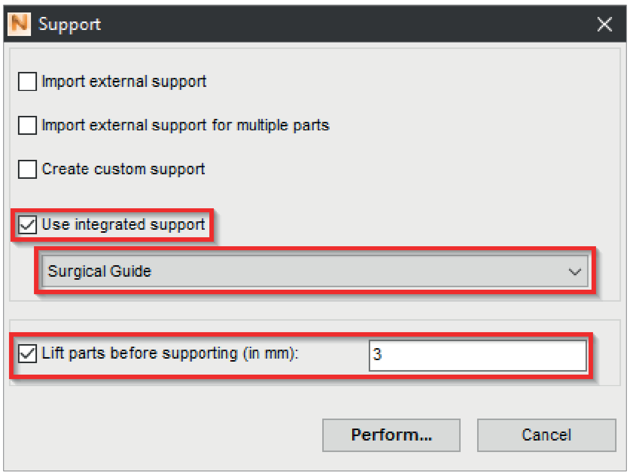


Figure 3:
Horizontal alignment of the drilling template and drilling sleeve receptacle with the fitting surface faced away from the building plate

3.1.4. Adding support structures

Figure 4:
»Support« window

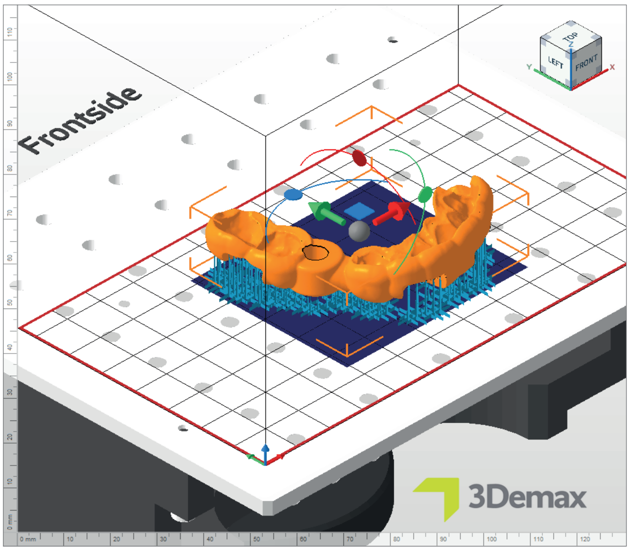


PRACTICAL TIP

You can also use these external upports if you are using a different program to generate support structures. To do this, select the item »Import external support« or »Import external support for several components«.

The objects require support structures to ensure a correct and exact setup of the drilling templates. In the DMG workflow area, select the »Add support...« item and in the next dialogue box, select »Use integrated support«. The preset support style »Surgical Guide« was specifically optimised for the printing of drilling templates and delivers the best results. The menu item »Lift components before support (in mm)« should also be selected to automatically lift your component a few millimetres from the building plate. A value of 2-4 mm is ideal. This allows for the support structures to be removed more easily in later process steps, and you will get a precise print result.

Figure 5:
Drilling template equipped with support structures



The program automatically calculates the optimal position of the supports and inserts it between the building plate and the drilling template.

Please examine the object for incorrectly placed support structures. To ensure a simple and precise installation of the drilling sleeves, ensure that there are no support bars near the drilling sleeve receptacles or on the fitting surface.

PRACTICAL TIP

If properly oriented, the automatic and integrated support script works perfectly in many cases. Because all printed objects are unique, it is possible that structures are placed incorrectly and have to be removed manually. It is usually not necessary to add individual support structures.

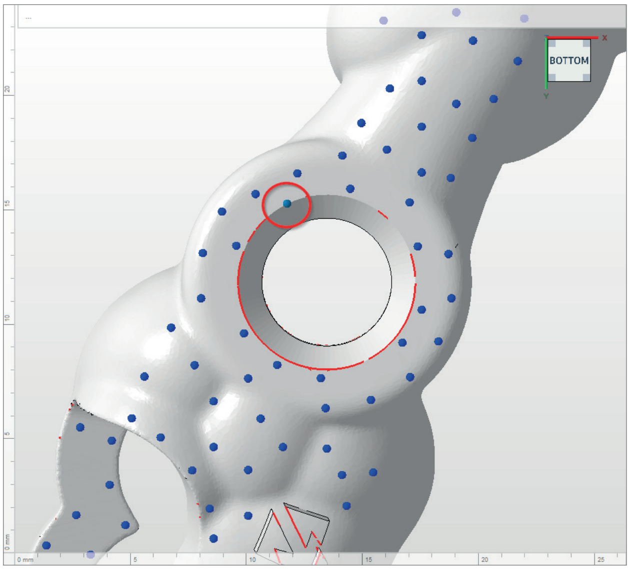


Figure 6:
Incorrectly set support bar

3.1.4.1. Removing and adding individual support bars

To remove or add individual support bars, first select the object in question and then »Add support...«. In the subsequent dialogue, activate the »Create individual support« box (see figure 8). Also ensure that the box »Lift components before support (in mm)« is not activated. You will then be taken to a reduced view of your object and the associated support bars, where you can remove or add individual support bars as you wish. With the function »Select support« you can mark and remove individual bars (right click: »Remove selection«).

