FORESTADENT®
GERMAN PRECISION IN ORTHODONTICS

Fact Sheet

Graphy Tera Harz TC-85

Update January 2023
Change of curing protocol
New equipment requirements

Updates and additions are highlighted in the text

1 *Foreword*

Graphy was rolling over us like an avalanche in the last two months. There is still much to find out and much to learn so that I can already say that this will be only version 1 of the Graphy Fact Sheet with further updates coming rather soon. Therefore we will do this in a rather improvised shape/lay-out.

2 *Graphy Inc.*

The company was officially founded in 2017 although Un-Seob, Sim (Founder and CEO) has been working on resins for the last decade or more.
Based in Korea the company has been recognized in Korea for innovations, excellence and GMP and has been CE certified in 2019/2020 (according to MDD).

3 *Tera Harz TC-85 DAC/DAW*

3.1 Properties, Advantages & Possibilities

3.1.1 In general

TC-85 DAC = Direct Aligner Clear
TC-85 DAW = Direct Aligner White
Medical Device Class: II a

Tera Harz TC-85 is the first printable material that has the flexibility and therefore force to be used for aligners. Other companies have splint materials for several years already but these resins are all rather passive in terms of force application.
Graphy launched TC-85 a couple years ago but needed some more time to finish the development especially with regards to successfully post-processing the resin and in a way that clinicians can make use of the unique properties.

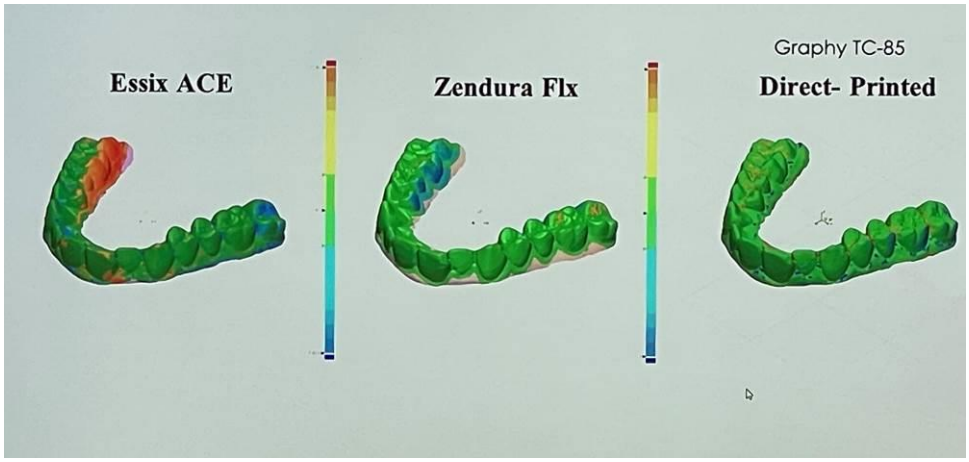
3.1.2 Shape Memory

TC-85 has a shape memory and is probably the first printable plastic with this special feature. So far, in orthodontics we know the memory effect with NiTi like "hot and stiff" or "cold and soft" and returns to its programmed shape when heated.

The shape memory of TC-85 works in a similar way. It is "glibbery" soft when immersed in hot water (>45°C) and becomes hard when it cools down. However, it also returns to its original shape when it is hot just like NiTi.

By being warmed up it restores not only the original shape but thereby it is also restoring the force it is supposed to deliver.

A study (which will soon be published in the JCO) done by Ki-Beom Kim from St. Louis University has shown that every traditional thermoforming aligner material (even premium sheets like Zendura or CA Pro) are deformed instantly and permanently when being removed from the model and later on every time they are taken off the teeth. In the picture you can see the blue and red areas which show such a deformation.

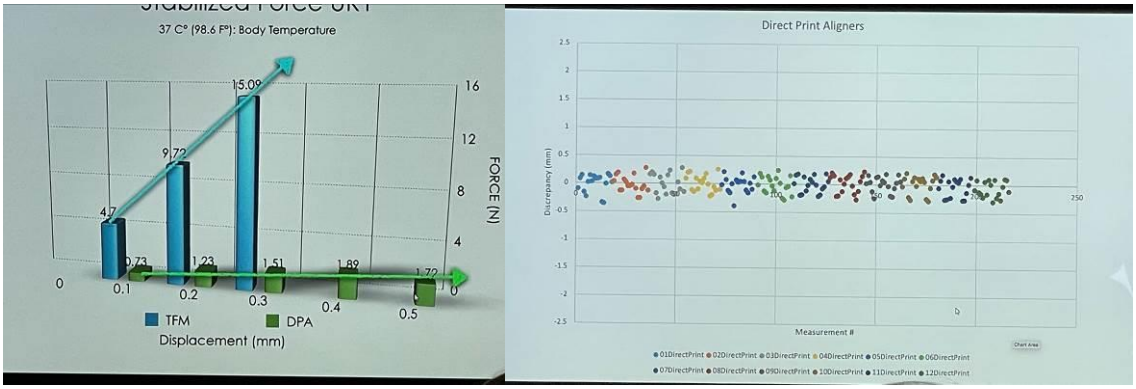


1: Deformation of aligner materials; Kim et al.

This deformation can influence the treatment progress in a negative way. It could well be that this deformation is another reason why some treatments do not at all go as planned (i.e. if the patient is a bit rough in treating his TFAs or has to be because there are many attachments).

However, TC-85 might be the right solution for this problem. As mentioned the Shape Memory restores the aligner to the actual planned shape and it does so within an hour (at 96%).

Aligners made from TC-85 deliver a constant force of approx. 1 N which is considerably less than with TFA. A classic aligner is losing the initial force rather quickly (again due to deformation) while a Direct Print Aligner can be reactivated by warming it up in hot water. This warming up triggers the Shape Memory which in turn restores the original shape and therefore the force applied.



2:Forces applied by aligners; Kim et al.

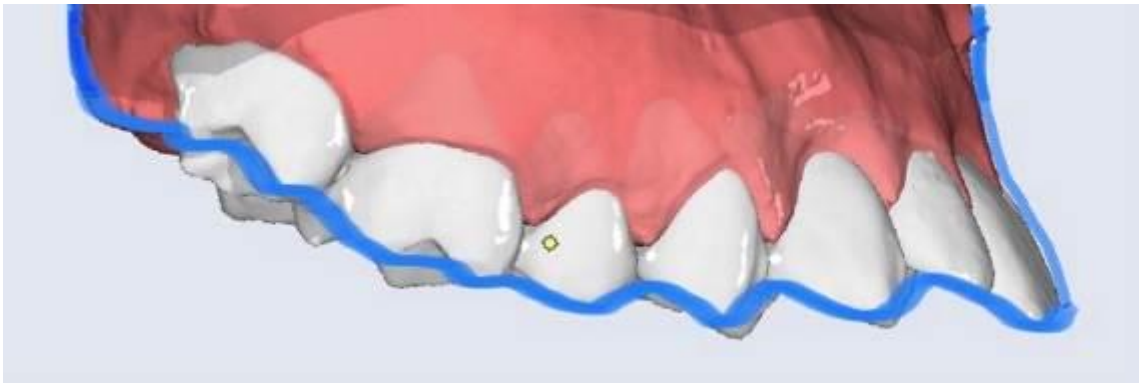
There are several other advantages of this feature for the patient.

