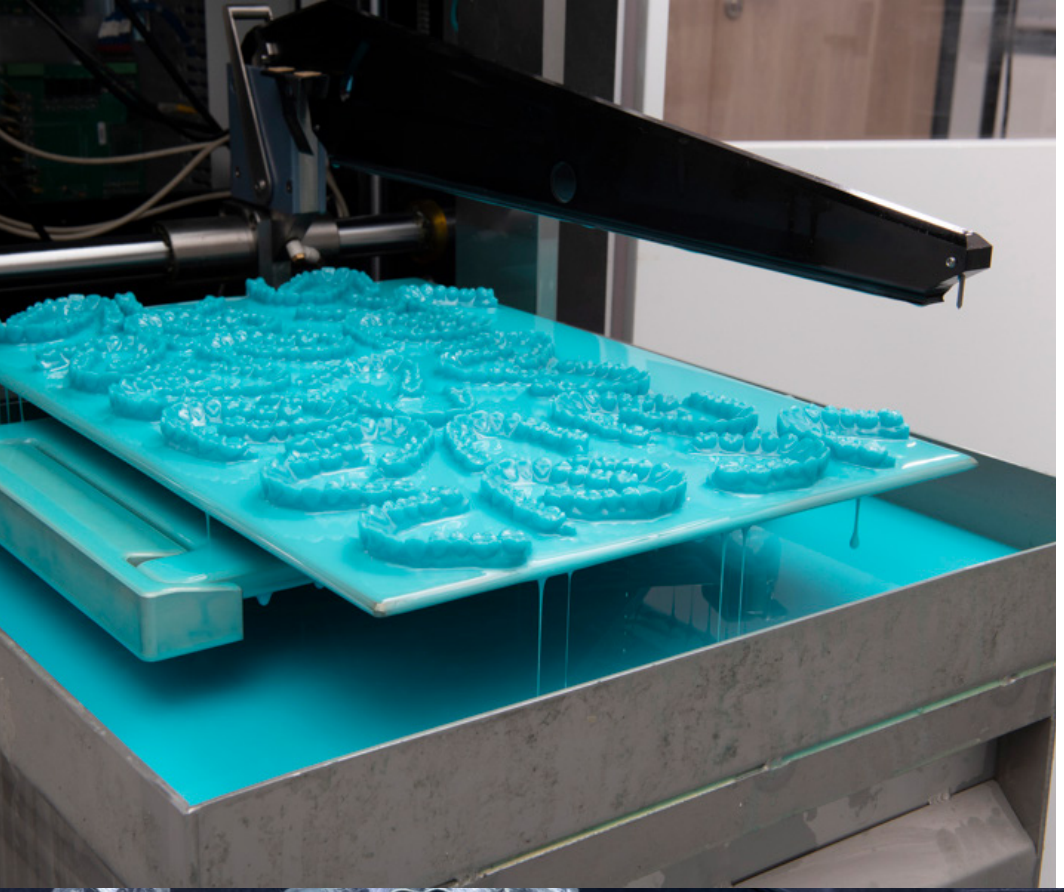

PRODWAYS MACHINES

Mastering Efficiency:

The Ultimate Guide for Clear Aligner Manufacturing in 2023

Contents

10 million

people have used their product

2.4 billion

in 2020 for the global clear aligner market

15.9 billion

by 2028 - clear aligner market

Introduction:

The Global Clear Aligner Market

It's no secret that the global clear aligner market is exploding. Align Technology, creators of Invisalign, reports that over 10 million people have used their product to date to straighten their smiles. The global clear aligner market was valued at $2.4 billion in 2020 and is expected to grow to $15.9 billion by 2028.

What's driving this growth? One of the main reasons is that clear aligners are the less invasive method of straightening teeth versus traditional braces.

Another reason is the 'The Zoom Effect'. Many people have been looking at their unedited image, sometimes on a daily basis, and not liking their smile. Enter a convenient alternative for changing that – the clear aligner.

Chapter 1: Malocclusion

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It's not just about aesthetics.