Figure 7:
Removal of individual support bars in the support module

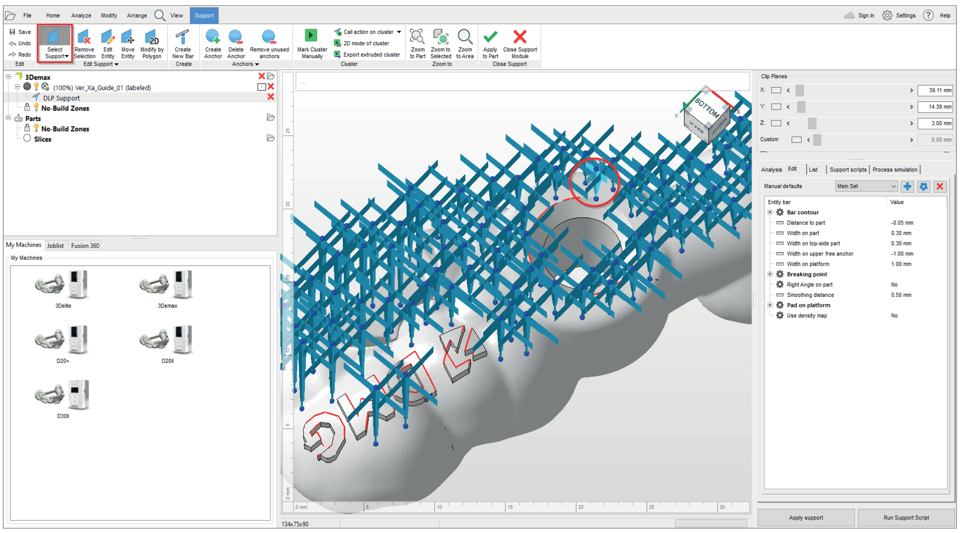
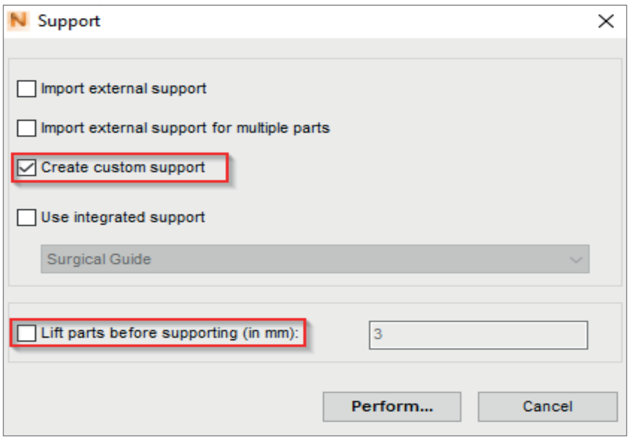


Figure 8:
Creating an individual support

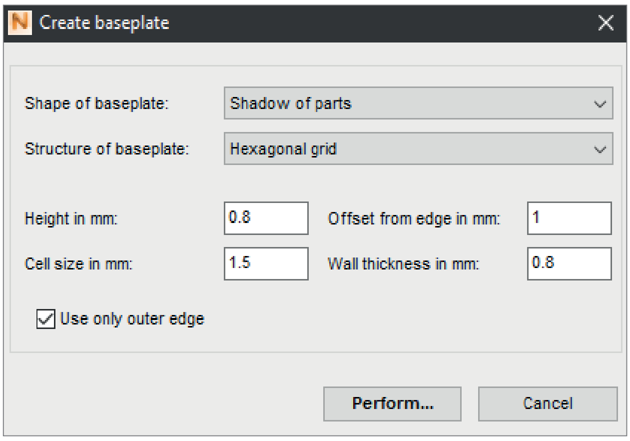


3.1.5. Baseplate

If necessary, a baseplate can be added to the object as a hexagonal grid. A baseplate ensures better adhesion to the building plate and thus minimises misprints. The following settings are recommended for the DMG LuxaPrint Ortho material:

Shadow depending on the component, grid with hexagonal cells, height: 0.8 mm, cell size: 1.5 mm, offset at edge: 1 mm, wall thickness: 0.8 mm.

Figure 9:
»Create baseplate« window



3.1.6. Creating a build job (»slicing«) and transferring it to the printer

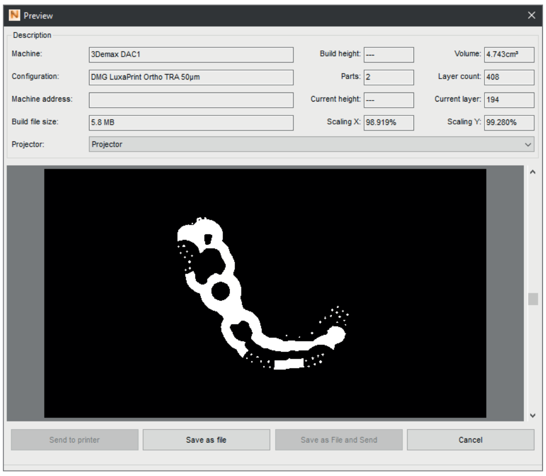


Figure 10: The entire build area is shown in black; the areas to be exposed are shown in white. As an example, at layer 194 in the illustration, support structures are still partially being created, but the drilling template contours are already largely recognisable.

