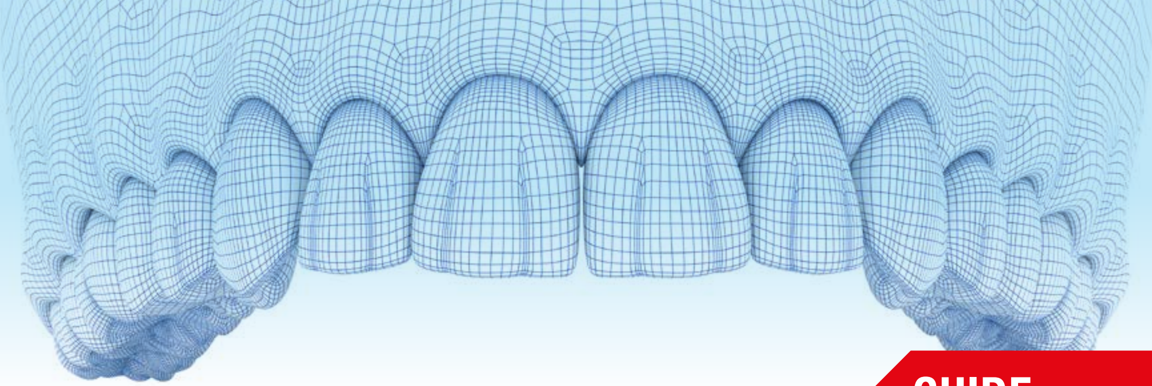
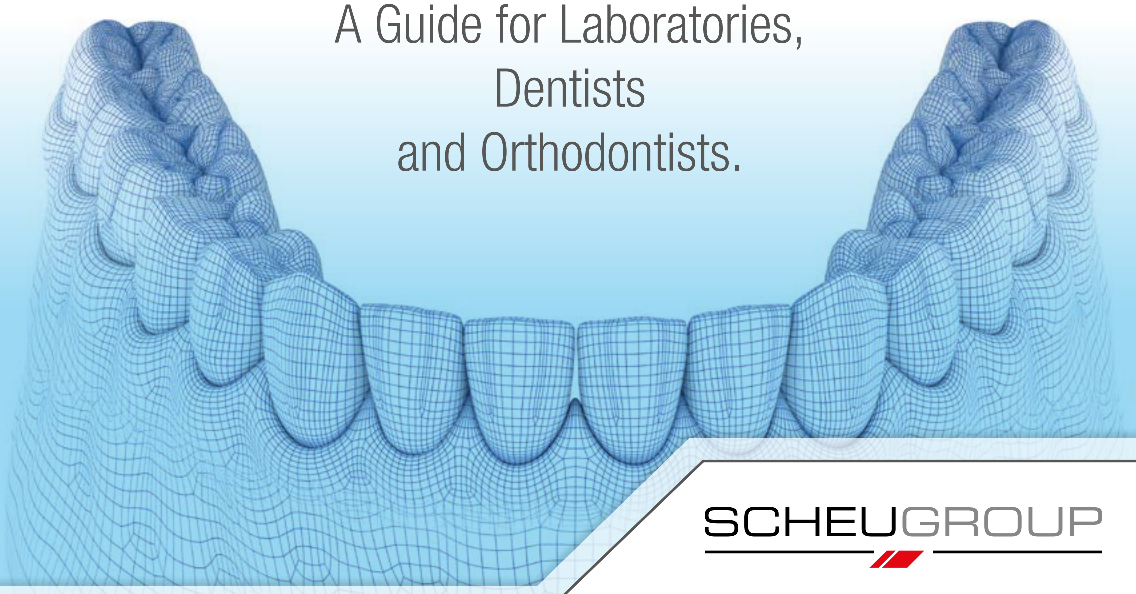


GUIDE

Digitalisation

in dental technology

A Guide for Laboratories,
Dentists
and Orthodontists.



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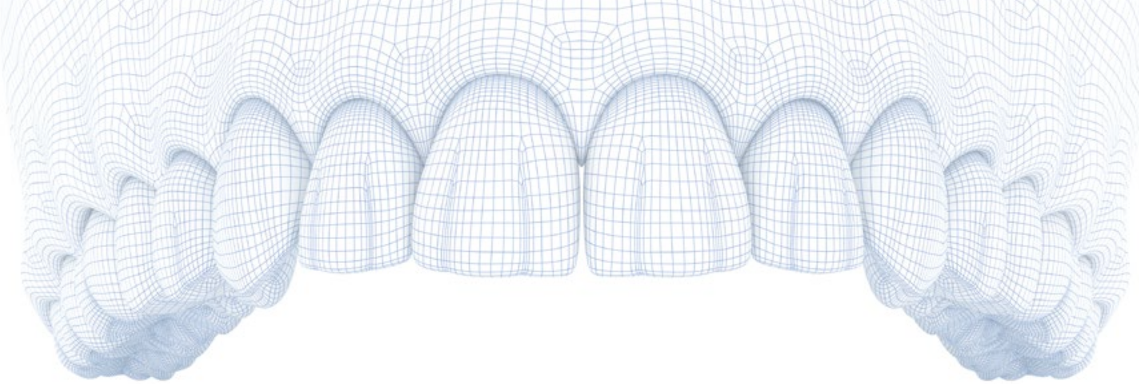

