APPLICATION NOTE

LuxaPrint Ortho Plus

Validated workflow with DMG DentaMile

DMG

Application Note: LuxaPrint Ortho Plus from DMG

The light-curing 3D print resin LuxaPrint Ortho Plus was specially developed for manufacturing transparent splints and orthodontic appliances.

As a Class II medical device, LuxaPrint Ortho Plus is optimally suited for manufacturing occlusal splints and appliances for orthodontic treatments. Its high transparency is equal to that of vacuum-formed splints and provides the basis for optimally checking the fit. An extremely smooth surface, together with odour and taste neutrality, make for a high level of wearing comfort.

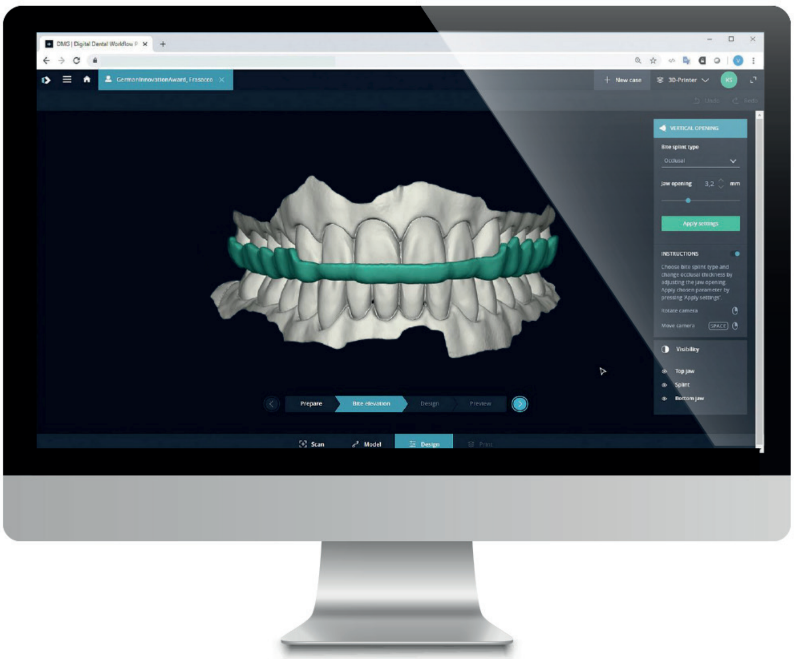
Validated workflow with DMG DentaMile

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.

DentaMile CONNECT

GERMAN INNOVATION AWARD '20 WINNER



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Required equipment and resources

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DESIGN
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Option b) Dental design software (CAD) for creating dental splints

PRINT
Option a) **DMG DentaMile connect** software
Option b) Slicing software suitable for 3D printers
(Autodesk Netfabb for DMG 3Demax, DMG 3Delite or Asiga Composer for Asiga printers)

- **DMG LuxaPrint Ortho Plus** resin
- **DMG 3Demax** 3D printer, **DMG 3Delite** 3D printer or Asiga 3D printer (e.g. AsigaMAX)
- **DMG 3Dewash** or ultrasonic bath and cleaning fluid (isopropyl alcohol, ≥ 99 % or Ethanol, ≥ 96 %)
- **DMG 3Decure** post-curing device or xenon flash lamp device (Otoflash G171 or Heraflash/HiLite Power 3D)

1. Scanning

For the digital creation of occlusal splints, digital patient data must first 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 digital patient data can then be exported to the design program.