- *Inserting and removing aligners becomes much easier. As one of the technicians of Graphy said it is more like putting the aligner around the teeth than just forcing them over crooked teeth with attachments on. Just put it in hot water and you can easily put them in. Same way you can take a bit of hot water in your mouth and take the aligner out without applying much force.*
- *Even if the aligner was "forgotten" for some time it can be put back in without too much pain.*
- *The teeth are held better by the material since the aligner is designed around them and enclosing them better than thermoformed aligners. This leads to better tracking, which in turn gives more control and probably makes for a more predictable and maybe even faster treatment.*

3.1.3 Uniform or even selective thickness

When thermoforming aligners, we have everything but a uniform thickness of the whole aligner. On average the foil is losing about 30% of its thickness per 1 cm way.

Example:
Track Sheet is 1.0 mm thick
Aligner model is 2 cm high
Accordingly, the aligner will end up somewhere around 0.5 mm thickness. But this is only when all teeth are rather upright and when there is no e.g. proclination and if the height of the model would be the same all over the arch. Strongly inclined teeth can increase the thinning of the foil during thermoforming since there is simply a "longer way to go" for the foil when following the contour of the teeth and gingiva.



3: Visualization thermoforming

The effect is probably somewhat less noticeable with a pressure unit but still there.

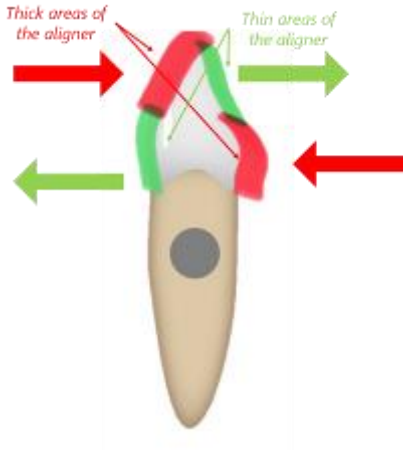
Now we are facing the problem that a thinner aligner applies less force than a thicker one. In the example with the proclination the aligner is thinned out where we actually need the force to change the inclination of the front. In this case we would preferably have a higher force on the labial side towards the incisal edge but actually have a higher thickness on the palatal side – i.e. less force where we need it, more force where we do not want it.
Another factor is the fit of the aligner. No matter whether it is a vacuum or a compressed air unit – There are usually spots where the airflow is blocked and the aligner cannot properly follow the contour of the arch. This will also always result in a less than perfect tracking of the aligner and therefore lack of force.

If you generate an aligner digitally there is no stretching of a thermoforming sheet. You simply design it in whatever software and define the thickness in the parameters which is then applied in every single spot of the aligner and leads to a uniform application of force all over.

This can even be taken further. Several software providers are already working on tools which allow you to change the thickness of the aligners selectively. This will allow to e.g. increase the thickness in spots where more force is needed and to thin them, where we need less.

<u>Example:</u>
We want to apply labial root torque on a tooth, i.e. we move the crown towards lingual and the root labial. It would help if we can apply a higher force on the labial side of the crown (red arrow) and a lower force on the lingual side (green arrow). To do this we can design the aligner thicker where we

need the force and thinner where we need the tooth to move to. On the height of the gingiva (rim of the aligner) we do it vice versa.



4: Selective thickness of aligner to support a treatment task

Same can be done for other tasks such as rotations, bodily movements, etc.

3.1.4 Treatment supports rather than attachments and other design options

Same way as changing the thickness in certain spots we could set e.g. "pressure points" on the inside of the aligner to support the rotation of individual teeth. Or a wedge that goes into the interproximal space and is helping to bodily move a tooth.
Maybe this way we could even skip one or the other attachment which in turn is a benefit for the patient and less work for the clinician.

Occlusal stops, bite ramps, etc. could be designed "into" the aligner. Basically, every 3D object could be added to the aligner file and printed out as one object.

5: Example of added 3D object

3.2 Packaging unit and range

Tera Harz TC-85 comes in bottles of 1 kg or 1,065 ml. Depending on size/height of the individual aligner we can assume a material consumption between 7 and 8 ml per aligner including the supports.

This way a bottle of TC-85 has a theoretical range of about 120 - 130 aligners. Theoretical because you can never use up a bottle completely as there will always be material remaining in the tank of the printer or excess resin on the printed model.

6: Graphy TC-85

3.3 Conventional aligners vs Direct Aligners

We should not make the mistake to think that printing aligners is saving time or money. Graphy is advertising it that way but looking at the whole process I firmly believe that the savings in time and material cost are, at least for the time being, neglectable. The advantages of Tera Harz lie in the superior features of the material and the benefits for the treatment resulting from them.

Step	Time DA	Time TFA
Software (Preparation, segmentation, setup, staging, export) in OnyxCeph	60	60
Supporting in sliceware	3	0,5
Printing (example NBEE)	35	5
Post process (Spinning/washing; curing; de-support)	25	45
Finishing aligners (thermoforming, trimming, etc)	5	15
Total	**128**	**126**

7: Time comparison Direct Aligners vs. Thermoformed Aligners in minutes

The shown values are assumptions, guesses and actual measured figures. The respective figures are of course strongly depending on the software and hardware you use. Another major impact factor is also the individual protocol, routine and experience.

Material	DA	TFA
Model resin 1000 ml Formabs Dental Grey @ 135 EUR → ca. 50 - 60 models		**2,25**
TC-85 1065 ml @ 490 EUR → ca. 125 aligners	**3,90**	
Track A sheet		**1,30**
Total	**3,90**	**3,55**

8: Material cost comparison

Material prices do vary from country to country. Also, the resin costs do vary from brand to brand. You can by a resin at 220 EUR the bottle (EnvisionTec E-Model Light) or cheap resins mostly used for hobby printing (e.g. Anycubic UV 405nm Plant Based Rapid Photopolymer Resin) for 28,99 EUR and almost anything in between. The example above was calculated with a standard and pretty common resin already somewhere in the upper range. And this does not even remotely consider the "dirt-cheap" aligner models you get from an FDM-printer (< 1.50 EUR).

4 *Technical Requirements to print with Tera Harz TC-85*

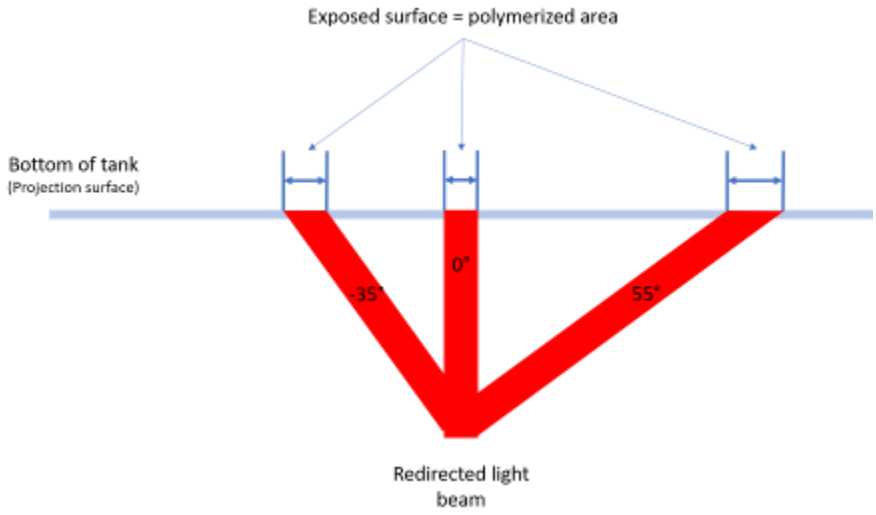
4.1 Printer

Since Graphy is not manufacturing printers but only the resins they do not have their own printer brand. Theoretically you can print Tera Harz TC-85 (and the other materials) on any printer with an open mode and the right technical specifications. Most important among them the wavelength of the light source and the exposure time.

