Renfert
making work easy

The digital model:

The future of efficient model fabrication in orthodontics

Table of contents

Renfert GmbH

Untere Giesswiesen 2
78247 Hilzingen/Germany

Tel. +49 (0) 77 31 82 08-0
Fax +49 (0) 77 31 82 08-70

www.renfert.com

The future of efficient model fabrication in orthodontics

Digital process flows are conquering the world of dentistry. Digital procedures are also increasingly used in orthodontics, e.g. in diagnostics and planning as well as in the manufacture of appliances or splints. The physical model remains indispensable. But how is a high-quality model fabricated in the digital workflow in both an efficient and ecological manner? The Whitepaper experts give us some answers.

Integrating digital processes into everyday orthodontic practice brings many advantages. Digital processes make providing therapy faster, more precise and more comfortable. Diagnostics, planning and results can be simulated and optimized on the computer. Work processes become more efficient; the time that's saved also saves money. But what does this mean for the orthodontic office and the orthodontic laboratory? How can we make the entry into digitization easier?

To get started with digital orthodontics, fundamental aspects (data capture (CAI), data processing (CAD), finishing (CAM)) must first be considered. Based on this, moderate investment decisions can be made.

Fabricating digital models – from CAI to CAD to CAM

Digital processes in orthodontics are nothing new. Corresponding software has long enabled virtual diagnostics and planning for therapy. What has changed is the potential of modern intraoral scanners. Intraoral scanners have experienced a massive surge in innovation and are becoming a game changer in digital orthodontics.

Although some offices utilize the potential of digitization even without their own intraoral scanner, for example via:

- the impression scanner (digitizing the conventional impression),
- the desktop scanner (digitizing the plaster model),
- outsourcing (sending plaster model to external provider).

However, these options only lead to the digital model via an indirect route i.e. with a diversion. The intraoral scanner is a real door opener to the digital world. Only with direct digital data capture can the entire orthodontic workflow be mapped digitally. Without time-consuming and error-prone diversions, the precise* digital model data set is created from the patient's mouth.

* Recent studies show that both acquiring regional accuracy and the accuracy of a full-arch scan using modern intraoral scanners are at least as precise as the conventional approach.

Digital model = Virtual model in the CAD software (STL format as a closed or watertight STL file)

Physical model = Tangible jaw model on the workstation

Digital model fabrication = CAM production of the model (3D printing, CAM milling)

The result of scanning the mouth is the digital impression (Computer-aided Impressioning (CAI)), which is further processed using the software (Computer-aided Design (CAD)). A physical model is required for many indications. This is also fabricated within the digital workflow (Computer-aided manufacturing (CAM)). The orthodontic office or laboratory can arrive at a physical model in different ways. While subtractive finishing (CAM milling of the model) is rarely used due to the significant time and costs involved, 3D printing has established itself as the popular choice. Common ways to produce digital models are:

- Additive production in dental office or laboratory (3D printing of the model)
- Outsourcing (sending to external service provider)

The same high standards apply to the digitally finished orthodontic model as usual: precise representation of teeth, alveolar ridge, jaw base, vestibular fold and gingiva in the upper and lower jaw.

3D printing of models is very economical compared to milling. Only with the availability of this technology, however, do we have a real alternative to analogue model production. The investment in the printer is usually lower, less material is used and production times are shorter. One disadvantage often cited is the additional expense of post-processing (additional remuneration), which is required with some printer technologies (DLP, SLA). This is why it's important to compare the different 3D printing technologies and to choose the optimal procedure for orthodontic purposes. For example, with filament printing (FDM/FFF procedure) the need for any post-processing work is eliminated.