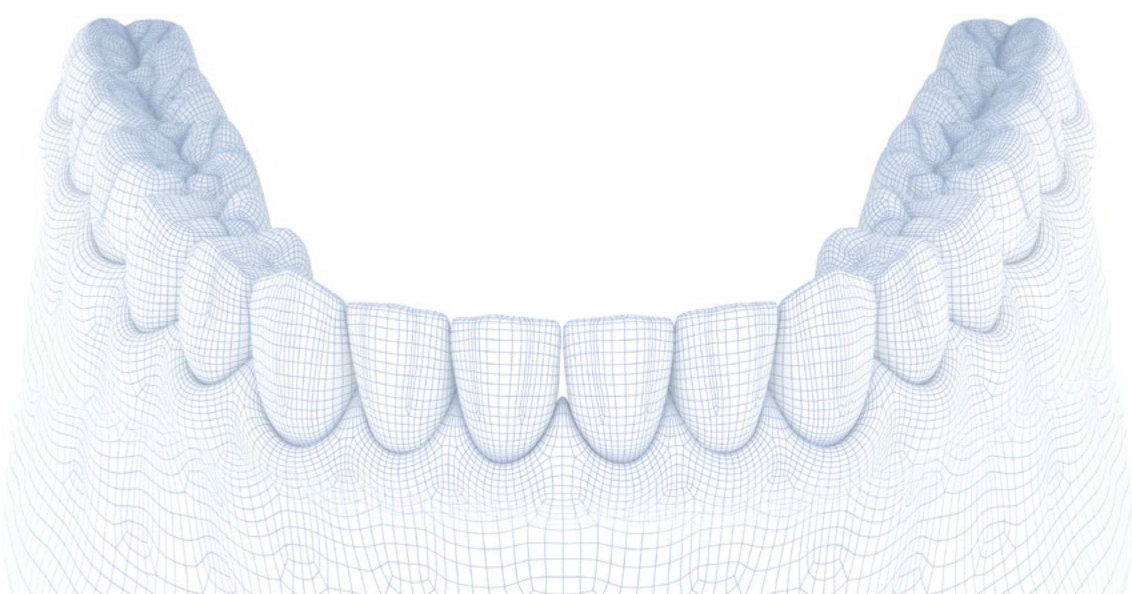

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1.

Digitalisation
in dental technology

1.1 The future is just around the corner

The technical achievements of our society have also led to fundamental changes in dentistry and dental technology. From their historical beginnings, a remarkable development has taken place, resulting in a variety of technical equipment with ever growing complexity – and effectiveness.
Today, we are experiencing on an almost daily basis how time intervals between technological innovations are getting shorter: Technologies are changing rapidly, becoming more efficient and opening up new fields of application. The desire for improvement and a higher effectiveness in processes is continuously leading to new and complex machines, made to assist in the daily work routines. 3D printers are currently about to follow the example of milling machines and to be firmly established in dentistry for more effectiveness.

1.2 Future prospects in dental technology

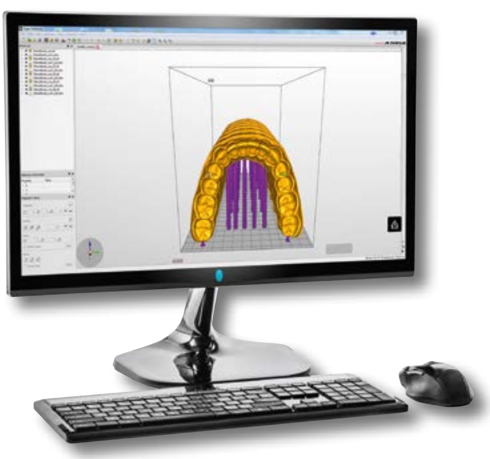
Future developments within the industry differ considerably between countries and depend on various factors, e.g. the prevailing health care system, national income, technological advances, demographics, etc.
In Germany, the number of dental technicians is very high compared to other European countries – this is also reflected by high competitive pressure. The price pressure for dentists is increasing, too, so that work is more and more sent out to external service providers abroad to keep manufacturing as cost-effective as possible. In addition, it is very likely that the existing shortage of skilled staff is going to increase in the next years. On the other hand, even the positive impact of disease prevention and better dental health has a negative impact on the industry: dentures – when they are considered to be necessary – are only inserted with well-advanced age. A conscious and healthy lifestyle as well as better information and regular checks are about to change the field of activity. In this context, milling machines and 3D printers in particular promise laboratories and practices to remain competetive and to deliver high-quality results for the patient. They reliably produce consistent high quality with web-based controlling and monitoring, leaving options for other kind of activities for the existing short capacities of skilled staff.

1.3 From manual manufacturing process to digitalisation

The cooperation between practice and laboratory often causes problems when it comes to the manual manufacturing process: Impressions show a high potential for inaccuracies due to compression or cavities. Treatment plans can lead to misunderstandings, sometimes queries about completed work are difficult to be traced back and last but not least the workload involved with order slips should not be underestimated. Poor or lack of communication can additionally aggravate these problems. At worst, the manual process and its implementation get unprofitable – to the detriment of all parties involved, including the patient.

This is where digitalisation can prove to be a useful concept for all parties: With technical support, fine-tuned work flows from diagnosis to treatment can be performed with fewer errors and still be individually adapted. Digitalisation can be entered gradually, so that you can choose step by step those elements that promise the greatest immediate benefit for your practice or laboratory.

Increased effectiveness of interfaces, reduced error potential and smoother and more efficient process management are the most evident advantages of digitalisation. In addition, archiving of patient data becomes easier: Legal requirements can be implemented with less administrative burden and if a patient work gets lost, a copy is still digitally stored.



Digitalisation promises to make process chains more efficient – from order acceptance to archiving.

1.4 Reduction of complexity leads to improved patient care

Many users could already be convinced by the advantages of computer-aided detection of the dental situation: An intraoral scanner is accurate and reliable and the file can be sent to the laboratory by just one click. The dental technician in turn receives more precise data and he can do without scanning the model in the laboratory later. Another plus is the reproducibility of every patient case at any time. The unified file format STL allows for the combination of various scanners with different planning software programs. For treatments and applications requiring an osteotomy (implants, surgical guides, etc.) an additional data set must be recorded by a CBCT/DVT scanner. Depending on the indication, a patient work can be created in the laboratory in the next step.