INITIAL CURING CONDITIONS			
Provision	**Unit**	**Condition**	**Remark**
Light Source	-	UV LED	
Wave length	nm	405	
Layer thickness	µm	100	
UV energy	mJ/cm2	30.8	UV energy applied to one layer
LED power	mW/cm2	11	LED energy applied to one layer
Exposure time	sec	2.8	
Operation temp.	℃	5 - 35	
POST CURING CONDITIONS			
Provision	**Unit**	**Condition**	**Remark**
Light Source	-	UV LED	
Wave length	nm	390 - 410	
Operation temp.	℃	5 - 35	
Curing time	min	30 x30	Post cure each side, front and bak of the printed object
UV energy	mJ/cm2	114000 - 120000	UV energy when curing 5min.
LED power	mW/cm2	380 - 420	

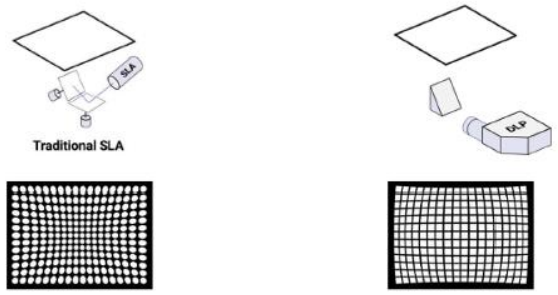
9: Printing and curing parameters

Classical SLA-printers such as e.g. Formlabs printers are not suitable. The Laser beam is redirected by mirrors which leads to a distortion when comparing different sections of the print platform.



10: Distortion of SLA printers

A similar but contrary distortion can be seen with classical DLP using a projector-type light sources and mirror (which can hardly be found anymore amongst half way professional units).



11: Distortion of classical SLA and DLP printers

End of the story is that these printing technologies lead to certain inaccuracies. Neglectable in combination with traditional aligner fabrication since the overall accuracy is compromised anyway through thermoforming but would probably have visible results in printed aligners.
In the annex of this fact sheet you can find a list of validated printers and for which Graphy materials they can be used.

Almost all of these models are LCD/LED-Printers. Same as with DLP this technology is illuminating a whole slice at a time but instead of using one light source which is distributed by a prism or mirror

they utilize a high energy LCD or LED-screen that illuminates every single point in the slice at once and every spot is exposed vertically without distortion. This makes for faster and more precise printing.

	Asiga MAX	Sprintray Pro 95	Uniz Slash 2	Uniz NBEE	Shining AccuFab-L4K
Lightsource Type	LED DLP	LED-based DLP Light Source	LED array light source with liquid cooling system	LCD High Power Collimated Projector with liquid cooling	UV LED + LCD 3 mw/cm²
Wavelength	405 nm	405 nm	405 nm	405 nm	405 nm
Build Space X/Y/Z	119 x 67 x 75 mm	182 x 102 x 200 mm	192 x 120 x 200 mm	192 x 120 x 180 mm	192 x120 x 180 mm
Resolution XY	62 µm		50 µm	50 µm	0.05 mm
Layer thickness	VARIABLE IN 1 µm (???)	50, 100, 170 µm	10 - 300 µm	10 - 200 µm	0.025 / 0.05 / 0.075 / 0.1 mm
Connectivity	Wifi, Wireless Direct, Ethernet	USB, WiFi, AdHoc Wifi, Ethernet	USB, WiFi, Ethernet	USB, WiFi, Ethernet	WiFi/Ethernet/Thumdrive
Printing speed	n.m.	up to 2 in/hour @100 µm or 1 in/hour @50 µm	Up to 200 mm/h	Up 6 dental arches in 5 min	10~ 50 mm/h
Printer size	260 x 380 x 370mm	350 x 400 x 500 mm	350 x 400 x 530 mm	350 x 400 x 1000 mm	360 x 360 x 530 mm
Weight	17.5 kg	18 kg	15 kg	60 kg	19 kg
Price RRP*	Package USD 14,000	Package USD 10,000	Package USD 4.500	Package USD 11,000	Package USD 3,000
	Incl. Printer, Asiga Flash Curing unit, 1 kg resin and 1 tank; sliceware	Incl. Printer, wash/dry unit, Curing unit (reg.), add. resin tank, 1 bottle model resin., sliceware	Incl. Printer, 0.5 kg resin, tank, sliceware	Incl. Printer, 0.5 kg resin, tank, sliceware	incl. printer and 2 kg of resin
* Prices as found on the internet in August 2022					

12: Comparison of several printers

To go even a step further, printers like the ones of Uniz do use monochrome LCD-screens which have less variation in light intensity and are more durable.

4.2 Centrifuge

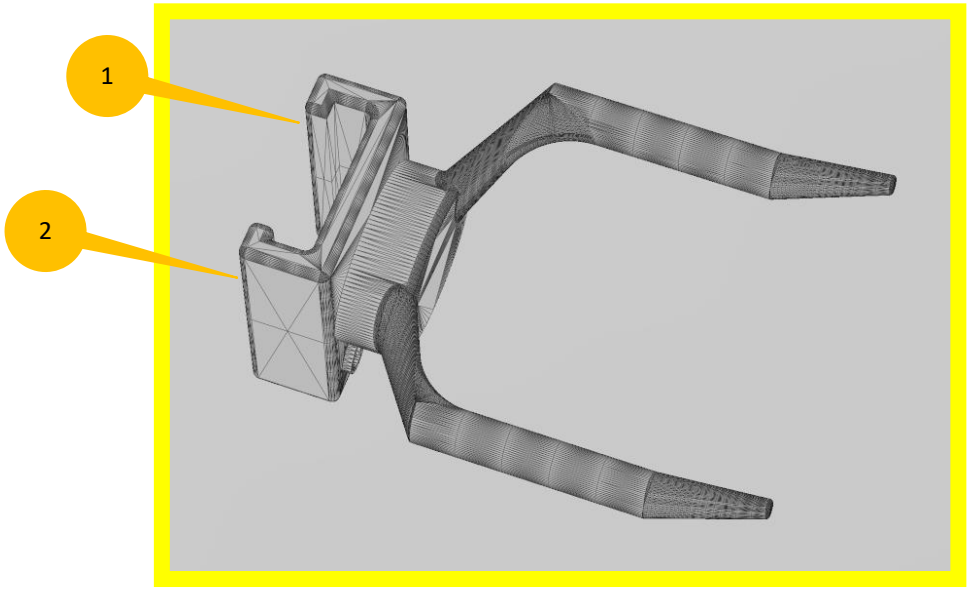
Usually a resin printed object has to be washed before final curing in order to remove excess material on the surface of the print. This is usually done with ethanol or isopropanol (or nowadays even water for some resin types). Even here, Tera Harz TC-85 is different. Instead of washing it to remove excess resin, the aligners (still on their support structure) are placed in a centrifuge.

This so-called centrifuge is nothing but a "misused" mini/camping washing machine of which the tumbler mode is used. The aligners are spinning in the barrel for 6 minutes and excess resin is shaken off in this process.

13: Centrifuge

Graphy is currently developing something more professional and dedicated to the purpose and with a reclaim system for the resin. But this will for sure take some time and this "Centrifuge" will have to do for a while.

The barrel has to be equipped with hooks on which you can hang the aligners.



14: Centrifuge hooks for Camry unit

In case clients have already purchased the shown unit (currently recommended by Graphy) we can provide the stl-files for printing these hooks. We have recently updated the design of these hooks over what was provided by Graphy to make fitting them easier and the structure is now more durable and stable.

Fitting: One side of the holder is longer (1). Place this first over the slats of the centrifuge barrel. The other side (2) the clicks easily in place.

Furthermore Graphy is working full-speed on their all new Tera Harz Spinner. This device is specifically designed for Graphy aligners and has a cleaning "latch" where you can easily remove the resin

shaken off during spinning. A concrete date is unfortunately not yet available but the unit will already be in catalog no. 37.