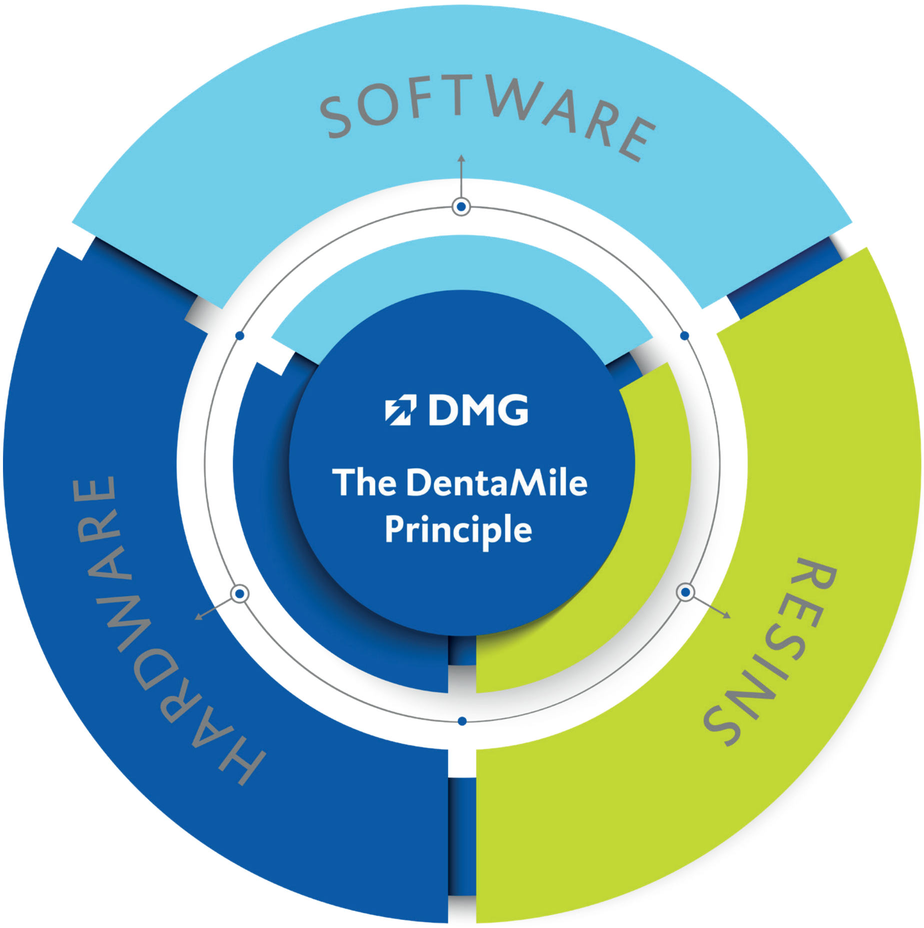
2. Designing

Based on the digital data of the patient's teeth, a splint can now be constructed using appropriate software. Regardless of the program you use, the following material-specific specifications should be followed:

Minimum material thickness for structures	Maximum material thickness
1.5 mm	7 mm

2.1. DentaMile connect

The cloud-based software developed by DMG simplifies 3D printing to such an extent that the technology can be fully integrated into everyday work – without any technological barriers. This earned DentaMile connect the 2020 German Innovation Award.



With **DentaMile connect**, you can not only start our validated workflow at the design stage, but also have other options for digitally storing your patient data, which makes your quality management much easier.

The program intelligently guides you through the workflow so that you can fully concentrate on your work. Thanks to the intuitive interface, no entries are forgotten - and the result is impressive.