As soon as you are satisfied with the arrangement of the pieces on the building plate, the support structures, and the baseplates, check the material and machine settings again and create a printer-readable file via »Create build job«.

After the calculation of the individual print layers (the so-called »slicing«), a preview window appears. Here, you can scroll through the layers of the print job and review your object.

Now, transfer the finished print job to your 3D printer via a network connection or USB stick.

3.2. Asiga Composer

3.2.1. Selecting material and machine

Open Asiga Composer and select a new project, or open a previously saved project. Select your printer and the material »DMG LuxaPrint Ortho TRA«. The layer thickness validated by DMG is 0.050 mm (= 50 µm) and provides the best results.

If you have not yet worked with the material, you can download the print parameter on the Asiga website in your account area in the material library (asiga.com/accounts/) and import it into the Composer program.

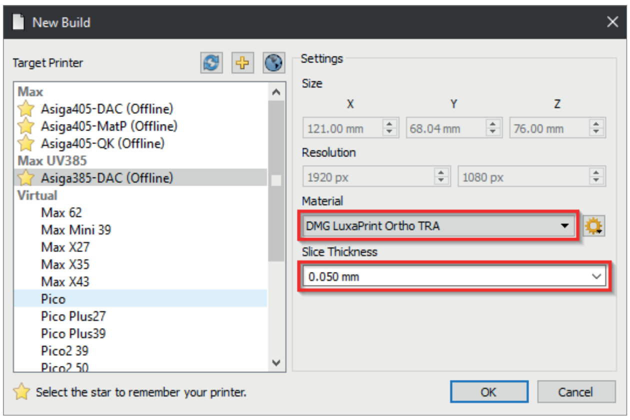


Figure 11:
Material and layer thickness selection in Asiga Composer

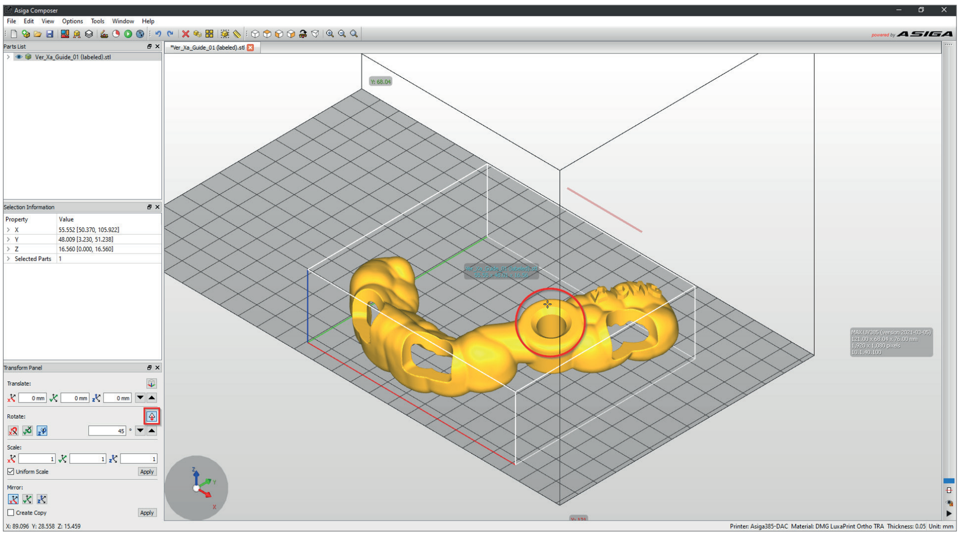
3.2.2. Importing in Asiga Composer

Import the previously-created drilling template design into Asiga Composer. To do this, simply drag your file into the program's 3D view or select the menu »Add Parts...« item.

3.2.3. Alignment of the drilling templates in the build area

Always align the drilling templates so that the inside of the template, relevant to the fit, faces away from the building plate. This achieves the highest level of accuracy and ensures that no support structures are generated on these surfaces.

Figure 12:
Orientation of the drilling template with the function »Rotate Facet Downwards«



The holder(s) for the drilling sleeve(s) should also always be as flat and parallel to the building plate as possible (so that the hole for the drilling sleeve is pointing in the Z direction or upwards) so that the drilling sleeve has an exact fit. To achieve a simple alignment, Asiga Composer offers the practical »Rotate Facet Downwards« function. To do this, first select your drilling template with a left click, then in the rotation area select the »Rotate Facet Downwards« function on the left side of the window. Then place the target cross on the plane surface of the drilling sleeve receptacle to orient this surface in the direction of the building plate (see figure 12).