4.3 THC2

Ever object printed in resin has to be cured after washing or in the case of TC-85 spinning/tumbling since no printer can polymerize the resin 100%. Depending on the resin this is done with light of a specific (or range of) wave length and some manufacturers also do use heat.

Theoretically you could use such a curing unit for TC-85 as well. It would cure but it would not be as clear and would not have the shape memory effect.
To get these features from the material a special unit is necessary – Tera Harz Cure 2.

15: THC2

In addition to a UV-light source and heater this curing unit has an attached nitrogen concentrator (the box on top) and requires a compressor or compressed air mains with a pressure of 7 bar (dry and oil free). In the initial stage of the curing process the THC2 is evacuating air from the curing chamber and replacing it by nitrogen. As soon as it reaches a level of 95% the actual curing starts (Takes in total about 15 min).

16: Curing process

Other resins (which use the same wave length range, refer to specs.) can be cured in the THC2. The N-concentrator can be switched off independently from the actual curing unit.

5 How can I get the print files for my aligners?

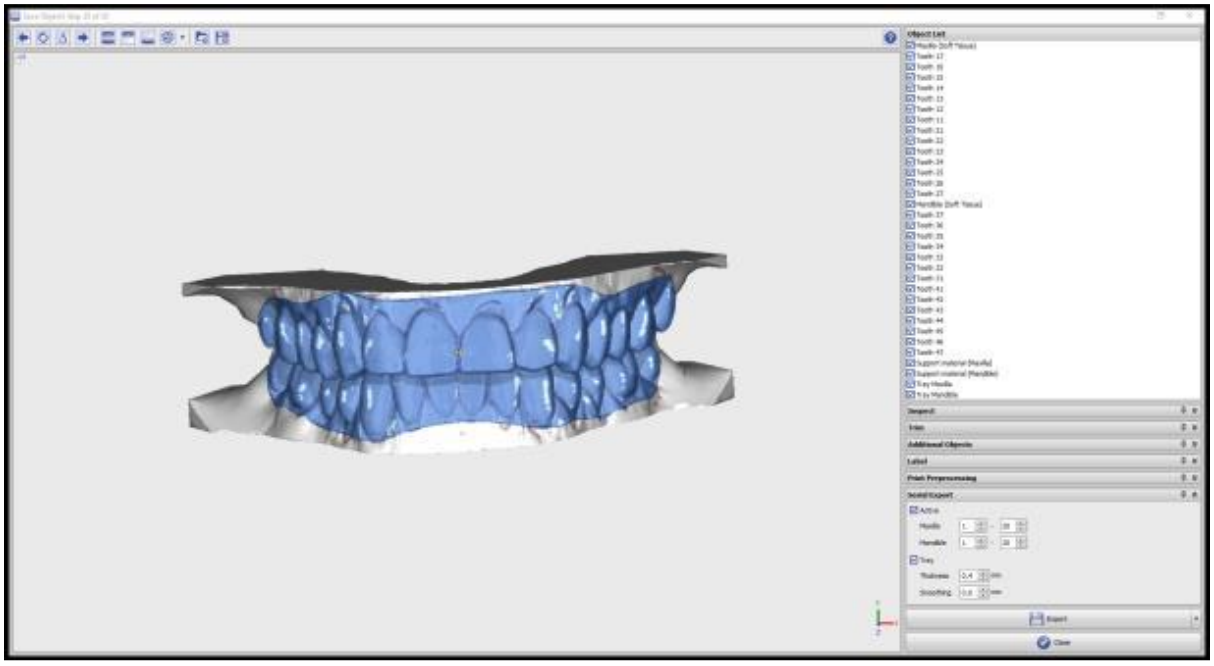
5.1 Basics

There are many programs on the market you can use to perform a setup on the data model. The basic necessities and functions are similar all over. Common software tools – to my knowledge – do not yet have the option to export aligner files directly. With these systems we still have to use by-passes to get a printable file for an aligner (or even a set of them) which is pretty time consuming.

5.2 OnyxCeph

Necessary modules: Onyx 3D Aligner (module not included in the basic package).
As always, we need the scans to start with. We align and trim them and add a base to them (close the open side of the model).
After that we segment the teeth and finally create a setup. Until now we can only export the models for each stage. Image Instruments is about to launch an update for Onyx providing a function where you can define the thickness and the "shape" (overlap over gingival margin or following the contour) and then do a serial export with labeling/marking of the aligners (ID; stage no.). This update will come with the new release in the first quarter of 2023.

Important: OnyxCeph³ is a certified Class I medical device under European law and may legally be used to plan aligner treatments.



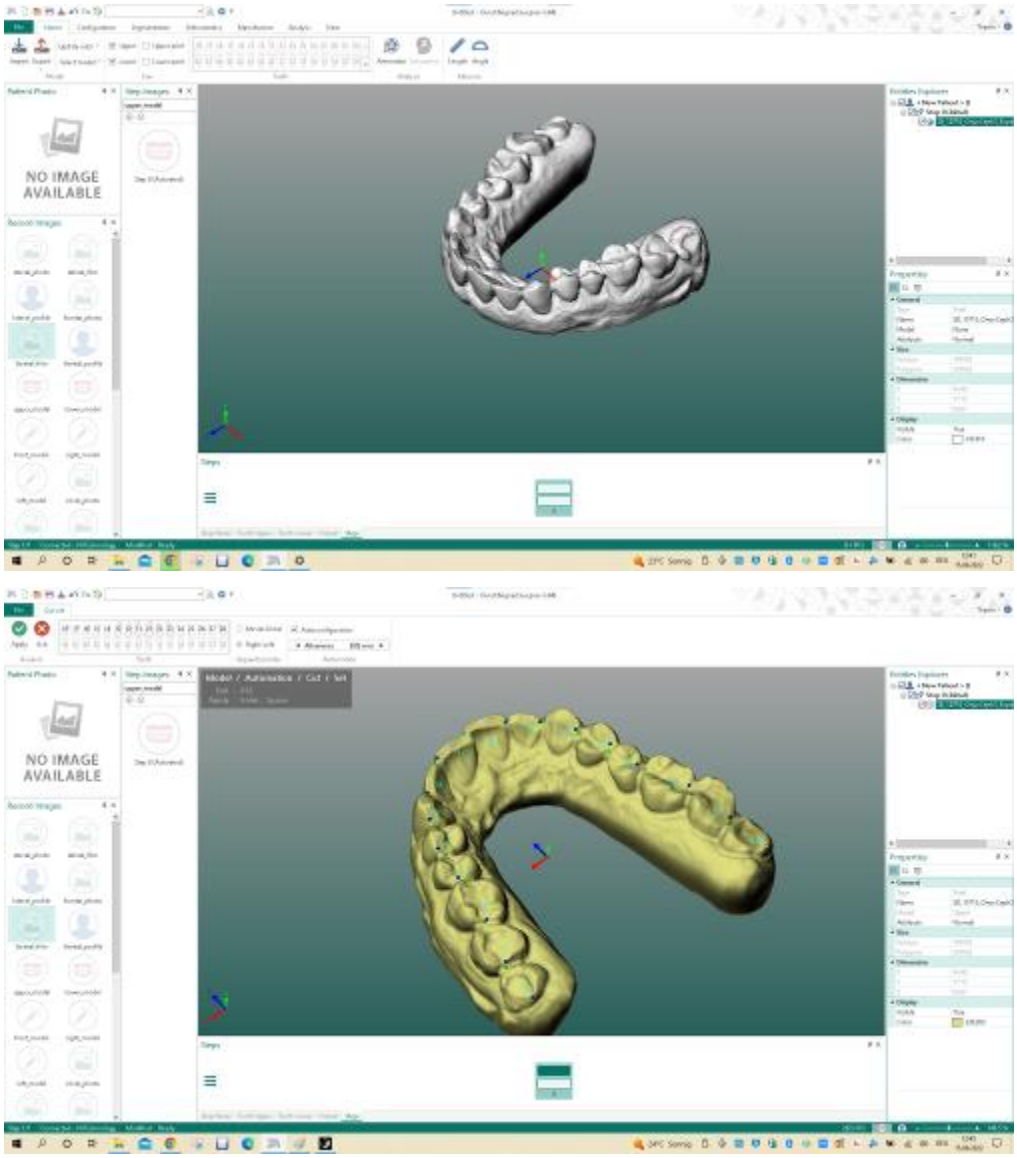
17: OnyxCeph Aligner Module with Cutting Line Patch