Visit **www.DentaMile.com** for more information

View of splint in entire jaw

DentaMile CONNECT

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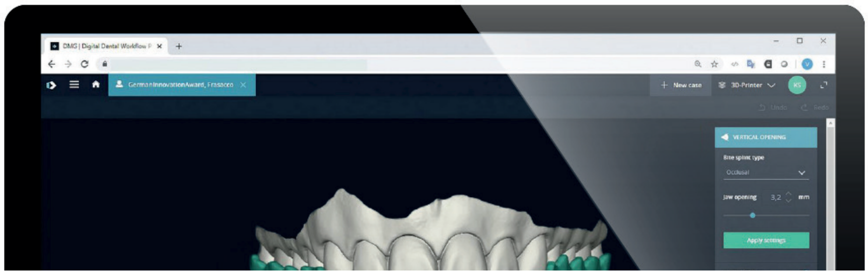
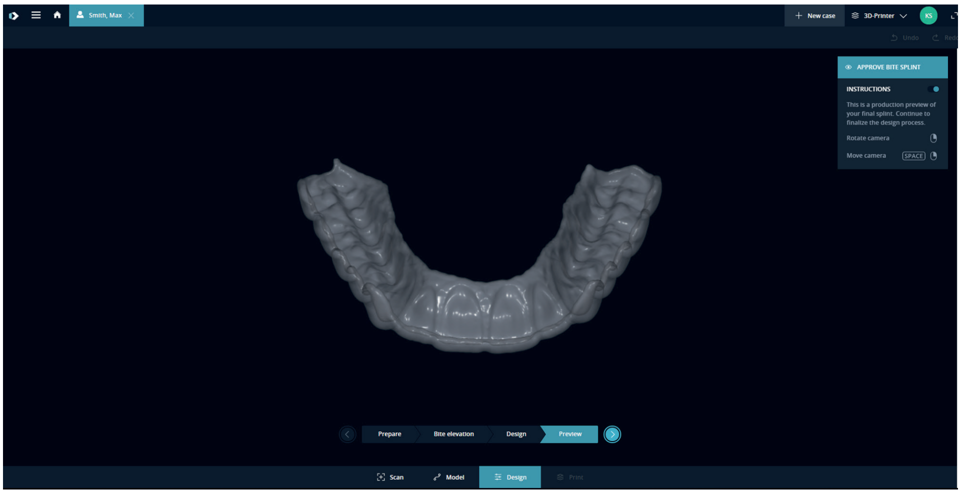


Final splint design



2.2. Dental CAD software from third parties (e.g. exocad or 3Shape)

When designing the splint in a CAD program, it must be ensured that the material does not fall below the minimum thickness of 1.5 mm and does not exceed the maximum thickness of 7 mm.

Next, import the patient's scanned data in the design program. The program will guide you through the design process of the digital splint in several process steps. Make sure you follow the specifications of the software developer.

Good splint design is critical to comfort, patient fit, and clinical effectiveness of the end product. Our 3D printers and materials are set up so that the digital data can be reproduced with great precision. The splint should therefore be designed carefully and accurately.

After completion of the splint construction, the final design is checked again and exported as an STL file (or another supported file format) for the printing software.

For detailed instructions on how to design dental splints, please contact your software developer.

3. Preparing the print

PRACTICAL TIP:

Please always ensure that the correct machine and material parameters are used. Incorrect settings can lead to misprints and splints with a bad fit, as well as inadequate mechanical properties and a lack of biocompatibility.

The digitally designed splint must now be imported in the printer software in order to prepare it for printing.

In this step, the digital splints are oriented, arranged and then provided with support structures in the build area of the 3D printer.