There are further benefits when it comes to software support during treatment planning: so it is for example very easy to comply with the limit values for tooth positions or material thickness.

Moreover, the software program allows for a more precise implementation of the treatment plan and helps the dental technician to save an enormous amount of time thanks to integrated design proposals. At the same time, material usage can be minimised because the actual implementation will be realised only once planning is completed. After completion of planning, the corresponding patient work can be printed or milled. The resulting patient works meet the high demands of the industry and are already in compliance with the new European Medical Device Regulation.

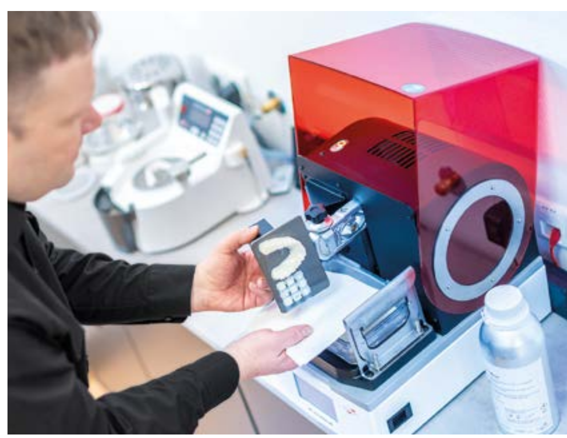
In case of simpler work such as pressure moulding splints, this process may also be immediately realised so that the treatment appliance can be handed directly to the patient after a short backup time. The factors time and quality as well as adaptation to individual patient needs are key factors for satisfied patients and a high recommendation rate.

1.5 Will the 3D printer replace the dental technician?

Basically, a machine can only operate as well as it is being used. Therefore there will always be a need for smart minds with good education and the ability to control the system and to manage digital processes wisely and efficiently.

“Everything a dental technician designs at the computer is based on the fundamental knowledge he has been taught in training. In any case and first of all, he has to be able to apply this knowledge manually and very reliably. This will be the basis for him to implement anything he has learned in digital applications – with the required competence and security”, says former president of VDZI (German Association of Dental Technician Guild) Uwe Breuer.[1]

3D printing therefore will not replace conventional dentistry, but rather be a useful complement in order to compensate the shortage of skilled professionals.



Digital solutions can enrich an employee`s field of activity and at the same time relieve him of unproductive routine activities.

[1] https://www.vdzi.net/meisterlabor/ihm-2016-spitzengespraech-der-deutschen-wirtschaft/digitalisierung-im-zahntechniker-handwerk.html; 26.03.2020

2.

Technology
comparison

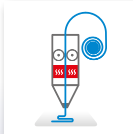
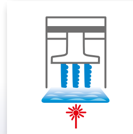
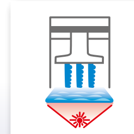
3D printing is by no means a new technology. Additive processes, meaning composing an object layer by layer through material application, have been known for many decades. The technology is already used in some industries where precision, individuality and delicate but complex structures are required – for example in audiology or jewellery production.

Different printers with different printing systems and an even greater variety of promises for ease of handling are available on the market. The most common technologies for printable resins are FDM (fused deposition modelling), SLA (stereo lithography) and DLP (digital light processing).

Other materials such as metal require other printing methods due to their material characteristics: metal powder is often used as basic material, providing additional supporting properties for the actual print object.

For the dental industry, printers with SLA or DLP technology are most promising as they realise the highest surface quality. They are providing reliable quality and differ mainly in printing time and only slightly in surface quality, which, however, becomes only visible at the most tiniest parts or at models with a very high level of detail.

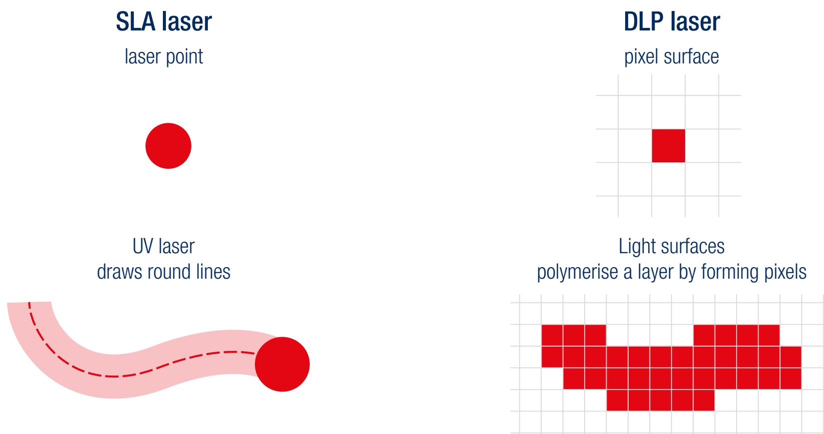
The FDM method generates the printing object by applying a previously molten resin. Accordingly, the print object may easily change shape, when it is further processed at high temperatures, as for example when being thermoformed. This is inconvenient for print jobs requiring a very high level of detail.