5.3 Direct Aligner Designer

The direct aligner designer is a software designed by Graphy. It allows to segment the scans, create setups and to finally generate and export the aligner files. Unlike Onyx you do not need to provide the scans with a base but can work with them as they are. Segmentation and setup are in my opinion a bit more difficult and time consuming than in Onyx. Probably a matter of preference and what you are used to. Big advantage is it already comes with a feature for serial export of the aligner files. That is if processor, memory and graphic card of your computer do have the necessary power. A standard business laptop will definitely not do.

As per latest information from Graphy they currently provide the software for free as they themselves consider it a work in progress. According to my knowledge the software is not certified as a medical device.

In addition Graphy has added a feature for auto support of aligners to the software.



18: Direct Aligner Designer by Graphy

5.4 Other software

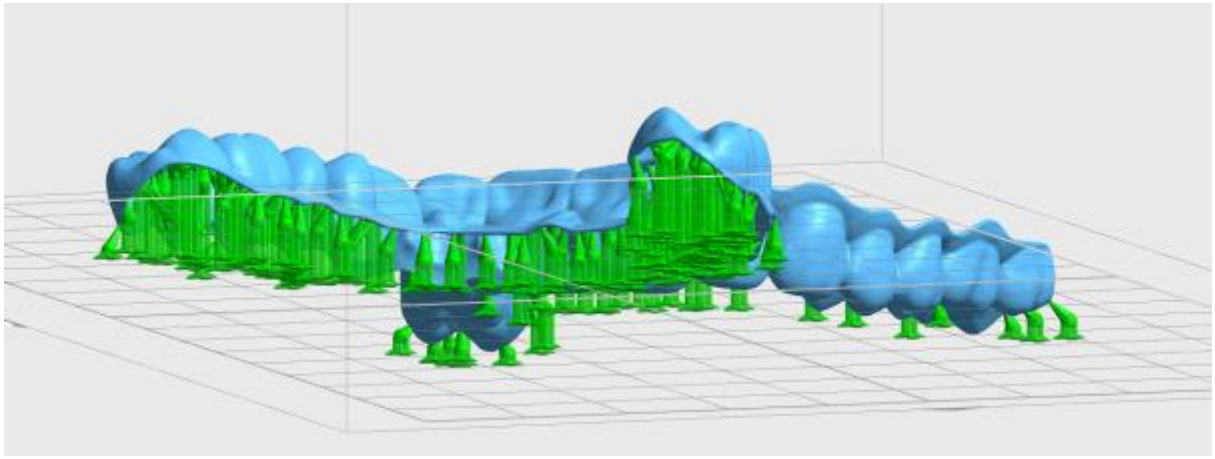
As mentioned there are other programs which can be used to do an aligner setup and

6 *Printing of aligners*

6.1 Supporting and Slicing

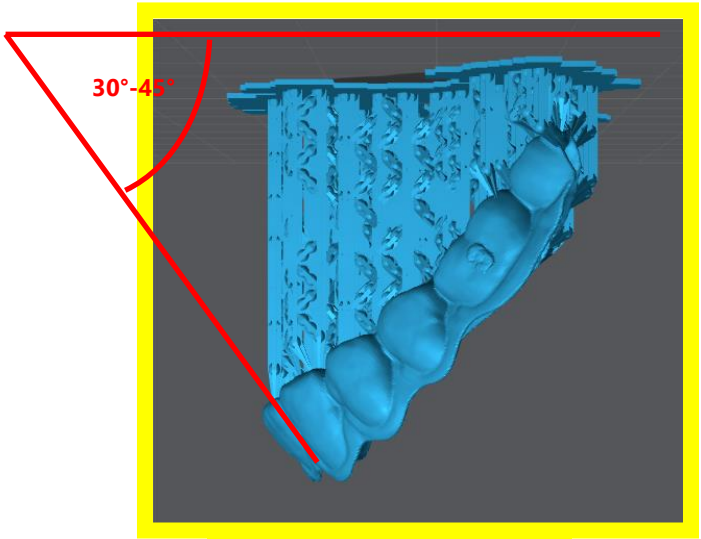
More than when printing stage models vertically we need to create extensive support structures for Direct Aligners. It even already starts with placing the aligners on the platform of the printer. The most precise results would be achieved if we would print the aligners horizontally. But then we would have the contact points of the supports either inside the aligner or on the occlusal surfaces. We would

have to polish them off which would affect the clarity of TC-85 (polishes spots become milky) and impair aesthetics in visible areas or even the bite when not done properly. Also it often happens that we would have the so-called islands in the area of cusps which can make printing more difficult.



19: Aigner horizontally with support

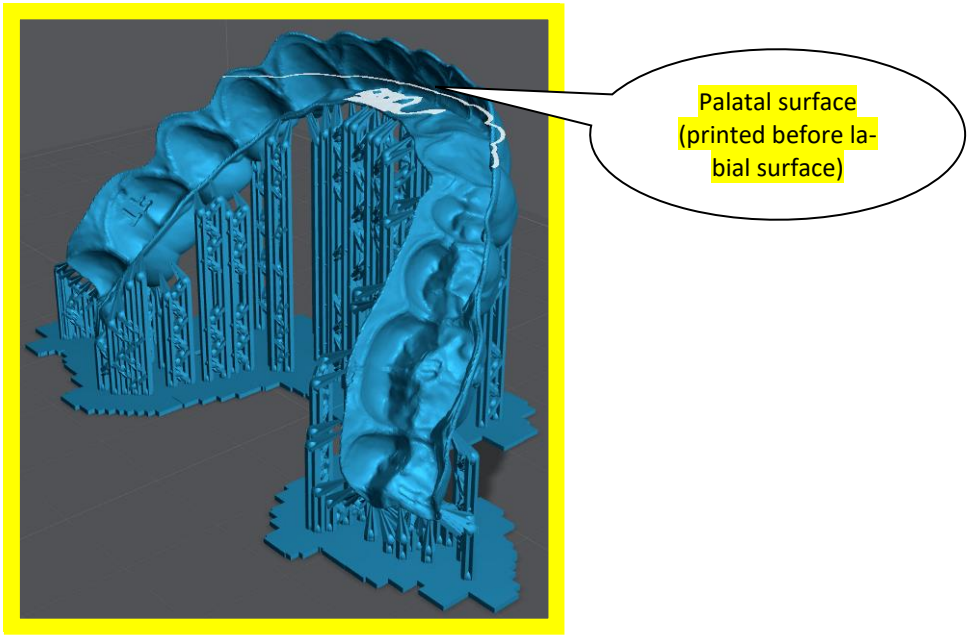
When placing the aligner on the platform we try do angulate them so that we avoid islands as much as possible. A rough reference is to angulate the labial surface of the front teeth by approx. 30° - 45° towards the platform with the "open side" facing down (towards the resin tank) so that the resin is not collecting inside the aligners.