3.1. DentaMile connect

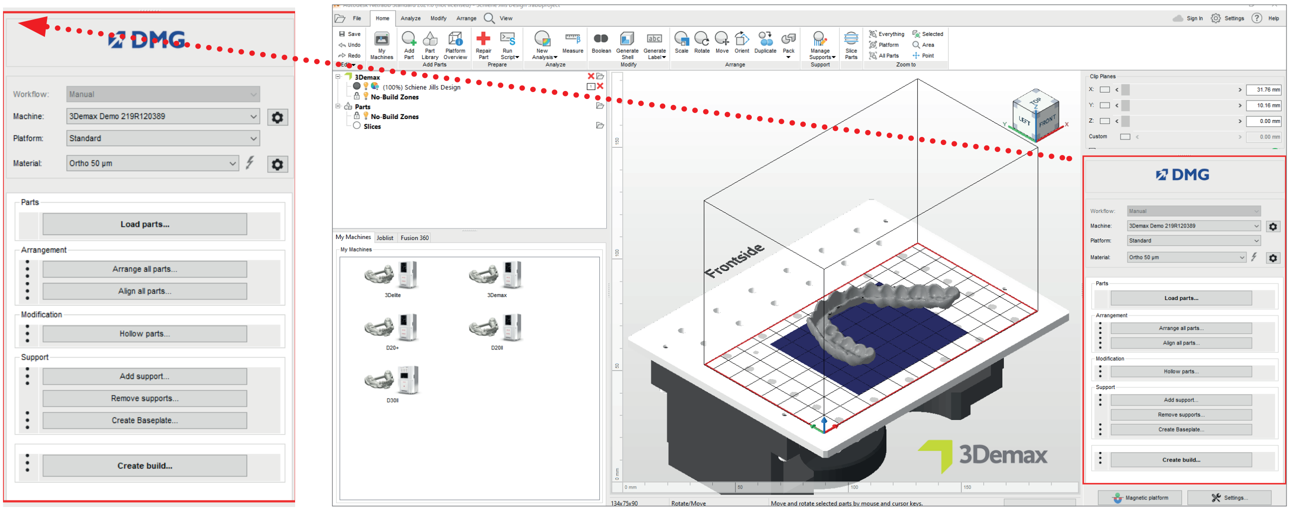
DentaMile connect from DMG takes over all the necessary work in the printer software for you. The arrangement and orientation of the splint to be printed, the addition of support structures and the selection of materials and parameters are fully automated on your DMG 3Demax or DMG 3Delite 3D printer, without having to start the program manually.

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

3.2.1. Selecting material and machine

Open 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 from top to bottom.



User interface
Autodesk Netfabb

First select your printer and the material »DMG LuxaPrint Ortho Plus« 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. Please note that a finer surface can lead to time savings when finalising. Choose the correct layer thickness depending on your specifications at the time available and the desired surface quality.

3.2.2. Importing in Netfabb

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

PRACTICAL TIP:

In most cases, printing splints in a 0° or 20° orientation is faster and more productive than printing in a 90° orientation.

For more information, see point 7: Productivity comparison 0° vs. 90°.

3.2.3. Aligning splints

Align the splints so that the inside of the splint, 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.

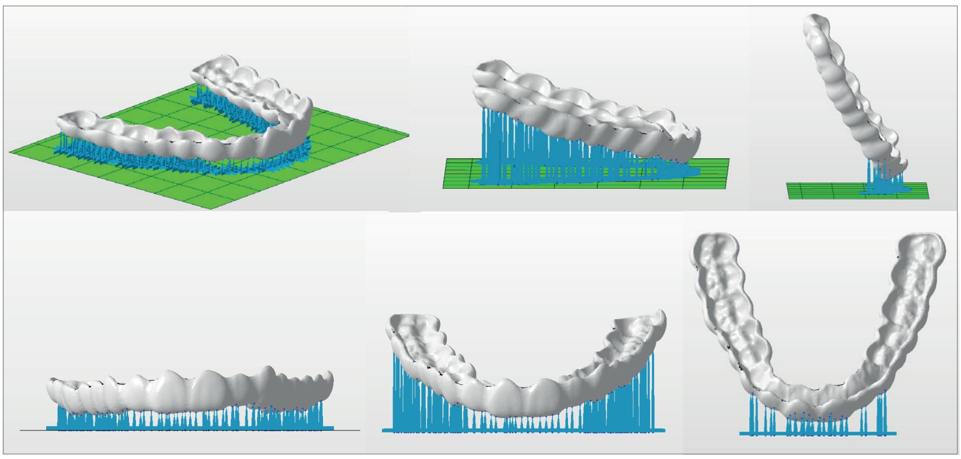
The best results are achieved with a horizontal alignment of the splints (between 0° and 20°). Steeper angles can affect the fit and precision of the pieces.