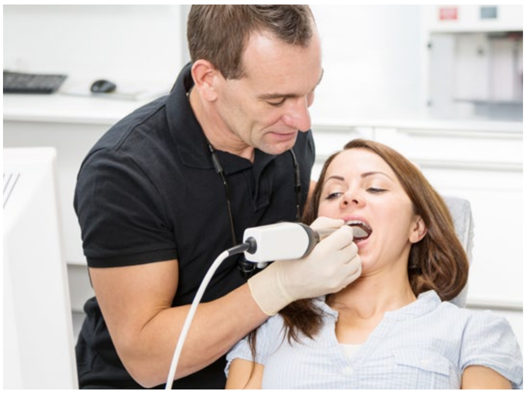
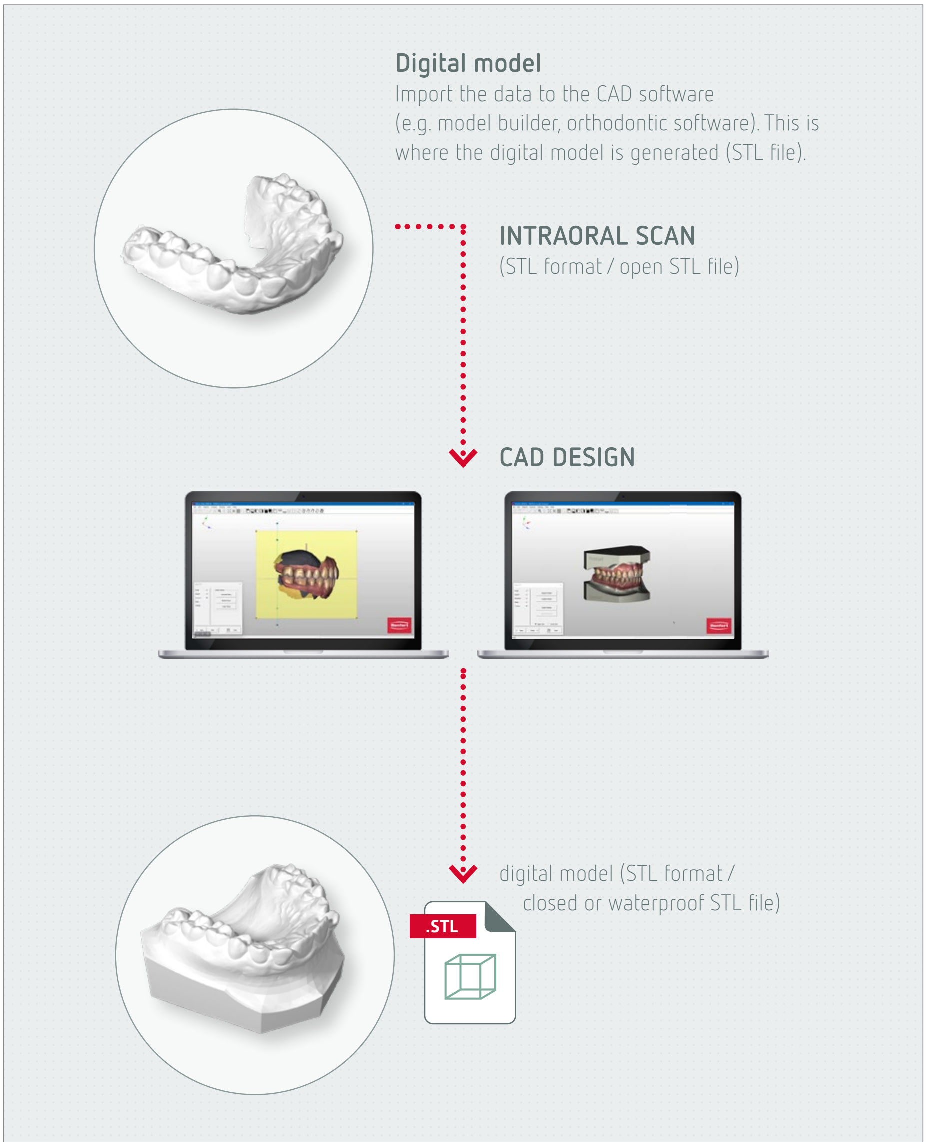



Fig. 1. Digitization via intraoral scanner
Fig. 2. Digitally manufactured orthodontic model

Advantages of the digital model

Advantages of a digital model (STL data set) are primarily: time, resource, cost and space savings, precise planning capability, reproducibility. Models can be fabricated in the CAD software with just a few clicks. Afterwards, the virtual model can be evaluated and processed at all levels. The software analyzes the patient's status and plans orthodontic treatment. Whether it be measuring tooth size and position or creating the set-up – digital tools provide helpful support. Treatment scenarios can be simulated in a simple way. A further advantage: the digital model can be archived in a way that saves space. The data set is filed digitally. You can retrieve it at any time by calling up the patient data. If required, a physical model is manufactured.