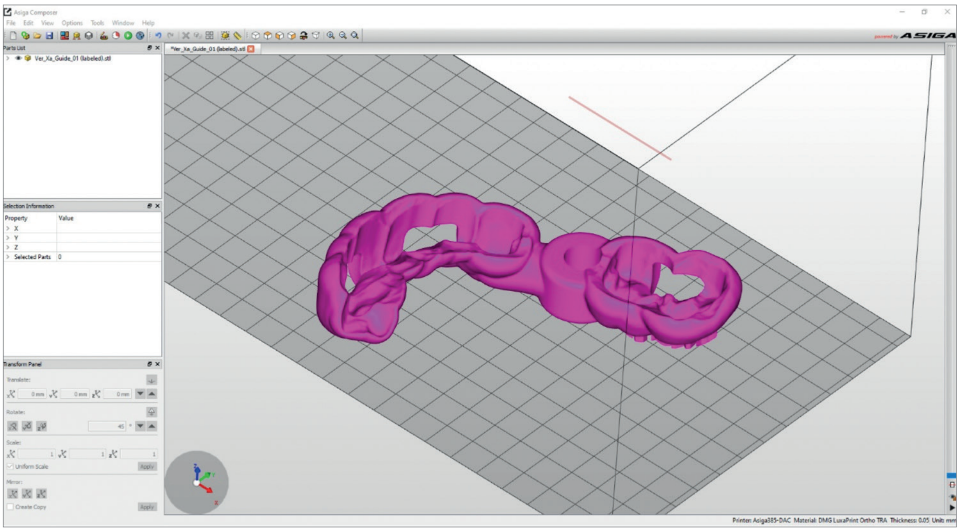


Figure 13:
Correct orientation in the build area

In the event of several drilling sleeves in one drilling template, all holders for drilling sleeves should be positioned as flat as possible and in a similar angle.

3.2.4. Adding support structures

Select the menu item »Generate Support« to add support structures to your work. The suggested values in the program have already been optimised for the material, so you can simply start the automatic support generation function by clicking on »Apply«. Also ensure that the »Height levelling« function remains activated so that your object is raised a few millimetres off of the building plate. The program automatically calculates the optimal position of the supports and inserts it between the building plate and the drilling template.

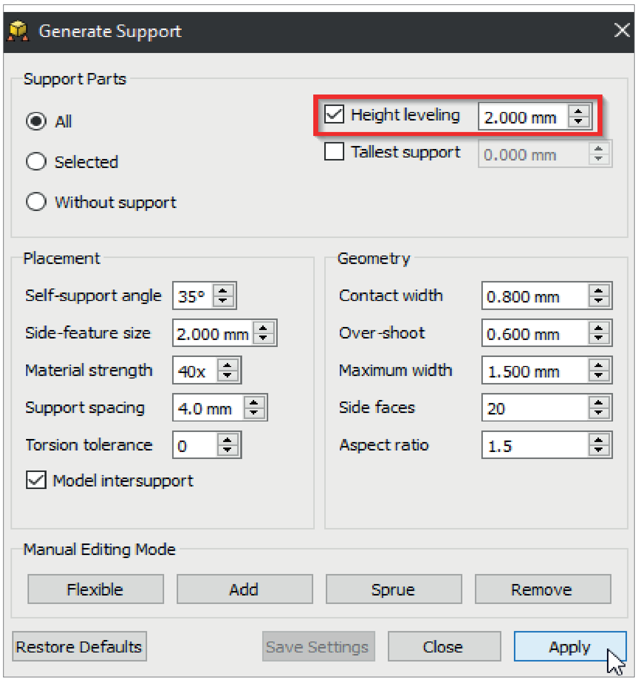


Figure 14:
»Generate Support« dialogue window

Please examine the object for incorrectly placed support structures. To ensure a simple and precise installation of the drilling sleeves, check that there are no support bars near the drilling sleeve receptacles or on the fitting surface. If necessary, remove individual support bars and/or add any.