Background information

One reason for the poorer fit at orientation angles greater than 20° 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 resin in the z-direction (beam path of the light rays from bottom to top or from the tub towards the building plate). With an alignment of 0° to 20°, the fitting surface of the splint (inside) is typically in the direction of the material tray (in contrast to a 90° oriented splint) so that overcuring does not take place there but only on the antagonist side, which will have to be treated in any case due to the existing support structures.

Exact reproduction of the digital data is therefore no longer guaranteed at angles greater than 20° (e.g. 60°, 90°).

Aligning splints (left to right) 20° (recommended), 60°, 90°



Aligning the splints in Netfabb, including support structures. Left: 0° (recommended), middle: 20° (recommended), right: 60° (not recommended)

PRACTICAL TIP:

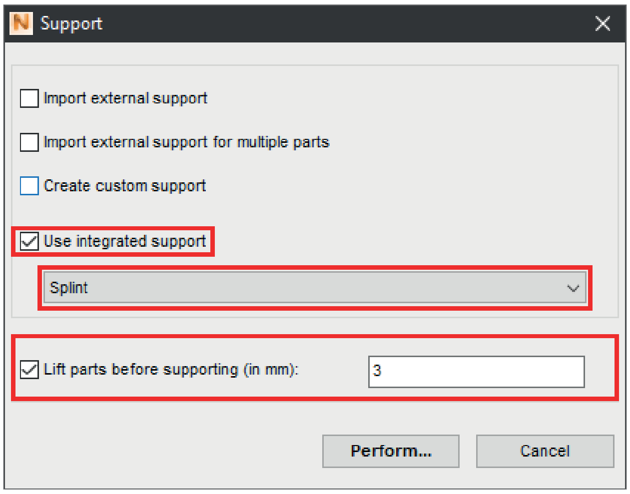
Do not place splints directly on the building plate! The longer exposure of the first layers of the print job, which is necessary for the object to adhere to the building plate, leads to a lower reproduction precision here.

3.2.4. Adding support structures

Then select »Add support ...« and in the next dialog window »Use integrated support« and in the dropdown menu »Splint« to provide your object with support structures.

The menu item »Lift components before support (in mm)« should also be selected in order to lift your component a few millimetres from the building plate.
For splints, 2-4 mm is optimal. This allows for the support structures to be removed more easily in later process steps and you will get a precise print result.

»Support« window



The program automatically calculates the optimal position of the supports and inserts it between the building plate and the splint. Please examine the object for incorrectly placed support structures. No support structures should be found on the inner surfaces relevant for the fit. If necessary, remove individual support structures using the editing feature.

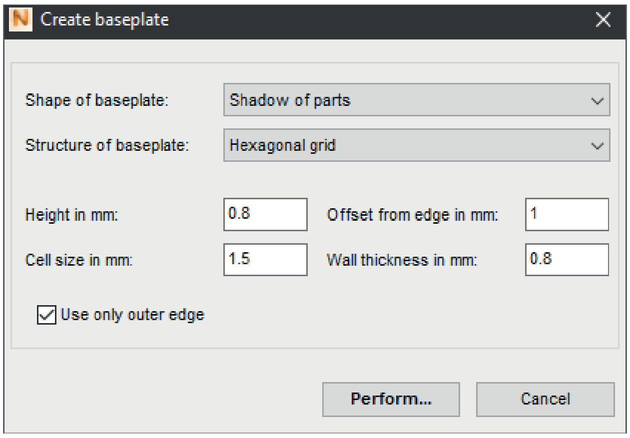
The integrated automatic support script works perfectly in most cases. However, because all printed objects are unique, it is possible that structures are placed incorrectly and have to be removed manually. It is usually not necessary to add individual structures.

The software can also import externally designed support structures.