Investment Strategy: The digital workflow

When considering the digital workflow in orthodontics, different stages must be identified, which ideally form a unit through coordinated interfaces.

1. Data set from CAI
2. 3D CAD model software
3. CAM slicer software
4. Output device (3D printer)

1. Intraoral scanner: Obtaining the surface data

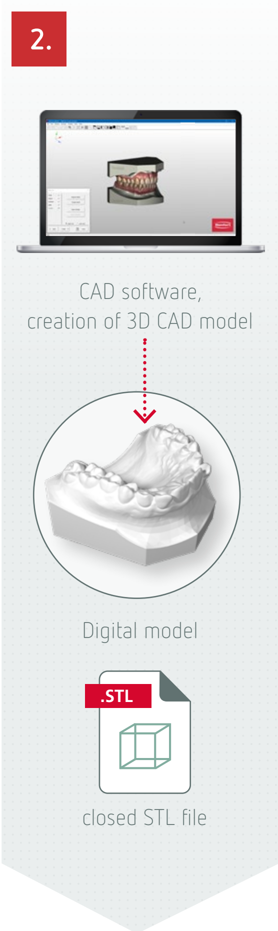
The intraoral scanner* is used to scan the surface of the intraoral situation. The data is usually stored in STL format (Standard Triangulation/Tesselation Language as the standard format of many CAD systems). They can be imported into the CAD software (orthodontic planning software or Model Designer software) via an interface.

*Intraoral scanners come in a wide price range. Comparing them is worthwhile. That being said, the focus should not just be on the price, but on the versatile possibilities. Many intraoral scanners have long since become much more than just a replacement for impressions! Completely new prospects are opening up in the world of orthodontics.

2. 3D CAD model software: Generating the digital model

The digital model can be created in just a few steps with the help of special 3D CAD model software. In the Model Designer*, basic steps of model fabrication are mostly carried out automatically (e.g. adding a base, trimming, aligning the occlusal plane, etc.).

*Model Designer: this application can be integrated in the CAD software package or added as an extra option. Stand-alone software exists as an alternative (e.g. SIMPLEX model designer, by Renfert).



3. CAM slicer software: Preparing the model print

In many situations, a physical model is necessary in addition to the digital model, for example:

- Models for aligner fabrication and thermoforming technique
- Planning models
- Diagnostic models
- Working models

For manufacturing a precise model from the digital data, 3D printing is the preferred method. Economical, ecological (depending on the printing process), precise, fast and simple – these are the advantages of model printing. To print the digital model, the data record must be imported into slicer software*. This works smoothly and almost without the user even noticing thanks to coordinated interfaces. The slicer software prepares the digital model for printing. Slicing is the process by which the software slices the digital model into individual layers. The printer is “fed” the saved data (G-Code).

*Slicer software: Often the software is integrated into the 3D printing system. Stand-alone software exists as an alternative. Being easy to operate, the error-free display of STL data, fast calculation of data and material-specific and printer-specific adjustment are important.

The slicer software plays an important role in the 3D printing system, as it is essential for printing. However, the software does not always come with the printer, and often has to be purchased separately. A coordinated slicer software being an integral part of the 3D printing system (such as e.g. the SIMPLEX 3D filament printing system by Renfert), offers gret advantages and simplifies the work considerably. Individual coordination between the software, the filaments and the printer ensures optimal results, since the functionality of the slicer software decisively determines the print result and handling. Software that virtually controls the printing process itself through automation is ideal for beginners.

4. Output device (3D printer)

The data set for the 3D printer is generated in the slicer software.
3D printing refers to a wide spectrum of technologies. The fundamental differences between 3D printing technologies are crucial when it comes to choosing the right printer.

3.

Slicer software

G Code
The G code integrates all the necessary commands and information to produce physical models with a printer on the basis of digital data sets

4.