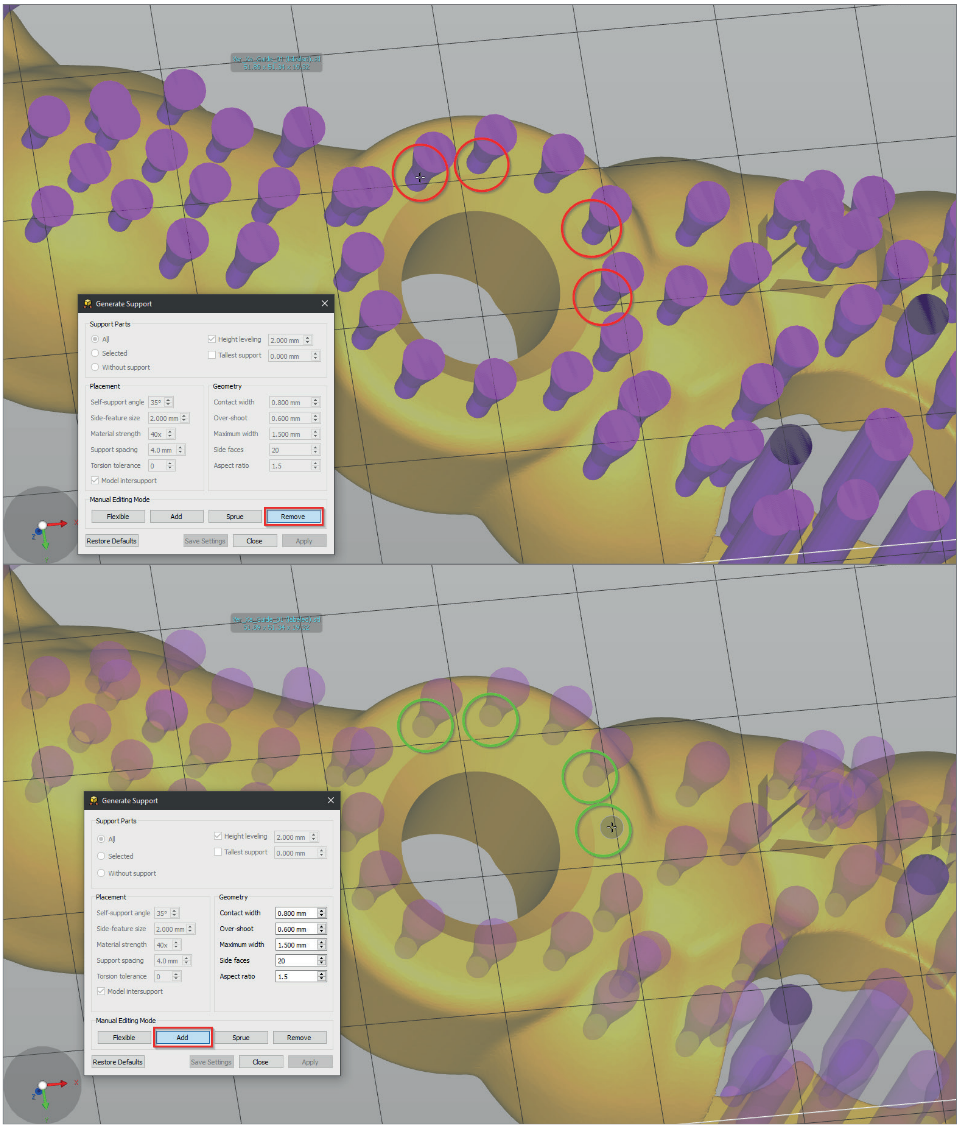


Figure 15:
Removing and adding individual support bars
in Asiga Composer

3.2.5. Sending a print job to the printer

The »Build« menu item takes you to the Build Wizard. Here you can check your settings again and, if necessary, create a baseplate under your work. Now send the finished print job to your 3D printer.

4. Printing

4.1. Shake the material

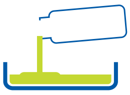
≥ 01:00
min.

DMG LuxaPrint Ortho must be shaken for at least one minute before use. This ensures that you always achieve a homogeneous product and thus consistently high-quality results.

4.2. Scanning RFID tags

Scan the material's RFID code for greater process reliability. The device can detect possible incorrect material information in the program and will warn you if necessary (supported by DMG 3Demax/DMG 3Delite (DMG), D10+ / D20+ / D30+/ D40 II (Rapid Shape), P10+ / P20+ / P30+ / P40 (Straumann)).

4.3. Adding printing material



Put LuxaPrint Ortho in the resin reservoir of your 3D printer. Make sure that the reservoir is filled far enough, so that the resin can continue to flow even if the build plate is fully occupied. Please never fill the resin reservoir to the brim, or the resin may overflow and contaminate your printer. Use separate material trays for every biocompatible printing material to avoid cross-contaminations.

4.4. Starting a 3D printing job

Start the print job on your 3D printer.

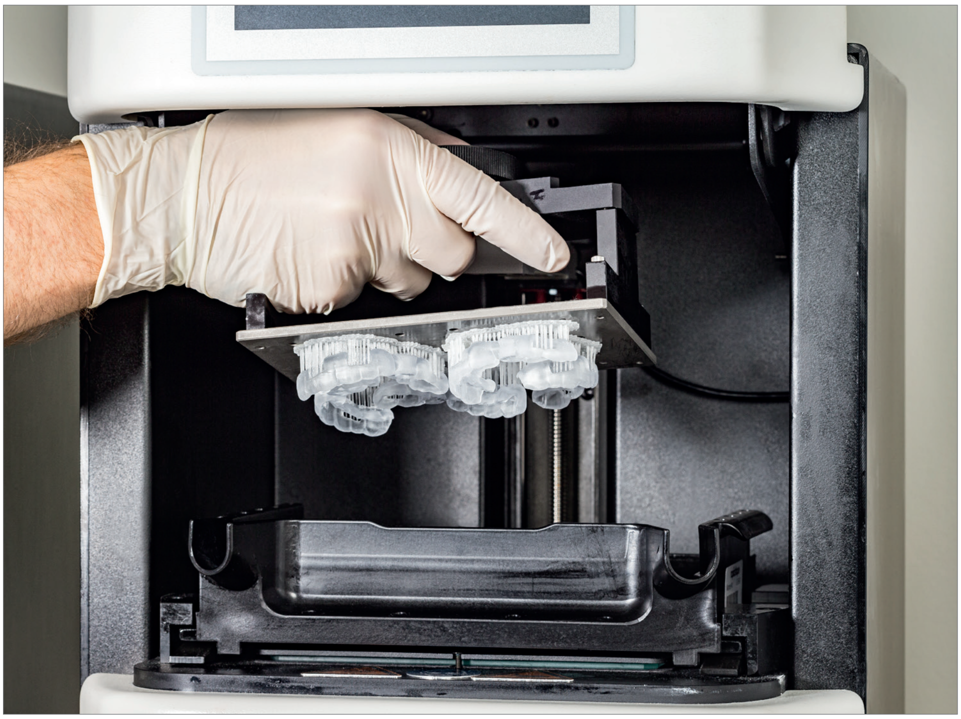


Figure 16:
Print object in the build area of DMG 3Demax

5. Post-processing

Intelligent connectivity

As a user of a DMG 3D printing system consisting of the printers and post-processing units, you can benefit from the intelligent linking of the devices. As soon as the print job is finished on the printer, all relevant information is transferred to the post-processing devices, where you only have to select the appropriate print job to start the individual post-processing.