3.2.5. 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 basic settings suggested by Netfabb lead to good results in most cases (grid with hexagonal cells, height: 1.5 mm, cell size: 1.5 mm, offset at edge: 0 mm, wall thickness: 0.8 mm)

»Create baseplate« window



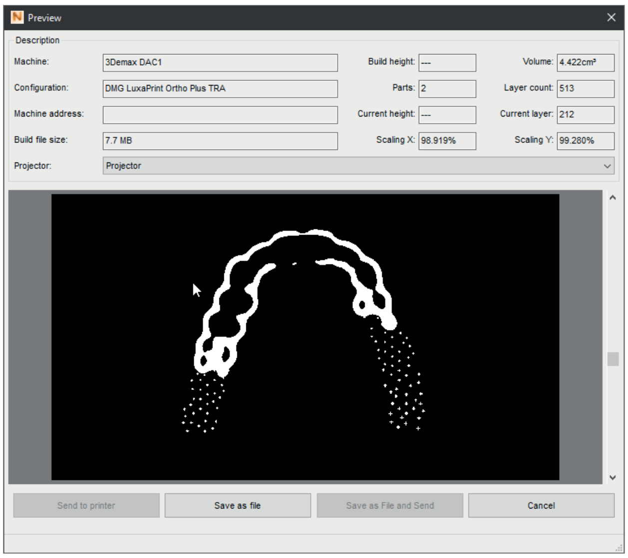
3.2.6. Creating a build job (slicing) and transferring it to the printer

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.

Preview of calculated print job

The entire build area is shown in black; the areas to be exposed are shown in white. As an example, at layer 187 in the illustration, support structures are still partially being created, but the splint contour is already largely recognisable.



3. Asiga Composer

3.3.1. 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 Plus TRA«. The layer thickness validated by DMG is 0.050 mm (= 50 µm) and provides the best results.

3.3.2. Importing in Asiga Composer

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

PRACTICAL TIP:

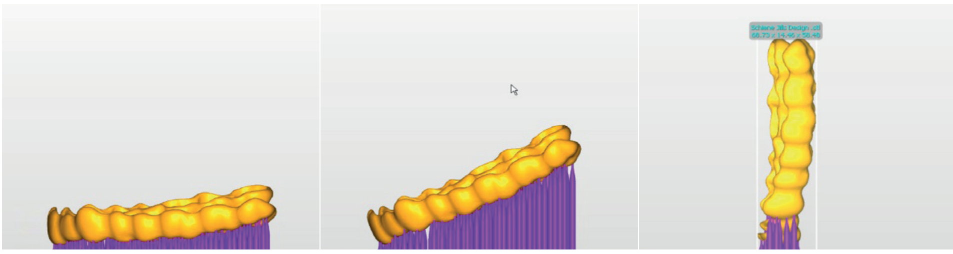
In most cases, printing splints in a 0° or 20° orientation is faster and more productive than printing in a 90° orientation.

For more information, see point 7: Productivity comparison 0° vs. 90°

3.3.3. Aligning the splints in Asiga Composer, including support structures

Align the splints so that the inside of the splint, 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 best results are achieved with a horizontal alignment of the splints (between 0° and 20°). Steeper angles can affect the fit and precision of the pieces.



Left: 0° (recommended), middle: 20° (recommended), right: 90° (not recommended)

3.3.4. Adding support structures

Select the menu item »Generate Support« to add support structures to your work. The suggested values have already been optimised for the material, so you can simply start automatic generation by clicking on »Apply«. The software analyses your object and positions the structures at all necessary points. At the same time, your object is lifted off the building plate a little. This means that the support structures can be easily removed in a later process step.

Please examine the object for incorrectly placed support structures. No support structures should be found on the inner surfaces relevant for the fit. If necessary, remove individual support structures.

PRACTICAL TIP:

Do not place splints directly on the building plate! The longer exposure of the first layers of the print job, which is necessary for the object to adhere to the building plate, leads to a lower reproduction precision here.

3.3.5. Sending a print job to the printer

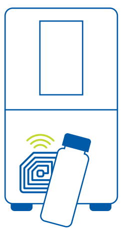
The »Build« menu item takes you to the Build Wizard. Here you can check your settings again and, if necessary, create a baseplate under your work. If you are happy with your design, send the print job to your printer.