3D printer
(eg. filament printer)

Finished models

Printing procedures for 3D printing of models

Additive manufacturing (3D printing) encompasses a number of different procedures. Either the material is applied layer by layer or material powder is melted by laser. The result is the three-dimensional object. There are also a variety of 3D printers with different printing procedures for dental uses. For example, common applications are:

- Stereolithography (SLA)
- Digital Light Processing (DLP)
- Filament printing / extrusion procedure (FDM = Fused Deposition Modeling / FFF = Fused Filament Fabrication)
- Laser sintering procedure (SLM) (metal printing)

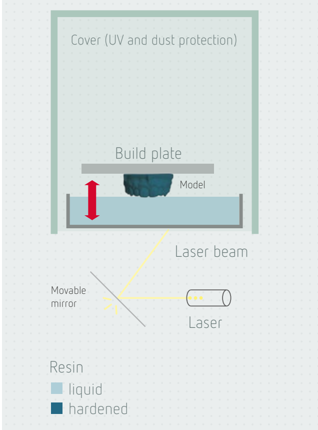
What they all have in common is that the model is built up layer by layer. SLA 1 or DLP printers 2 are currently popular picks – e.g. for many uses in dental laboratories. The starting point is a liquid photopolymer that solidifies after a certain exposure time. In the stereolithography procedure (SLA), the liquid resin is cured selectively via a laser beam. In contrast, the DLP printer works with a DLP projector as a light source, similar to a projector.

With both of these processes (DLP, SLA), the printed object (resin) must be cleaned and cured under UV light (complex post-processing).

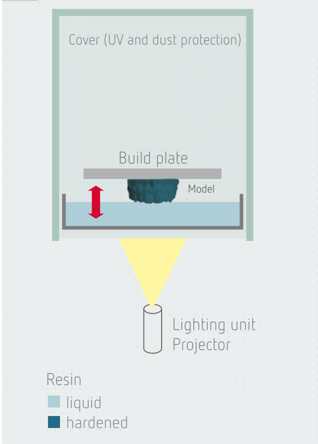
Convenient alternatives (e.g. for orthodontic models) are printers that work according to (FDM/FFF) procedure, i.e. filament printers 3. During this procedure, the filament (thermoplastic plastic in wire form assembled on a roll) is heated and applied with the help of an extruder, which is almost like a hot glue gun.

The models printed with a filament do not require any post-processing. They are completely hardened and already clean directly after printing.

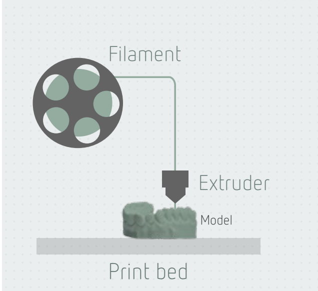
1 **Stereolithografie (SLA)**



2 **Digital Light Processing (DLP)**



3 **Filament printing (FDM/FFF)**



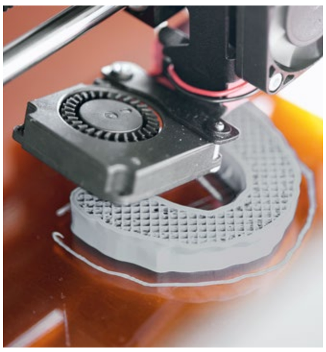


Fig. 3 Filament printing (FDM/FFF procedure)
Fig. 4 Finished orthodontic models directly after printing

Resin printing vs. filament printing

When comparing filament printers (FDM/FFF procedure) and resin printers (SLA/DLP procedure), it becomes clear that both have their application-specific advantages and disadvantages. When looking at dental model printing (e.g. orthodontic models), the advantages of the filament printer will impress. To better understand the advantages and disadvantages, it's worth taking a look at printer technology, materials and some practical aspects.

Costs

The price range in the dental printer sector is vast. The prices range from 600 EUR to 40,000 EUR and beyond. Filament printers are available for a comparatively low budget with good features (e.g. SIMPLEX 3D filament printing system by Renfert). There are no running costs – except for the material. In the meantime, there are also inexpensive resin printers. However, there are additional costs here for the cleaning and light-curing devices.

- Filament printers (FDM/FFF):
  inexpensive to purchase with low running costs
- Resin printers (SLA/DLP):
  more expensive to buy with higher running costs

Accuracy

Both printing methods can have a very high accuracy for jaw models, depending on the printer and printing parameters. The accuracy of a filament printer depends, among other things, on the nozzle outlet (level resolution up to 50 μm). Small diameter nozzles allow a very high resolution / accuracy. However, the printing time depends, among other things, on the layer thickness. Thicker layers allow higher speeds with lower resolution. Thinner layers require more printing time, but offer better resolution.