	FDM fused deposition modelling	**SLA** stereo lithography	**DLP** digital light processing
Materials	· Filaments of meltable processable resins such as thermoplastics · Printable objects are for example food, concrete, corn starch, plaster and sandstone-like material	· Synthetic/photopolymer resin	· Synthetic/photopolymer resin
Pros:	· Affordable way to generate a 3D object	· Production of undercuts, cavities and complex geometries · Extremely precise surface design · High accuracy and representation of smallest details	· Production of undercuts, cavities and complex geometries · Short production times, because layers are cured · Excellent surface design
Procedure	· The wire-like basic material is being heated in a heatable nozzle (extruder) and melted · The print object cures by cooling · Principle of a glue gun · The extruder actuates each point of the print object individually to apply material (like a customary ink jet printer) · Filling structures and support structures for cavities are required · Finishing is possible by separating the „flags" (surplus), grinding and varnishing	· Liquid photosensitive resin is punctually cured by laser beam · The laser must polymerise every point of the print object individually · Print object is built up from bottom to top · Support structures are required to secure overhangs of the object in the liquid · Finishing is done by removal of supports, cleaning, postcuring, grinding and varnishing, if required	· Liquid photosensitive resin is cured in layers by laser beam · Building platform rising by layer thickness · Print object is built up from bottom to top · Support structures are required to secure overhangs of the object in the liquid · Finishing is done by removal of supports, cleaning, postcuring, grinding and varnishing, if required
Miscellaneous	· Limited complexity · Print time is high because every single point of the object must be individually actuated by the extruder · Print time also depends on drying time of material	· The world`s first rapid prototyping process (about 1970)	· Ratio of surface quality to print speed ideal for use in the dental industry

2.1 Differences between SLA and DLP

The FDM process is mainly used in model making or in the creation of cost-effective prototypes. Due to its low accuracy, it is not widely used in the dental industry. The following sections therefore only compare SLA and DLP technology.



Procedure

The idea behind these two technologies is basically the same: a resin is being cured using light. The only difference is the light cone.

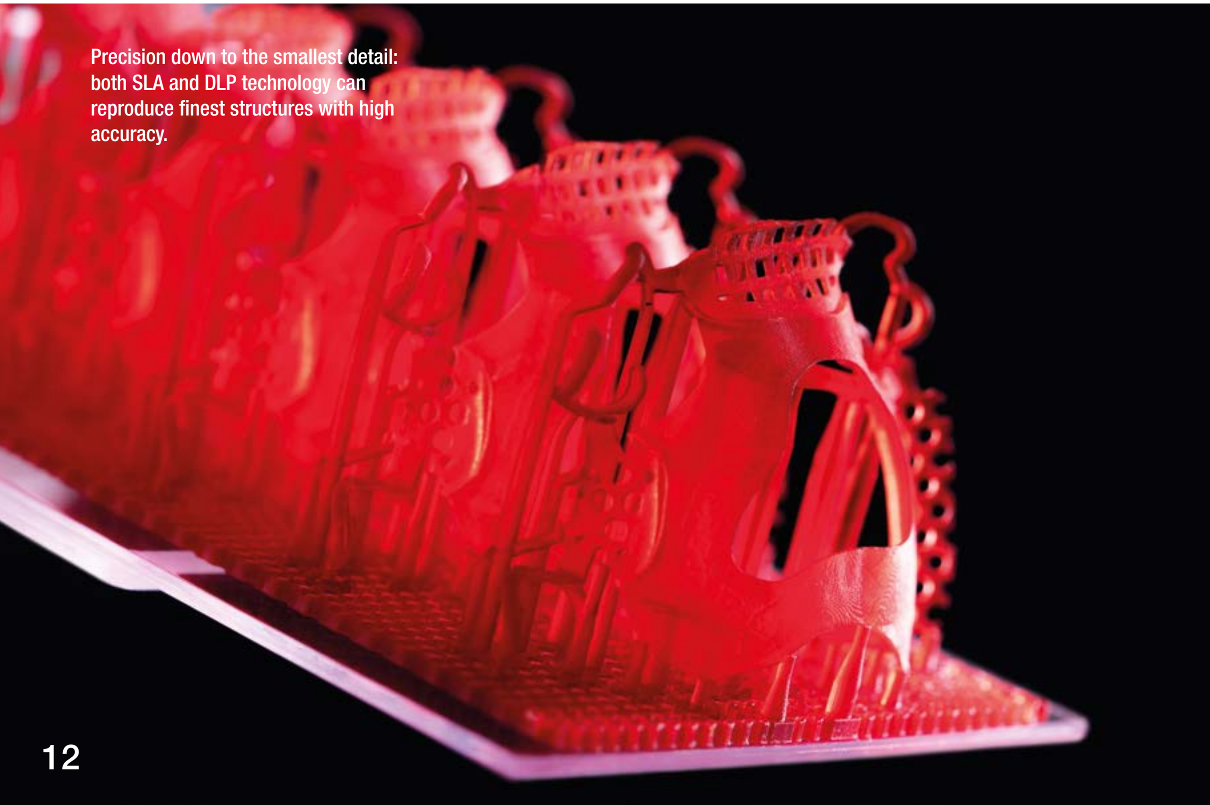
The SLA printer uses a round laser, actuating and curing the corresponding areas of the print object during the building process. It is the laser beam that defines the minimum size of the laser point. The DLP method operates with a surface where least squares (pixels) are cured. In this method, the minimum size to be cured is defined by the pixels. The projector operates so precisely that it can control exactly which pixels are to be exposed and which remain unexposed. The complete area in the building space is being exposed simultaneously. Therefore, printing time only depends on layer thickness.

The DLP technology uses a so-called anti-aliasing program, avoiding an unwanted edgy appearance in the finished print object. With the help of this grayscale technique that also dimly lightens adjacent pixels, an optimum antialiasing can be achieved. The layer thickness can be increased by means of softer edges, having a positive effect on the printing time without affecting the optical result.

The printing time of small objects such as casting moulds for rings is about the same with both, SLA and DLP technologies. Bigger objects such as dental arcades or massive models on the building platform, however, account for a difference in printing time. Accordingly, the choice of the appropriate technology depends on the desired application: for small, delicate and very detailed print objects an SLA printer is the better choice. If you, however, intend to use the complete building space in order to print simultaneously as many larger objects as possible, you should consider a DLP printer.