20: Angulation of aligner in slicer

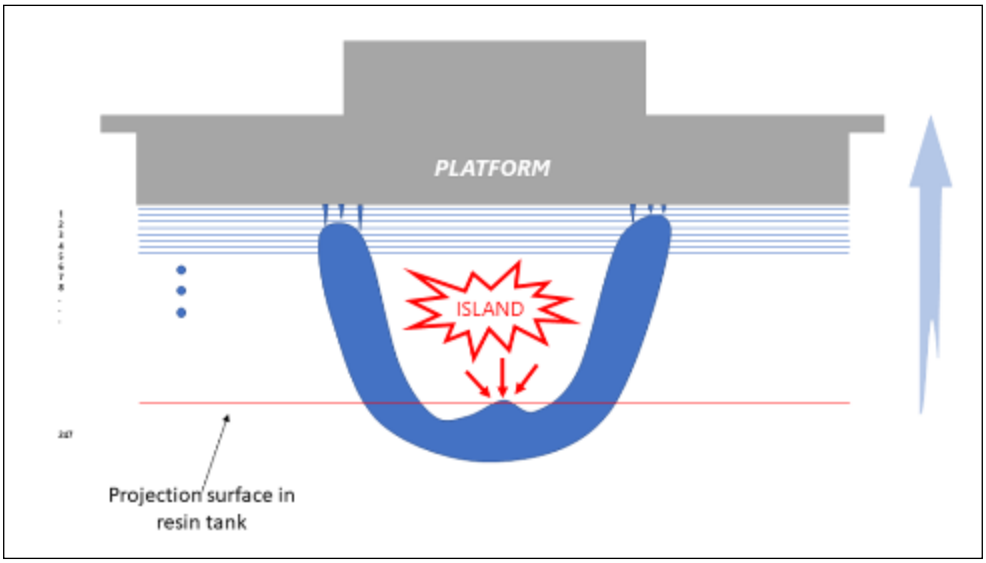
By angulating the aligners we try to keep the contact surfaces to the tank bottom as small as possible. Pull-off forces (how strong the object is adhering to the foil in the tank). The flatter the labial surfaces are aligner towards the tank, the bigger the problem can be.

At the same time, angulating the labial surface as shown above can also result in palatal/lingual surfaces being oriented rather flat towards the tank as shown below. In such case you have to try to find the middle ground.



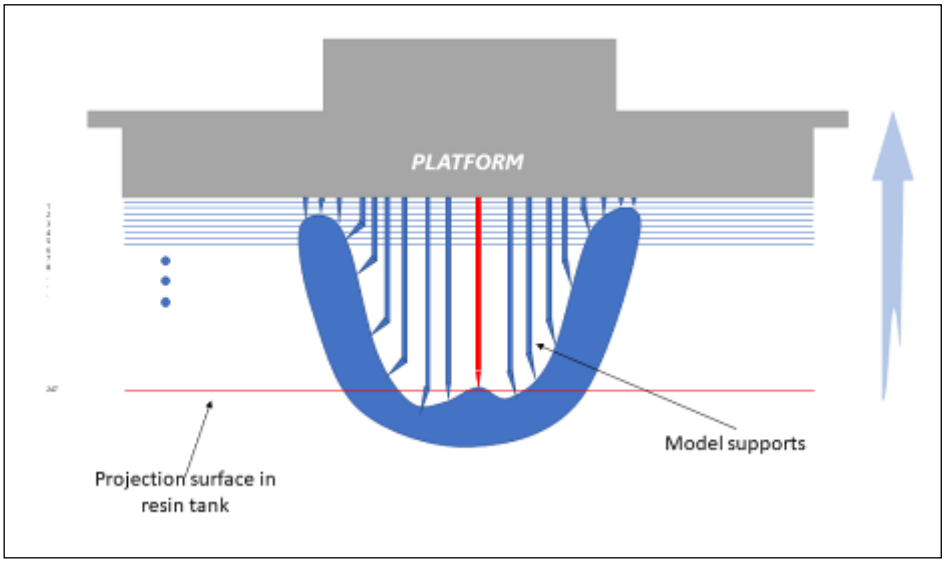
21: Labio-Lingual dilemma

Islands are polygons (triangles the stl-net is made of) that are isolated during printing. They would have to be printed before the structure they are attached to. If an island is not supported the print will most probably fail.



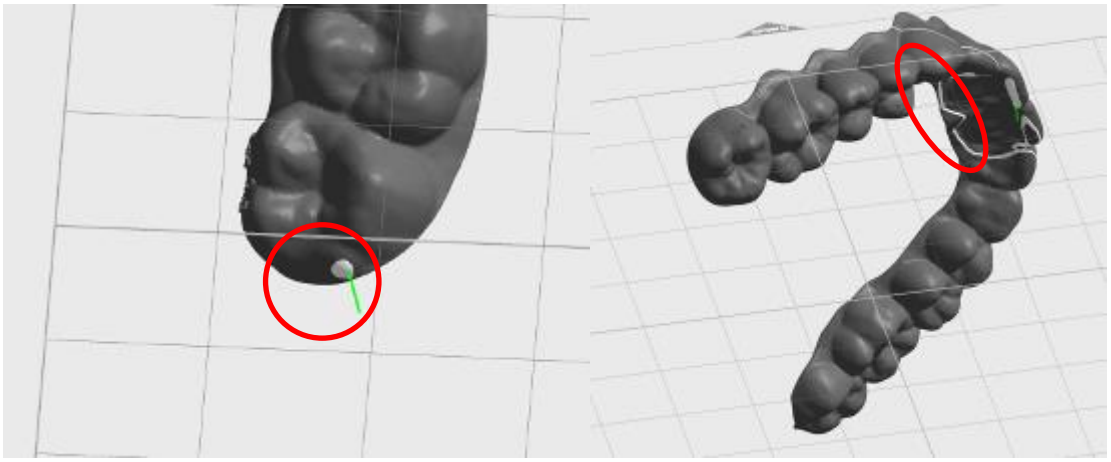
22: Island in 3D printing

As I tried to illustrate in the graphic above the printer works layer by layer. After photopolymerizing a layer, the platform is moving upwards and then the next layer goes underneath and so on.
On the sides the print is building up and theoretically carrying itself. When it comes to the layer indicated by the red line the part of data model marked with arrows is isolated on the projection surface and would be cured without connection to neither printed object nor to the platform. It would stick to the bottom of the resin tank and the next layers would be polymerized uncontrolled on/around it and the print would inevitably fail and potentially even damage the tank.



23: Island printed with support

If such isolated sports are supported sufficiently they do not cause any problems during printing. But in order to detect all of these islands you will need some experience and a trained eye.