4. Printing

≥ 1 min.

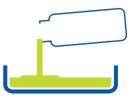
4.1. Shake the material

Before use, DMG LuxaPrint Ortho Plus has to be shaken for at least one minute. 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 software and will warn you if necessary (supported by DMG 3Demax/DMG 3Delite (DMG), D30/D20 +/ D20 + cartridge/D10 + (RapidShape), P20 +/P10 + capsule (Straumann).



4.3. Adding printing material

Put LuxaPrint Ortho Plus 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 building 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-contamination.

4.4. Starting a 3D printing job

Start the print job on your 3D printer.

5. Post-processing

Intelligent Connectivity
As a user of a DMG 3D printing system consisting of 3Demax, 3Dewash and 3Decure, you benefit from the intelligent linking of these 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, let your splints hang in the printer for about 10 minutes, so that any liquid resin can drip off. This saves material and cleaning.

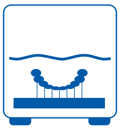
5.2. Detaching pieces from the building plate

Carefully detach printed objects from the building plate. Use a spatula or the cutter that came with the printer (or similar cutting tool).

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

5.3. Cleaning

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



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

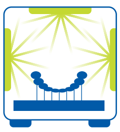
Simply place your printed objects in the cleaning chamber and select the program for DMG LuxaPrint Ortho Plus or the appropriate print job (requires Intelligent Connectivity). The cleaning should be done with isopropyl alcohol (≥ 99 %).

5.3.2. Ultrasonic cleaning

If you do not have any of the cleaning devices mentioned above, pre-clean your splint 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. Finally, clean your pieces again in a separate container with clean ethanol (≥ 96 %) or isopropyl alcohol (≥ 99 %) for a maximum of 2 minutes.

Ensure the splints have completely dried before you proceed with post-curing. Use compressed air for this, or let the pieces air dry for about 30 minutes. Also make sure that no residue of uncured resin is left on your splints.

5.4. Post-curing



Correct post-curing of the 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 splints on top of each other in the exposure chamber and make sure that the pieces receive light from all sides.

PRACTICAL TIP:

Too short, but also too long or too intensive post-curing leads to a loss of accuracy due to distortions in the component and to discolouration of the pieces.

5.4.1. DMG 3Decure

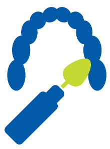
Simply place your printed object in the cleaning chamber and select the program for DMG LuxaPrint Ortho Plus or the appropriate print job (requires Intelligent Connectivity).

5.4.2. Otoflash/Heraflash/HiLitePower3D

Place your printed objects in the chamber of the exposure device and cure with the following settings.

Light-curing unit	Light-curing time	Tips
Otoflash G171 (N360 bath)	2 x 2,000 flashes	After the first 2,000 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

5.5. Detaching support structures



Carefully detach the support structures. It is best to use a hand tool with a cutting disc. The remains of the support structures can then be carefully removed with a milling machine.

5.6. Polishing

- **PRE-TREATMENT:** Rough remnants of the support structures should first be sanded down with sandpaper/corundum paper (e.g. grain size 120 µm).
- **FORM GRINDING:** Ceramic milling cutters or fine, cross-cut plastic milling cutters can be used for changing the shape of splint edges or shortening them.
- **PRE-POLISHING:** To remove, round off or smooth edges and surfaces, we recommend a silicone-impregnated fibre fleece wheel (optional).

  The splints should be pre-polished with pumice stone powder and a goat hair brush.
- **GLOSS FINISH:** Finally, you can create a high gloss with a high-gloss buff and a universal plastic polishing paste.

6. Validated fitting accuracy

All of our materials and printing processes are examined and evaluated in terms of achieved accuracy.