Precision

The precision of a 3D printer depends on various factors, such as the printing method used, the materials used, individual software settings or post-processing. Of course, the printer components are crucial, too: high-quality components provide a better result, but also increase the retail price. In addition to the inaccuracies inherent with the printer, the parameter setting for the appropriate printing resin can also lead to inaccuracies. Therefore, printers are often used in a closed system allowing exclusively the use of specific materials. In open systems, the use of the printer is not limited to materials from a specific manufacturer. In order to use a specific resin, a file with the appropriate parameters that is available with the manufacturer has to be imported into the system. Since printing materials can vary widely in their characteristics, calibration of the printer with the printing resin is crucial to ensure an attractive print result.



Precision down to the smallest detail: both SLA and DLP technology can reproduce finest structures with high accuracy.

Resolution

A widely discussed topic in the context of 3D printing is resolution. This term, however, is used in the most diverse contexts, making it difficult for the user to compare the individual values. The letters xy and z are often used here: X and Y refer to the surface and Z refers to the height of the element that is to be cured.

When using the SLA system, the diameter of the laser used determines the surface which will be cured. Here, the arrangement of the laser in relation to the building space is another relevant factor. If the laser is arranged at a slight tilt and is thus hitting the building platform and the print object at a slight tilt, too, the laser point may get distorted in the outer areas. With the SLA system, the xy resolution usually defines the size of the laser point. The height z is defined by the user.

With the DLP system, the xy-resolution refers to the surface of a pixel which is exposed. The term "pixel size: 62 µm" within the DLP method refers to the surface and indicates that a pixel has a square base area of 62 x 62 micrometres.

The layer height z, that is the intensity of light penetration, can be set individually by the user. A layer thickness of 50 -100 micrometres is sufficient for dental applications; reducing it significantly increases the printing time. Curing of surface and height results in the formation of a cube (voxel). Ultimately, the print object is built by a very high number of these cubes.

What is the size of a micrometre (micron)?

For a better understanding of the dimension, the more commonly used unit of the millimetre can be helpful: a micrometre corresponds to one thousandth of one millimetre.

Accordingly, 100 micrometres equal 0.1 mm.

The graphic illustrates various size ratios in the range of millimetres and microns:

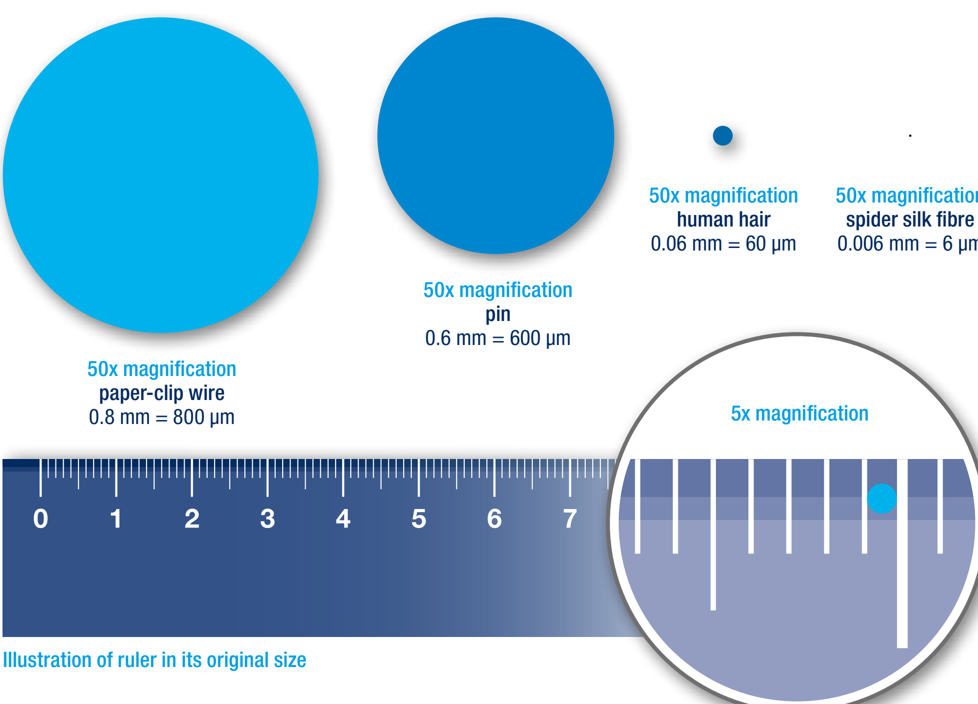


Illustration of ruler in its original size

3.

What is the benefit of digitalisation?

Digitalisation concerns dentists and dental technicians to a varying extent and with different options. When it comes to the cooperation of practices and laboratories, digitalisation can contribute to a greater degree of accuracy in initial situations. It may also help to combine partial processes to a useful overall process, while still considering the different focuses of practice and laboratory. A good way to a successful transition to digital processes is to start on a small scale verifying the processes before gradually developing them.
This is exactly where the SCHEU GROUP will support you with customised solutions. You know best which priorities you want to set and which subprojects you want to tackle first. Together, we develop a useful digitalisation approach that is fine-tuned to your individual requirements – at your own pace, according to your personal preferences. You can enter the digital work flow at any point, determining your individual level of digitalisation. Another option for you is to transfer digital planning or fabrication of aligners or other appliances to our service provider CA DIGITAL.

We accompany you on your way to the digital work flow – step by step, as long as you want us to.