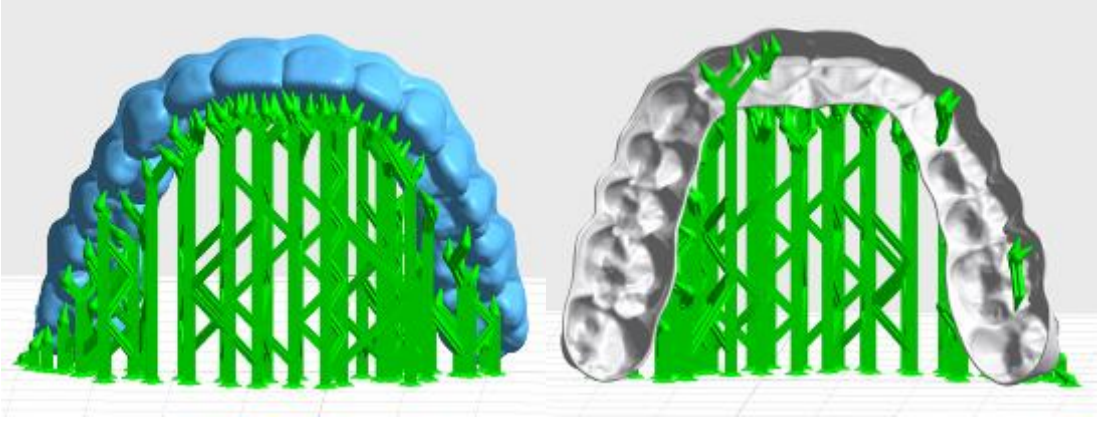


24: Island detection in Uniz Sliceware

The Uniz Dental Sliceware offers a tool that makes such islands visible (when you move over the object with the mouse pointer you see the slice line. Islands are indicated as white areas instead of the line). The sliceware could even do an automatic supporting of such areas. Unfortunately this feature is not sufficiently reliable at the moment and does not allow the selection of contact point thickness. Currently the recommendation is a diameter of 0.4 mm for contact points which allows for easy removal of the support structure without the necessity of polishing them off.

Scheu Dental had announced in August 2022 that they would launch an Auto Support Software for Graphy Aligners during the 2022 Meeting of the German Society of Orthodontist. As per today (end of January 2023) it seems not to be available, yet. However, Graphy has added such a feature to their DAD software (not registered as Medical Device) and Image Instruments is planning to add this feature to the Aligner Module of OnyxCeph.

To make a long story short: In order to get precise and good prints we have to support the aligners heavily. This means not only supporting islands but also the whole structure of the aligner to prevent it from distortion by sagging during printing. We want to avoid supports on the occlusal and buccal surfaces. Therefore, the supports currently still have to be placed manually.

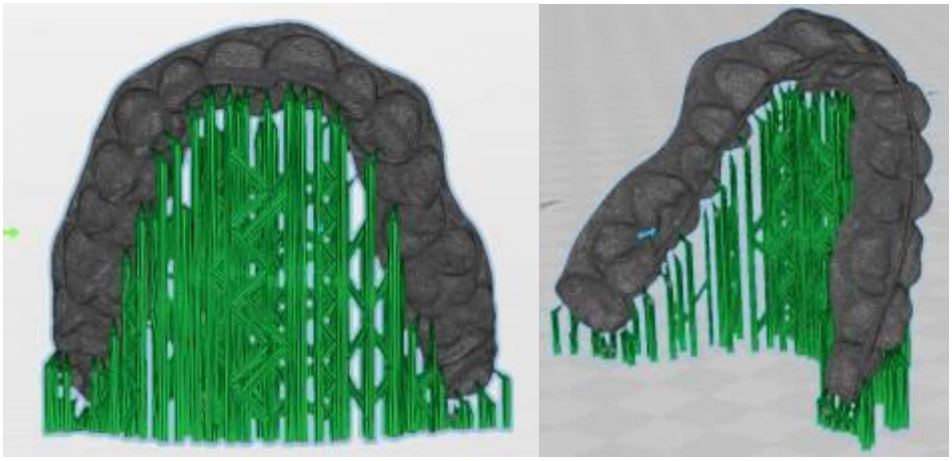


25: Angulated aligners with auto supports

As we can see the sliceware has placed supports pretty much all over the occlusal surfaces and even the inside of the aligners. Besides aesthetic effects this can also affect the fit of the Direct Aligner. Finally it is also important to lift the aligners about 2 mm off the plattform. This way we avoid direct contact of the aligner and potential print failures (e.g. deformation of the dorsal ends).

***Something to keep in mind as well:** Some users had the problem that they were only printing the supports and the actual aligner was only a big lump in the resin tank. The problem was probably that they used single supports (not connected to each other) and due to the flexibility of the material*

before curing this support structure might have been moving a bit. Therefore supports should always look like in the pics below.



26: Proper supported aligner

6.2 Printing

As mentioned before we absolutely need to make sure that the clients are using a printer that can process TC-85 according to the specs. Still there are a couple of things that are a bit different. When printing with TC-85 you must not use alcohol to clean platform or tank. TC-85 can be wiped off with a dry, lint-free paper towel. Actually any contact with alcohol should be avoided.

27: Aligner on printer platform

IMPORTANT: Whenever you are handling uncured TC-85 you have to wear gloves. The material is in uncured condition highly aggressive and can cause allergic reactions and skin irritations.

6.3 Remove excess material in Centrifuge

During printing excess resin from the print process sticks to the surface of the printed object. This comes from the already done print layers being immersed in the resin in the tank during printing. This uncured resin is not part of the actual object and has to be removed. Typically this is done in a washing unit where the objects are rinsed with pure alcohol (manually or in a machine). Uncured Graphy TC-85 must never be exposed to alcohol as it damages the material and its properties. Instead the aligners (with supports still on) are placed on the hooks inside the barrel of the centrifuge. Make sure that the inside of the aligners (the one going over the teeth) is facing outwards. Otherwise excess resin might be spun-off properly. When curing the aligner with unwanted resin inside this can negatively affect the fit of the aligner.

28: Aligners in centrifuge

We run the aligners for a total of six minutes in the unit. Resin inside the centrifuge can be wiped out with dry, lint-free paper towels.

6.4 Removing the support structure

After the excess resin is taken care of we can remove the support structure. We can do this easily by tearing them off manually (no instruments needed) or kind of scarping them off with the thumb. You do not have to worry about distorting them. The shape memory will take care of that.

6.5 Optional: Varnishing – Good but an error source

Depending on your printer settings the layers might be slightly visible and sometimes you can see traces of the former contact points of the supports. To make these less visible or smoother you can do something our Korean friends call varnishing. This means simply to apply a thin layer of resin with the gloved fingertip or a fine paint brush to the outer surface of the aligners before curing them. You let it sit for a couple minutes so that the resin is distributing itself. Then comes the tricky party. It is pretty much unavoidable that some resin is collecting on the gingival rim of the aligners or in the dental fissures on the occlusal surface. You have to carefully but nevertheless clean this off. Otherwise we might have spots where we have lumps of resin affecting the fit of the aligner.

29: Lump of resin from varnishing

It should be thoroughly considered if this varnishing is really necessary as I see a large potential of failures in it.

6.6 Curing

The curing protocol had some significant updates in recent weeks. There were some cases where patients had soft tissue irritations, that most probably were caused by not fully cured aligners. To avoid any potential trouble Graphy has increased the curing time recommendation and also changed the washing protocol.

To cure the aligners we place them on the plate. By properly nesting them you can get six to eight aligners on it. Make sure that they do not touch each other. Then we place the place inside the curing chamber.

30: Aligners in THC2

The plate of the THC2 will over time be smudged with resin. Users have to make sure that the plate is as clean as possible. Cleaning at least once per month is mandatory. Only if the plate remains reflective the UV light can reach all sides of the aligners.

31: Dirty vs. clean plate of THC2

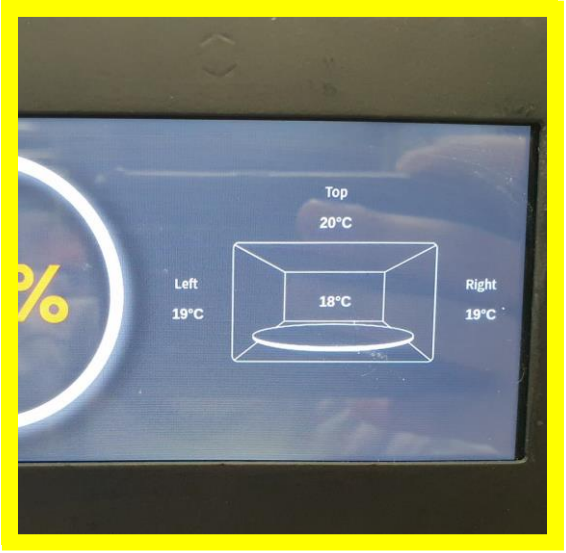
The respective program for curing TC-85 is stored in the THC2 and started via the touchscreen of the unit. The actual curing happens under a 95% nitrogen atmosphere. For this we need the compressed air feed with 7 bar. In the display (Touchscreen) you will see a counter showing %. The unit is set to a limit of 5 minutes in which it tries to build up the required atmosphere and the percentage is indicating the elapsed time of this limit. Once the 95% nitrogen threshold is reached the curing process automatically starts.