- Filament printing:
  high accuracy for models and aids
- Resin printing:
  very high accuracy possible

Printing material

In the case of the FDM/FFF procedure, a filament is heated and melted in an extruder and printed through the nozzle onto a printing bed. There are different filament materials. Filaments are often made of PLA (polylactic acid), which is obtained from renewable natural raw materials and is biodegradable. Resin printing involves processing liquid, light-sensitive resin – often in a material tray. Please note that liquid or partially cured resin must not be disposed of down the sink or in household waste. Liquid plastic resin is classified as hazardous waste and must therefore be disposed of carefully.

- Filaments:
  often made from renewable raw materials
- Resins:
  light-curing resins, environmentally critical

Post-processing

This is where the filament printer really shows off what it can do. Resin printed objects must undergo post-processing, which includes cleaning with isopropanol (IPA) and light curing. Meanwhile, there are also IPA-free liquids for cleaning, but they are quite expensive. With filament printing, none of this post-processing work is required.

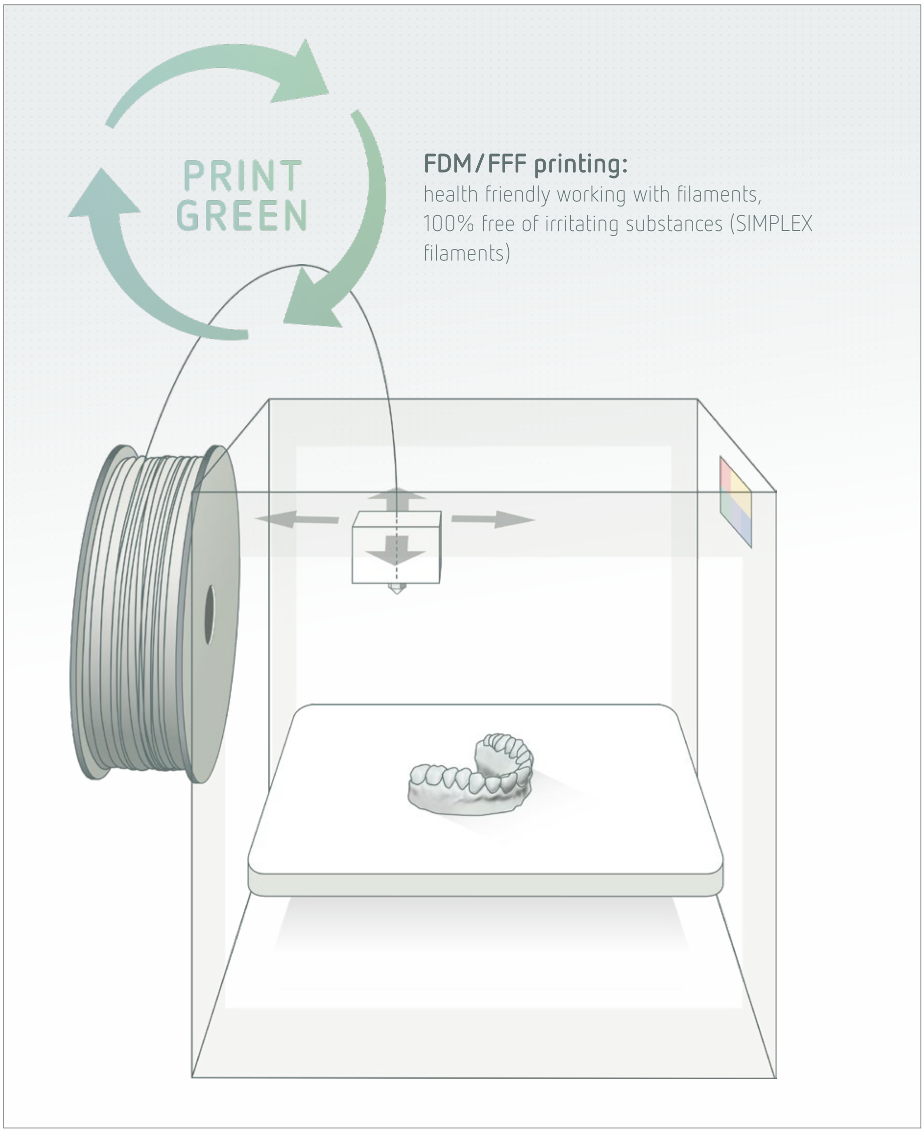
- Filament printing:
  no post-processing
- Resin printing:
  cleaning, light curing

Fig. 5 SIMPLEX filaments:
Made of high-quality and health-friendly materials, especially for orthodontic model fabrication.