3.1 Digitalisation in the orthodontic practice

Many orthodontists have already made the first step to digitalisation by adding an intraoral scanner to their equipment. This does make sense, since scan results show a significantly higher preciseness and fewer errors than conventional alginate impressions. For a quick start in digitalisation you just need a program that allows for individual data processing for model analysis, patient data archiving and reproducing, order placing and direct billing for services. Ideally, all these functions can be performed from any work station in your practice.
You might additionally consider the option of an extensive planning program for the practice laboratory, so that you can directly use STL files of the scanner for treatment planning.
Depending on the degree of digitalisation of the laboratory, you can for example plan an aligner treatment using the software and directly realise it by 3D printing. Working models of the new tooth position are printed for subsequent thermoforming of customised aligners for your patient. Special plus: Full treatment control remains with the orthodontist/dentist enabling him to interfere any moment in case of lack of cooperation of the patient. At the same time, the treatment goal can be visualised at any time directly at the chair, thus increasing the patient`s motivation and satisfaction.
Depending on the existing equipment in your practice, you have the option to buy specific subprocesses (e.g. treatment planning, printing or splint fabrication) first before gradually implementing them on your own. This means that depending on capacity and resources, specific elements of value creation remain with your own laboratory, leaving you the option to adapt the degree of digitalisation gradually to the individual situation in your practice and laboratory.
Once you have opted for the purchase of a 3D printer and the entire digital work flow is available, you can select the appropriate printer resins. The choice of the right material depends on the applications you intend to print.
If you intend to print only working models or mock-ups at first, you just have to find the matching printer resin for these applications. Later on, you can decide to realise further applications and add the corresponding resins, too.

»We have been printing more than 30,000 dental models with the IMPRIMO® system since 2015 in our lab, enabling us to enhance the smiles of about 5,000 patients with CA® CLEAR ALIGNER splints.
The printing procedure with Asiga MAX™ is precise and extremely reliable and has, together with the trustable 24/7 technical support, guaranteed our confidence and the satisfaction of our doctors and their customers.«

Rolf Faltin, DDS, MSc, PhD., CTO, CA® CLEAR ALIGNER do Brasil

3.2 Digitalisation in the dental practice

Precise scanning using an intraoral scanner is a useful option for dentists, too. Conventional impressions show a high potential for inaccuracies that can be eliminated by a scan of the oral cavity. Scanners allow for recording occlusion and each indivdual tooth. Using the corresponding program, for example a bruxism splint can be made quickly and easily in the next step. Only after a short waiting period, the patient can already take home his useful splint. You can just as well reduce the waiting time for an individual functional tray, by creating and printing it in a few steps using the software.

More complex patient works, however, require the profound expertise of the dental laboratory. Here, too, the experts will benefit from a quick and precise digital impression. At the same time, costs in terms of logistics can be reduced by sending out the scan by just one click. Crowns and bridges can then be fabricated more easily in the laboratory of your choice - or surgical guides, simple mock-ups, veneer restorations and working models.

The same principle applies here, too: The degree of digitalisation can be adapted to the individual situation in practice and laboratory and can be expanded, if required. Digitalisation provides a clear basis for communication between practice and industrial laboratory. A clean digital impression helps to avoid additional work caused by faulty fit to the patient's mouth, which might occur even if the fit had been fine on the model.

»Our Asiga MAX™ 3D printer is the perfect complement to our digital work flow. Thanks to the accuracy of the 3D printing results, we can do completely without conventional impressions when scanning for preparations and models for planning.«

Dr. med. dent. Matthias Nagengast, dentist, Bamberg, Germany

3.3 Digitalisation in the dental laboratory

In a dental laboratory, technology supports the expertise of the dental technician. A software program for treatment planning is required to process STL files. Such a program often reflects the manual working steps of the dental technician. Additional features like the compliance to stored limit values during planning, the automation of certain steps and the detection of errors are incorporated to faciltiate the daily dental work. Using the planning software, a variety of patient works can be realised digitally with a few steps, before being converted by milling or printing technology into a physical work. Currently, the field of possibilities is only restricted when it comes to the use of milling blanks or equivalent printable resins. However, the manufacturers are continuously working on improvements and on extending the range of these new resins. So you can for example virtually design a model cast denture and then print it in the next step. The burn-out resin can be embedded and cast like conventional wax.

Same as a milling machine, a 3D printer provides customised products with high accuracy, so that the process can be completed with as little corrections as possible to the full satisfaction of the patient. At the same time, the time factor is reduced, as there is no need to repeat individual steps and yet the result is reproducible at any time. Specific printers are available for high printing volumes, so that an increasing number of already specialised laboratories decide to offer their well-functioning digital processes as a service to other laboratories as well.

»The IMPRIMO® system fully completes our laboratory's digital work flow, with a reliable and fast printer we can confidently rely on for our high production work flow. It is a very smart and easy to use system that has been a straightforward integration to the lab, thanks to exellent support from SCHEU-DENTAL. The diversity of materials gives us the possibility to provide a wide range of restaurations to our customers.«

Toni Uski, dental technician and lab owner, Tulo Tandteknik, Täby, Sweden

3.4 Costs involved

For starters, digitalisation of work processes involves high investment volumes in terms of hardware and software as well as in staff qualification. It will take expenses for testing, consultation and a learning curve before the digital process is completely implemented, fitted and well-functioning.
Digitalisation helps to save money in the long term by improving processes. The 3D printer can produce without involving any working time of the technician, there is no more need to work out the treatment planning, as it can be assessed visually in the software. Faulty work due to inaccuracies during impression taking can be almost completely excluded. Digital archiving of patient data also saves considerable costs and space.

Finally, let's take a look at manufacturing costs:
Working models made of plaster for upper and lower jaws involve relatively low material costs. Depending on the model type (only dental arcade, hollow or full models), the cost for material usage for upper and lower jaws made of resins vary, but you can save costs for impression trays and impression material.

3D printing of dental arcade models arranged horizontally over two levels

4.

An open system – perfectly matched

The portfolio of the SCHEU GROUP ranges from the required devices and consumables to the orthodontic planning software, complementary training and individual support for the single system components.