5.1. Draining

After completing the printing process, ideally let your drilling templates hang in the printer for about 10 minutes, so that any liquid resin can drip off. This saves material and cleaning.

5.2. Detaching pieces from the build plate

Carefully detach printed objects from the build plate. Use a spatula or the cutter that came with the printer (or similar cutting tool). Push the tool under the base plate and loosen the parts with slight leveraging movements. If the adhesion to the build plate is too strong, you can place the spatula on the base plate and carefully hit the handle of the spatula with a little hammer to loosen the parts.

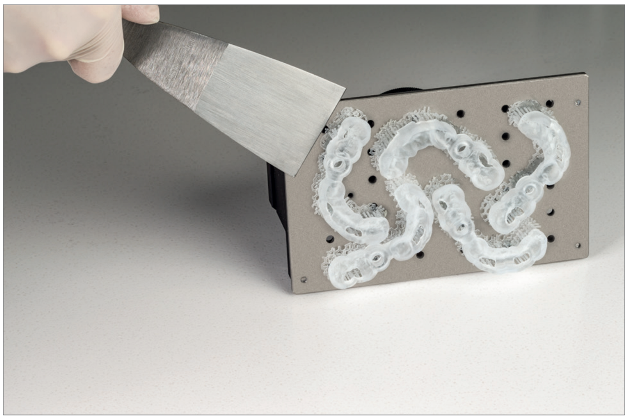


Figure 17:
Loosening the printed objects from the build plate

If you are using a DMG 3Delite (DMG), D10 + (RapidShape) or P10 + (Straumann), leave the objects on the build plate and hang the entire plate in the provided cleaning device (DMG 3Dewash, RS wash or P wash).

5.3. Cleaning

After printing, the drilling templates must be carefully cleaned of any non-hardened resin. Use separate cleaning solutions for every biocompatible printing material to avoid cross-contaminations.

PRACTICAL TIP

Prolonged contact with the cleaning liquids can affect the accuracy of the objects as well as their mechanical properties. Please keep to the times stated here.

5.3.1. 3Dewash (or RS wash / P wash)

Simply place your printed objects in the cleaning chamber and select the program for DMG LuxaPrint Ortho or the appropriate print job (requires Intelligent Connectivity).
For best cleaning results, place the drilling template in the cleaning chamber with the mating surface facing downwards. The cleaning should be done with isopropyl alcohol (approx. 99%).

Figure 18:
Drilling sleeve in the 3Dewash unit

5.3.2. Ultrasonic cleaning

If you do not have any of the cleaning devices mentioned above, pre-clean your drilling template with ethanol (≥ 96%) or isopropyl alcohol (≥ 99%) in an ultrasonic bath, for a maximum of 3 minutes. You can also use a brush, if necessary. If available, you can then clean your objects with compressed air. Clean your pieces again in a separate container with clean ethanol (≥ 96%) or isopropyl alcohol (≥ 99%) for a maximum of 2 minutes in the ultrasonic bath.

Figure 19:
Rinsing off resin residue

Inspect the drilling template thoroughly after drying and ensure that

- the drilling template is clean and completely dry,
- No cleaning fluid or resin residues remain on the surface (indicated by a shiny object surface).

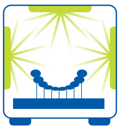
If there are still liquid resin residues on the surface, they can be removed e.g. with a spray bottle containing isopropyl alcohol or a cloth soaked in isopropyl alcohol. Then dry your drilling template completely as described above.

5.4. Drying and visual inspection

Ensure the drilling template has completely dried before you proceed with post-curing. Use compressed air for this, or let the pieces air dry for about 30:00 minutes. When drying, ensure that the drilling template is not exposed to any direct sunlight or other intense radiation (e.g. daylight lamps).

Figure 20:
Drying a drilling template with compressed air

5.5. Post-curing



PRACTICAL TIP

Post-curing that is too short, too long or too intensive can lead to a loss of accuracy due to distortions in the part and to discolouration of the pieces.

Correct post-curing of the printed pieces is important to obtain a biocompatible result with optimal mechanical properties and a perfect fit. Therefore, always pay attention to the correct post-curing and adhere exactly to the given specifications. Never place drilling templates on top of each other in the exposure chamber and make sure that the pieces receive light from all sides.

5.5.1. DMG 3Decure

Simply place your printed objects in the cleaning chamber and select the program for DMG LuxaPrint Ortho or the appropriate print job (requires Intelligent Connectivity).