Odor and fumes

FDM/FFF printers that work with PLA filaments emit virtually no fumes. But the resin printer is another story. Printing with a resin printer leads to the build-up of odors and unhealthy fumes. It's therefore recommended that respiratory protection (protective equipment) and chemical-resistant nitrile gloves be worn during resin printing. Plastic resin and solvents may cause skin irritation or allergic skin reactions. In addition, resin-printed objects are cleaned with isopropanol alcohol, which also releases fumes. On the other hand, filament printing (depending on the filament) does not produce any substances that are harmful to health.

- Filament printing:
  health friendly working with filaments 100% free of irritating substances (SIMPLEX filaments)
- Resin printing:
  unpleasant, chemical odor during printing and cleaning (mainly isopropanol). Not completely harmless to health.



Filament printer for orthodontics

Filament printers specifically designed for dental use offer many advantages, e.g. the SIMPLEX 3D filament printer from Renfert. To suggest this is "only" a 3D printer would be modestly understating the case. It is a 3D filament printer system for orthodontics with coordinated slicer software, specific filaments for orthodontic models and a precise printer. Everything is adapted to the respective indication (e.g. aligner model). Preset parameters in the software ensure a high level of convenience, intuitive operation and, above all, high processing reliability.

Easy to use

With the SIMPLEX filament 3D printer system, getting started with 3D printing technology is effortless and convenient. Without any prior knowledge and quite cleanly too i.e. no biologically harmful chemicals. In addition, the printed models don't require any post-processing. The device is easy to operate, can be placed anywhere, operates quietly and offers high resolution. High-quality special filaments meet the special requirements in orthodontics. Use errors regarding the parameters are avoided by automatic pre-settings.

- 100% free from irritants
- No polymerization in the light-curing unit necessary
- No post-processing with chemicals necessary
- Eco-friendly and health-friendly printing

Environmentally safe and sustainable

A large proportion of filaments for printing with the SIMPLEX consist of renewable raw materials (e.g. maize starch). No post-processing or isopropanol is needed. No chemicals are used. It's environmentally friendly and health-unfriendly harmful fumes (emissions) are not created in the dental office or laboratory during the printing process.

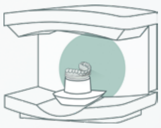
More information about SIMPLEX – the 3D filament printer system made especially for the orthodontic field:

Printer, software, filaments:
The specially coordinated system of three components is what makes SIMPLEX such a simple option for the orthodontic sector.

Workflow overview: filament printing with SIMPLEX

Step 1

Scan



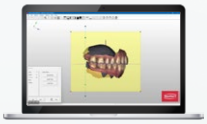
Extraoral scanner

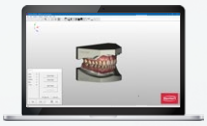
Intraoral scanner

Extraoral scan/Lab
Intraoral scan/Clinical
Generate the digital dataset for the mouth. This is performed using the intraoral scanner. Alternatively, use an impression or model scanner.

(open STL file)

CAD-Design





SIMPLEX model designer
Data import to the CAD software for 3D modeling. This is where the open scan is closed and the digital model is created.

(closed or water-proof STL file)

Step 3

Model Production

3.1 SIMPLEX sliceware
The slicer software is a software interface between the CAD 3D modeling program and the printer, and is what makes the 3D printing possible in the first place. This is where the required G code is generated.

transfer G-Code via
USB A-B cable
USB Stick

3.2 SIMPLEX 3D filament printer
Printing with the SIMPLEX 3D filament printer. The filament is heated and melted in the extruder and then printed onto the print bed by a nozzle. The model is created layer by layer.

Step 4

Production of orthodontic works

Orthodontic application
The model can be used as usual, e.g. for the production of aligner splints or orthodontic appliances, without the need for any post-processing.

Done!