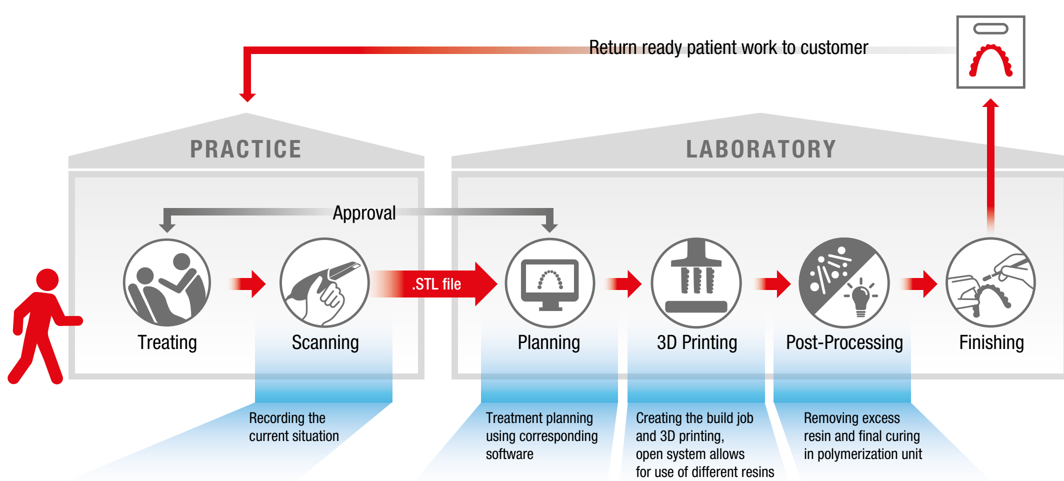


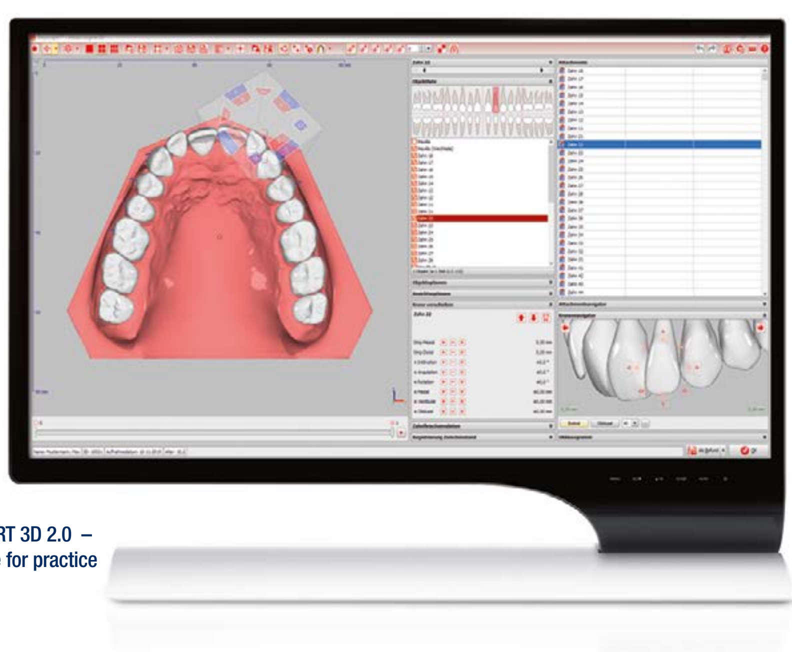
Illustration of a possible work flow using digital technologies.

Scanning

The first step into digitalisation is usually the purchase of an intraoral scanner. The required STL file can also be generated by model or optical scanners, but they do not eliminate the known error potentials of conventional impression taking. If you are interested, we will be happy to consult you on appropriate devices.

Planning

Depending on the application, a corresponding software program is required for subsequent treatment planning. Thanks to various optional modules, the OnyxCeph3™ CA SMART® 3D 2.0 software can be customised, matching almost any orthodontic scenario like virtual bracket positioning in the fabrication of transfer masks or virtual aligner planning. Moreover, 2D and 3D image data are available as presentation or report for the exchange of information between laboratory, physician and patient.

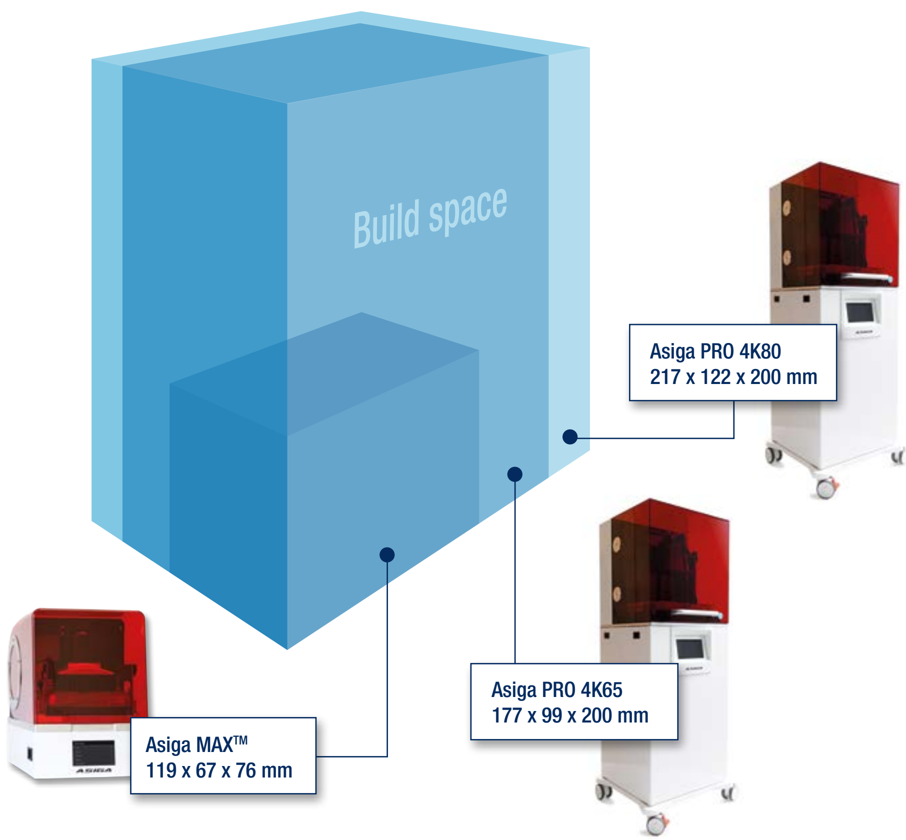


OnyxCeph3™ CA® SMART 3D 2.0 – the orthodontic software for practice and laboratory