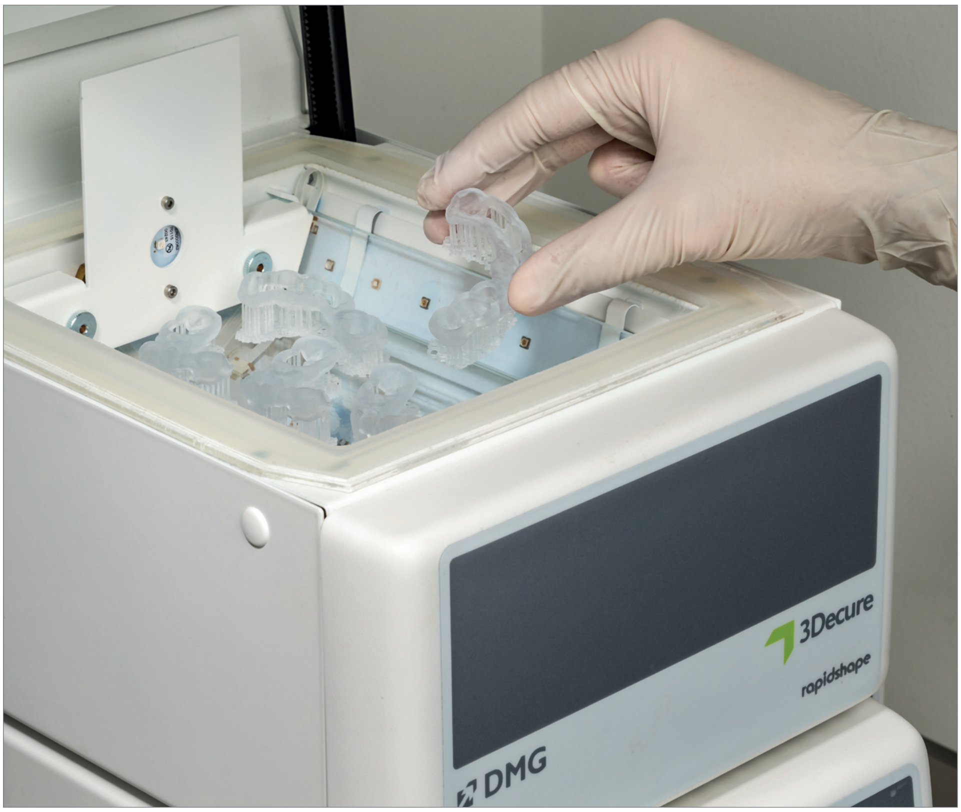


Figure 21: 3Decure

5.5.2. Otoflash / Heraflash / HiLite power3D

Place your printed objects in the chamber of the exposure device and cure using the settings given below.

Light-curing unit	Light-curing time	Tips
Otoflash G171 (N360 bath)	2 x 2,000 flashes	After the first 2000 flashes, let the printed object cool down and turn it over
Heraeus Heraflash / Kulzer HiLite power 3D	2 x 180 seconds	After the first 180 seconds, let the printed object cool down and turn it over

5.6. Detaching support structures

Carefully detach the support structures. It is best to use a hand tool with a cutting disc or a small pair of forceps, side cutters or scissors. The remains of the support structures can then be carefully removed with a milling machine or a polisher.

PRACTICAL TIPS

Although cutting off the supports by hand is quicker than using a tool, it can tear out small areas from the splints and thus damage the drilling templates or even make them unusable. We therefore recommend using a tool.

Always remove the supports **after** the post-curing to avoid distortions in the component. An exact fit is crucial for optimal treatment, especially when it comes to drilling templates.

Figure 22:
Remove the support structures using a cutting disc

5.7. Finish and polish

The drilling templates should be prepared under active suction due to the resulting dust exposure.

- Rough remnants of the support can be sanded down with **sandpaper/ corundum paper** (e.g. grain size 120 µm).
- **Ceramic milling cutters or fine cross-cut plastic milling cutters** can be used for changing the shape of template edges (shape grinding) or shortening them.
- A **silicone-saturated fibre fleece wheel** can be used for removal, rounding and smoothing (pre-polishing) of the edges and surfaces.
- The pre-polishing should be done at the **polishing motor with a fine pumice stone and a goat hair brush**.
- Use a **high-gloss buff** and a **universal plastic polishing paste** to create a high gloss.

Figure 23:
Polishing tools used
(example image)

Figure 24:
Finished drilling template
with drilling sleeve

PRACTICAL TIP

Please inspect your finished objects after completion for any damage or cracks. Damaged drilling template should never be used in patients.

6. Preparation prior to use on the patient

6.1. Assembly of the drilling templates

Only use the drilling sleeve type that you selected during the design process. The drilling sleeve should have an exact press-fit in the template and be held in position by retention. If you find that it does not fit exactly, the drilling template should not be used on the patient. An exact fit can be achieved by adjusting the design parameters (»Distance to the drilling sleeve«). Subsequent work on the drilling template may impair accuracy in the event of clinical intervention.

6.2. Sterilisation

DMG LuxaPrint Ortho drilling templates can be sterilised once in the autoclave before use on the patient. Please use the following autoclave parameters for the steam sterilisation:

Temperature: **134 °C / 273 °F** at a pressure of **2 bar** and a duration of 05:00 min.