In a recent study by Spies et al. ***(Wesemann, C.; Spies, B. C.; Schaefer, D.; Adali, U.; Beuer, F.; Pieralli, S. J. Mech. Behav. Biomed. Mater. 2021, 114, 104179)*** the accuracy of 3D-printed splints and their influence on the fit was examined in comparison with conventionally manufactured splints. The authors come to the conclusion that mean deviations of up to 174 µm in relation to the fitting surface (i.e. the inside of the splint facing the teeth) are within the scope of clinical applicability. In the same study, mean deviations of 42 µm were found for the fitting surfaces of conventionally manufactured dental splints using injection moulding. In the case of ~~~milled splints, the mean deviations were also 42 µm.

The fitting surfaces of dental splints produced with the validated workflow using LuxaPrint Ortho Plus Resins, DMG 3Demax printer, DMG 3Dewash cleaning unit and DMG 3Decure post-curing unit, show mean deviations of 40 µm, and are therefore comparable to the accuracy achieved according to the above-mentioned study conventionally manufactured splints as well as milled splints. In other words: 99.4 % of the object surface deviates less than 150 micrometres from the digital output data. 92.5 % of the object surface deviates less than 100 micrometres from the digital output data.

Comparison of the fitting surface of a dental splint manufactured in the validated DentaMile workflow compared to the digital output data. 99.4 % of data points lie within a tolerance of 150 µm. The median deviation is 40 µm.

7. Productivity comparison orientation 0° vs. 90°

Printing splints in a vertical orientation seems very efficient at first sight, as more pieces can be produced at once with one printing process, compared to a flat orientation (up to 11 splints in 90° vs. 3-4 splints in 0° on a building plate of the DMG 3Demax).

Due to the necessary overcuring in DLP and SLA processes, the achieved reproduction accuracy of the print job also decreases with steeper orientation angles (greater than 30°) of the splints (see also 3.2.3). This can lead to difficulty fitting the patient with the splint. In the worst case, the splint cannot be used.

3D printing of occlusal splints in a flat orientation is not only recommended for the above-mentioned reason. If you take a closer look at the overall process, it becomes clear that, in most cases, printing in a flat orientation also means a clear advantage in terms of productivity and speed.

The following shows a productivity comparison between the two print orientations (0° and 90°) when printing occlusal splints. In our test scenario, we printed 6 splints in both a vertical (90°) and a horizontal (0°) orientation and post-processed them as described in this document. The time required for the individual processes was recorded (LuxaPrint Ortho Plus, DMG 3Demax, DMG 3Dewash, DMG 3Decure):

Required time for printing of splints and post-processing.

PRINTING		
Orientation	Quantity (max.)	Duration
0°	3-4	0:45:30
90°	11	02:36:00

POST-PROCESSING		
Process	Quantity (max.)	Duration
Draining (optional)	–	00:10:00
Detaching pieces	–	00:02:00
3Dewash	5	00:07:30
3Decure	5	00:18:30

Since the dripping and loosening of the pieces is inherent to 3D printing, these processes and the printing of pieces have been summarised for a clearer overview. Since the DMG 3Decure post-exposure unit offers enough space for 5 splints, post-curing has to be carried out twice in both orientations. For the 0° orientation print, however, this can already be done during the second printing process, while with the 90° print, the second post-exposure process can only take place afterwards. The time required for this must therefore be taken into account in the overall process.
Depending on the print orientation, the time required for 6 printed splints, is 02:21 hours (0° orientation) or 03:33 hours (90° orientation), as shown in the following figure. In a 0° orientation, two printing processes with 3 splints each must be carried out. During the second printing process (print 02, blue), the entire post-processing (time required 26 minutes) of the first print can be performed. The post-processing (orange) of the second print job must then be carried out.
When printing at 90°, one print job suffices (blue; time required: 2 hours, 48 minutes). A maximum of 5 splints can then be re-exposed in the 3Decure at the same time. Therefore, post-curing (green) will have to be performed again.

Time required in hours for the 3D printing of 6 splints in the validated DentaMile workflow in 0° (left) and 90° orientation (right). When printing 6 splints in a flat orientation, you can save more than one hour compared to printing in a vertical orientation.