3D Printing

To meet different needs of production capacity, SCHEU-DENTAL offers Asiga MAX™ and Asiga PRO 4K devices that differ in size and build space: While Asiga MAX™ is an all-rounder in a handy desktop format, the floor-standing models of the Asiga PRO series are primarily destined for the demands of users with high printing volumes. A comparison of the build space size illustrates the differences: Asiga MAX™ will print about 7 dental arcade modes in one build job, whereas Asiga PRO 4K80 can build 21 models per build job.

Both model types feature precise and reliable DLP technology, ease of use and maintenance. They are equipped with web-based controlling and monitoring and work quietly and efficiently. A built-in light sensor continuously adjusts the performance of the projector, ensuring uniform curing of the materials. The license-free Asiga Composer software automatically generates support structures when creating a build, the Smart Positioning System prevents unnecessary travels within the build space, thus ensuring time-optimised printing. The user does not have to be in the same room during the printing process, as the current print status can be retrieved from a mobile phone via Internet. If the printer, however, happens to be in the same room, it is quiet enough so that other work can be carried out in a concentrated manner.



In DLP technology, the number of available pixels/voxels depends on the type of projector and its placement in the device. If the projector is positioned closer to the optical window, the pixels are getting smaller, which leads to an increase of resolution but also to a reduction of available build space. In order to significantly increase production volume, some manufacturers tend to position various projectors next to each other or to use an HD-4K projector. Due to the considerably higher cost, these models are more interesting for laboratories expecting high utilisation and therefore requiring high production capacity.

SCHEU-DENTAL offers you to test both types of printers at the site in Iserlohn (Germany). In case you are interested in testing a printer in your own practice or laboratory, please contact your authorised local SCHEU-DENTAL partner. We also offer online demonstrations via video call. Our training and the support of the SCHEU-DENTAL team will make sure that the printers are being operated properly.

The extensive IMPRIMO® LC material portfolio provides a wide range of printer resins for a variety of applications already tailored to use with Asiga printers. The system is deliberately an open one leaving you all the options and providing the possibility to easily use materials of other manufacturers. In case of using other materials, a so-called .ini file is required from the manufacturer, as any kind of resin shows different properties. The file contains all the parameters for material processing and must be imported prior to use with the printer.

This ensures that the 3D printer recognises the material characteristics, so that it can react to them for example by a longer heating phase at the beginning of the printing operation or by slower moving the build platform. It is understood that these parameters are already stored for the resins of the IMPRIMO® system.

Build space can be utilised optimally by a sensible arrangement of the print objects on the building platform.

Post-processing

Once printing is completed, the print object is removed from the build platform and released from its support structures. This step is assisted by the use of touch-sensitive support structures: they show minimal contact points with the print object, so that it can be easily removed and only minor support tracks are left.
The print object is being cured layer by layer in liquid resin during the printing process. A cleaning device like the RS wash is still required for final cleaning and to completely remove any resin residues.
You can use either high-percentage alcohol for cleaning or an appropriate cleaning agent such as IMPRIMO® Cleaning Liquid.

Certain functional materials that are used for technical or biocompatible objects require additional post-curing. For the purposes of the European Medical Device Regulation, we recommend post-curing of any printed object using UV light and vacuum (optionally protective gas) in order to prevent the formation of an inhibition layer. The polymerisation unit RS cure is already equipped with pre-installed programs, ensuring appropriate curing of the IMPRIMO® printing resins according to their properties.
In the next step, the print object can be finished depending on material and indication.

Post-processing devices
RS wash and RS cure.

5.

Conclusion

Your first step

In dental technology, the change in fabrication from entirely analogue to a combination of analogue and digital techniques has long since taken place and is continuously being complemented by more recent digital technologies. The dynamic allowing replacing long proven manual working steps by digital ones is exciting, as it is about to significantly change our professional world and offer possibilities to develop new competencies. Our vision is to contribute to and to shape this exciting development so that you, the user, can benefit from the efficient work processes that are made possible by these new technologies.

Our approach is simple: new technologies involve considerable investments for all participants – associated with entrepreneurial uncertainties. So why not spread the risks over more than one shoulder and address them step by step? You are free to complete proven treatment approaches gradually by innovative technologies – at your own pace, according to your personal preferences. Enter the digital work flow wherever you want to and wherever it makes sense for you, determining your individual level of digitalisation, for example by choosing for starters the option of cooperating with an external laboratory or service provider. Thus you can access innovative technologies and treatment solutions and can gather experience, before deciding to which extent you want to do digital planning and manufacturing on your own.

Whatever you choose, the SCHEU GROUP accompanies you in this process with individual solutions and excellent service. This is especially important to us, because any technology is just as good as the knowledge of the user. This is why we provide instructions on operating the printers as well as reliable support from our application engineers – by phone, TeamViewer or on site. A variety of training opportunities and an online reference tool complete our service package and enable you to shape your digital future using our experience and competence.

Shaping
the future together!

On your way to digitalisation, three reliable partners within the SCHEU GROUP will be at your side covering conventional dentistry and innovative orthodontics just as well as groundbreaking 3D technology.

Together we can achieve more – this applies to our partners and subsidiaries as well as to you, our customers. You can rely on us: as your technology and innovation partner for dental products and services.

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GB 05/21 pdf REF PM0306.02

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