32: THC2 building up N-atmosphere

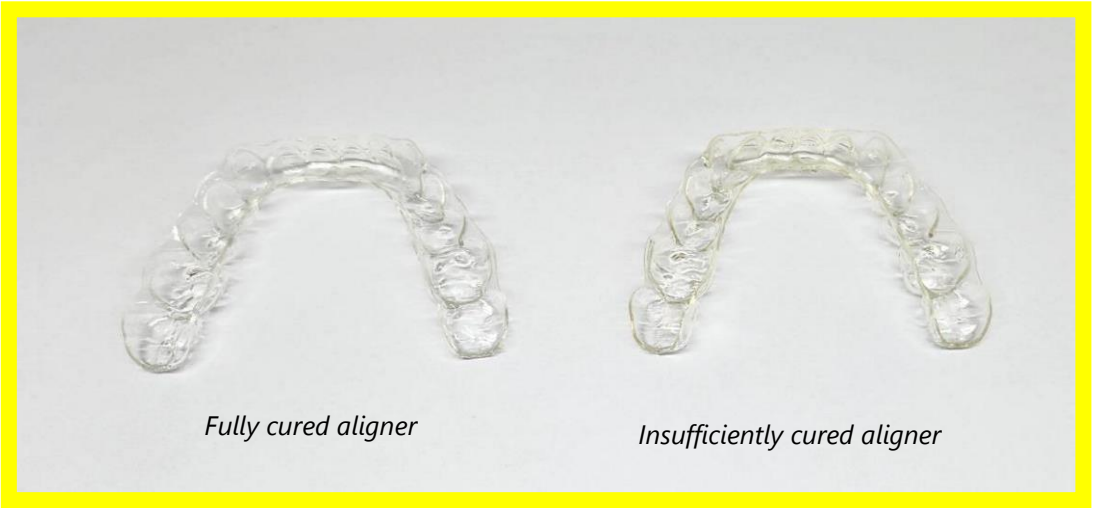
New recommended settings: 20 minutes at level 2.

33: Settings of THC2

Also worth noting is that the curing chamber is getting quite warm during the process (up to 55° C on the upper side). The temperatures in the chamber is measured and displayed by the THC2 (once you press the Start button). It is highly recommended to leave the door open and let the unit cool down before starting the next run. Temperature in the chamber should not exceed 25° C at start. A too high temperature could cause resin to dry rather than cure and affect the final outcome.



By the way: If aligners are showing a yellowish color after curing (see aligner on the right side of the pic below) it means that curing was not properly done. Such aligners must not be used and can also not be cured a second time (and therefore must be disposed-off).



34: fully vs insufficiently cured aligner

6.7 Boiling and final touches

When curing is completed we can polish of remains of the dorsal supports if necessary. More important is to properly wash and boil the aligners. This washing/boiling has three reasons/effects:

- *It cleans off the last remaining free radicals and makes sure that the aligner is not carrying any reactive material anymore*
- *It provides a certain sanitation of the aligner*
- *It works as a quality control. Should there be defects such as holes or seizures inside the aligners (resulting from faulty printing or even a faulty print file) this will show up as hazy area inside the aligner.*

Step 1:

Washing in an Ultrasonic bath with demineralized water at 80°- 85° C for about 1 minute.

Rinse the aligners in demineralized water.

Step 2:

Place the aligners for one minute in boiling demineralized water.

Rinse aligners demineralized water.

Dry them, pack them, ship them!

The maximum time inside boiling water must not exceed 3 minutes as this can damage aligner properties.

7 *Market & Competition*

8 *Benefits*

Simply from printing the aligners

- *Uniform thickness of the aligner*
- *Selective thickness of the aligners*
- *Better fit of the aligner*
- *Uniform trimline of all aligners*
- *Addition of 3D objects to the aligner possible*
- *No cutting, trimming and almost no polishing*
- *Less residual waste*
- *TC-85 resists mastication longer and better then thermoforming materials*
- *Partial waiver of attachments possible by designing them into the aligner*

Of the material itself

- *Shape Memory Property*
- *Low but constant forces*
- *Proven non-cytotoxicity*
- *Hypo allergic*

9 *Conclusion*

Many people are currently thrilled by and enthusiastic about printing aligners directly with TC-85. Graphy themselves are promoting their material under the claim that it saves time and money compared to traditional aligners. This is a trail we should not walk down as it is actually not true according to our calculations. Just based on time and material cost we assume that we are talking about roughly the same amount.

The foundation of our marketing and promotion therefore should always be the properties of TC-85.

What most people do not have on the screen is the investment they have to make before even being able to use the resin.
Suitable printers need to have an open mode and the necessary technical capabilities in order to be able to use Graphy in it.
Besides the printer the user definitely needs a centrifuge and the Tera Harz Cure 2.
To run the THC 2 the user needs a compressor capable of providing clean, dry and oil-free compressed air at 7 bar min.
All this technical equipment can easily amount to an initial investment of 10,000 EUR and more before they can even start. And even once they have the infrastructure, they have to consider that they will probably "burn" through a bottle of resin until they have found a protocol/routine working for them. TC-85 is in many ways different from other resins and requires a learning curve before you have a reproducible process and successfully printed aligners.

To avoid frustration for all players, all of the above-mentioned facts should be in the basic information you give to your clients interested in printing Direct Aligners.

FORESTADENT
PM
31.01.2023

Annex 1: Validated printers

Type	Material	Tera Harz & S-Plastic										
	Company / Machine Name	TC-85DAC TC-85DAW	TC-80DP	SG-100	SG-100	THD	TFDH	S-100M	SC-130	TE-Series		
		Direct Aligner	Permanent C&B	Sergical Guide	Sergical Guide	Denture Base	Flexible Denture	Model	Castable	Mouth Guard & Night Guard		
DLP	SprintRay / Pro 95	O	O	O	O	O	O	O	O	O	O	O
	SprintRay / Pro 55	O	O	O	O	O	O	O	O	O	O	O
	Carima / IM2	O	O	O	O	O	O	O	O	O	O	O
	Carima / IMD(IM3)	O	O	O	O	O	O	O	O	O	O	O
	ASIGA / Pro 4K	O	O	O	O	O	O	O	O	O	O	O
	ASIGA / MAX UV	O	O	O	O	O	O	O	O	O	O	O
LCD	UNIZ / SLASH2	O	O	O	O	O	O	O	O	O	O	O
	Shinwon Dental / Kave	O	O	O	O	O	O	O	O	O	O	O
	Ackuretta / Sol	O	O	O	O	O	O	O	O	O	O	O
	Cybermed / OnDemand3D	O	O	O	O	O	O	O	O	O	O	O
	Phrozen / Shuffle	O	O	O	O	O	O	O	O	O	O	O
	Sindoh / SD	O	O	O	O	O	O	O	O	O	O	O
	Ray / Ram600	O	O	O	O	O	O	O	O	O	O	O
SLA	Sindoh / A1+	O	O	O	O	O	O	O	O	O	O	O

Parameters can be provided