6.3. Disinfection

According to the manufacturer's specifications, the following disinfectants may be used:

- PrintoSept-ID (on the basis of quart. ammonium salts)
- SprayActiv, alcoholic disinfectant spray (also contains didecyldimethyl-N-chloride)
- Dentavon (solution prepared from granulate; contains penta-potassium-bis(peroxymonosulfate)-bis(sulfate), anionic surfactants, non-ionic surfactants, soap, phosphonate)

7. Validated fitting accuracy

In our digital application centre, the fitting accuracy of all of our materials and workflows are set, checked and evaluated according to a defined validation process. Each workflow must meet strict criteria that has been developed for each application individually and according to clinical relevance and applicability.

The fitting surfaces and the drilling sleeve receptacle of a drilling template, which was fabricated with the DMG validated workflow while using DMG LuxaPrint Ortho print resin, DMG 3Demax 3D printer, DMG 3Dewash cleaning unit and DMG 3Decure post-exposure unit (design in 3Shape Implant Studio with default settings for the material DMG LuxaPrint Ortho) show mean deviations of 29 µm. In other words, 99.0 % of the surface is within a tolerance of 100 µm, with the total fitting surface showing no deviations greater than 150 µm. The linear deviation of the receptacle for the drilling sleeve is 14 µm with an angular deviation of 0.85°.

In a current study by Bencharit et al. (Dalal, N.; Ammoun, R.; Abdulmajeed, A. A.; Deeb, G. R.; Bencharit, S. J. Prosthodontics **2020**, 29, 161–165), the accuracy of printed drilling templates was examined as a function of the layer thickness in the printing process and orientation in the build area. The authors find mean deviations of the intaglio surface from 25 µm to 98 µm, linear deviations of the drilling sleeve receptacle from 8 µm to 23 µm as well as angular deviations of the drilling sleeve receptacle from 0.56° to 1.57°.

The drilling template fabricated according to the validated DMG workflow accordingly has similar or smaller deviations than those examined in the study. The studies mentioned here and others (Henprasert, P.; Dawson, D. V.; El-Kerdani, T.; Song, X.; Couso-Queiruga, E.; Holloway, J. A. J. Prosthodontics, 2020, 29, 534-541; Geng, W.; Liu, C.; Su, Y.; Li, J.; Zhou, Y. Int. J. Clin. Exp. Med. 2015, 8(6), 8442-8449) also suggest that the determined deviations have no clinical relevance and the use of printed drilling templates offer clinical and economic advantages.

Table 2:
Accuracy of a drilling template fabricated with the validated DMG workflow

	Accuracy
Amount of area within 100 µm deviation (fitting surface and drilling sleeve receptacle)	99.0%
Amount of area within 150 µm deviation (fitting surface and drilling sleeve receptacle)	100.0%
Mean deviations of the fitting surface	29,3 µm
Maximum deviation of the surface of the drilling sleeve receptacle	39 µm
Linear deviation of the drilling sleeve receptacle	14 µm
Angular deviation of the drilling sleeve receptacle	0.85°

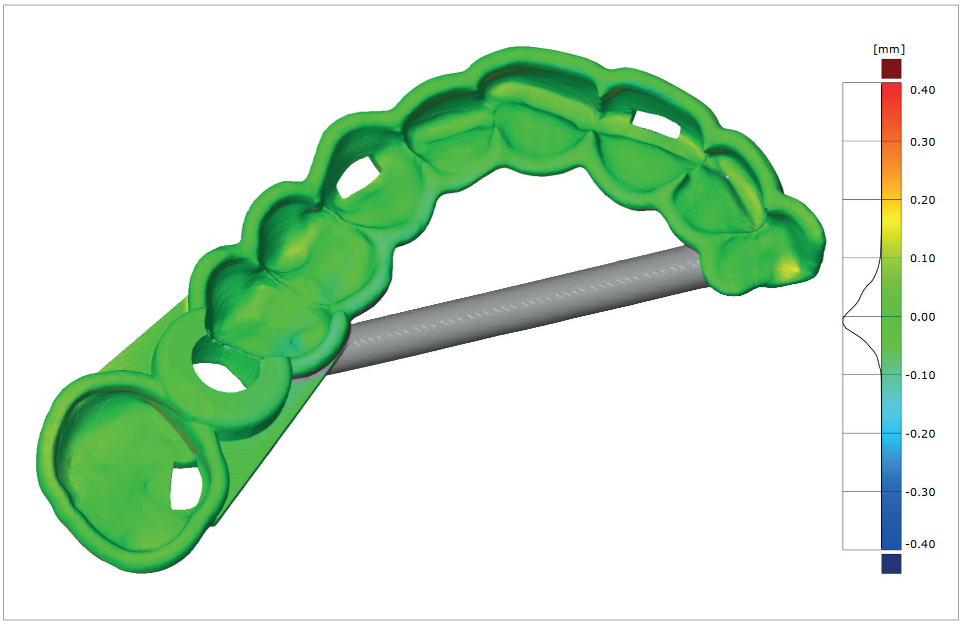


Figure 25:
Comparison of the fitting surface of a drilling template fabricated in the validated DentaMile workflow compared to the digital output data.
99.0% of data points lie within a tolerance of 100 µm. The median deviation is 29.3 µm.