The benefits of straight teeth don't just start and end with looks. Straight teeth can help reduce your risk of cavities, gum inflammation, disease, and aid in a proper bite. Misaligned teeth can lead to the chipping of teeth from grinding, which can also lead to jaw pain and headaches.

While one should always get a professional opinion before making any decision to straighten their teeth, clear aligners are an excellent solution for anyone looking to treat mild to moderate misalignment conditions.

Malocclusion can cause health problems.

Dangers of having misaligned teeth:

1. Gum disease. Crooked teeth make it difficult to clean your teeth properly, which can lead to the buildup of plaque and tartar. This buildup can cause gum disease, which is a serious infection that can damage your gums and teeth.

2. Tooth decay. Crooked teeth can also make it difficult to floss, which can lead to tooth decay.

3. Jaw pain. Crooked teeth can put extra stress on your jaw, which can lead to pain. This is because your teeth are not aligned properly, so your jaw has to work harder to chew.

4. Low self-esteem. Crooked teeth can make people feel self-conscious about their appearance. This can lead to low self-esteem and social anxiety.

5. Difficulty eating. Crooked teeth can make it difficult to eat certain foods. This is because your teeth may not be able to properly break down food, which can lead to indigestion and other digestive problems.

6. Increased risk of tooth loss. Crooked teeth are more likely to develop cavities and gum disease, which can lead to tooth loss.

7. Increased risk of heart disease. Studies have shown that people with crooked teeth are more likely to develop heart disease. This is because gum disease can increase the risk of inflammation, which can damage the heart.

Orthodontics, although a common treatment with many pre-adolescents, also concerns a good number of adults bothered by aesthetics and also sometimes by more technical issues. Properly aligned teeth improve mastication, which is essential for good digestion and oral expression. But they are also easier to care for on a daily basis because they limit the emergence of future problems.

Appearance is important.

Appearance plays a key role in a person's own experience and quality of life, and straight teeth are a necessity for many adult patients who will agree to orthodontic correction if they are offered a technique that is not visually stigmatizing. This is why it is essential to offer an alternative to metal or ceramic braces placed on the front of teeth, considered too visible for many people.

The ortho-lingual technique, where braces are placed on the inside of the dental arch, is invisible but more expensive than the traditional procedure. It can also be inconvenient and requires greater care and attention at mealtimes and when brushing.

Techniques
for Fixing Misaligned Teeth

There are a number of ways to fix malocclusion or crooked teeth. The best treatment option for you will depend on the severity of your malocclusion and your overall health.

1. **Traditional Metal Braces –** Worn on the outside of the teeth, braces are not easily hidden and may cause embarrassment, especially in older patients

2. **Surgery** – For severe cases, and especially in adults with already formed jaws, surgery may be needed

3. **Tooth Removal –** If crowding is present, tooth removal may be needed to allow space for the teeth shifting.

4. **Orthodontic Appliances -** Older teens and adults may need headgear to help move the already developed jaws. Often used in conjunction with orthodontics.

5. **Clear Aligners -** Clear aligners are removable and fit over teeth. With clear aligner treatment, a series of aligners is designed, each with subtle pressure points and bite changes that guide teeth through a gentle progression to proper alignment. If aligner molds are printed with high-quality 3D printers, the aligners are barely noticeable.

Benefits
of Clear Aligners

Clear aligners or aligner trays are made from a clear material and so are invisible; it is worn all the time except at mealtimes and when brushing your teeth. It is replaced according to how the teeth change during the treatment.

The trend is to produce a digital impression, which is flexible and allows its different stages to be modeled and an additive manufacturing process to be followed by thermoforming.

Although an exacting process, this proposition checks a lot of boxes when it comes to patient and practitioner appeal (dentists and orthodontists) as the method provides them with a product free from the criticism often leveled at traditional solutions.

Prodways, a major player in 3D digital dentistry, places its 3D printers in a comprehensive and certified ecosystem, combining a scanner as chosen by the practitioner, robotized printer, appropriate material, the laser marking system, a thermoforming system, and automated aligner trimming inside a consistent, hyper-functional, productive, and highly profitable workflow.

Chapter 2: Benefits of All Digital

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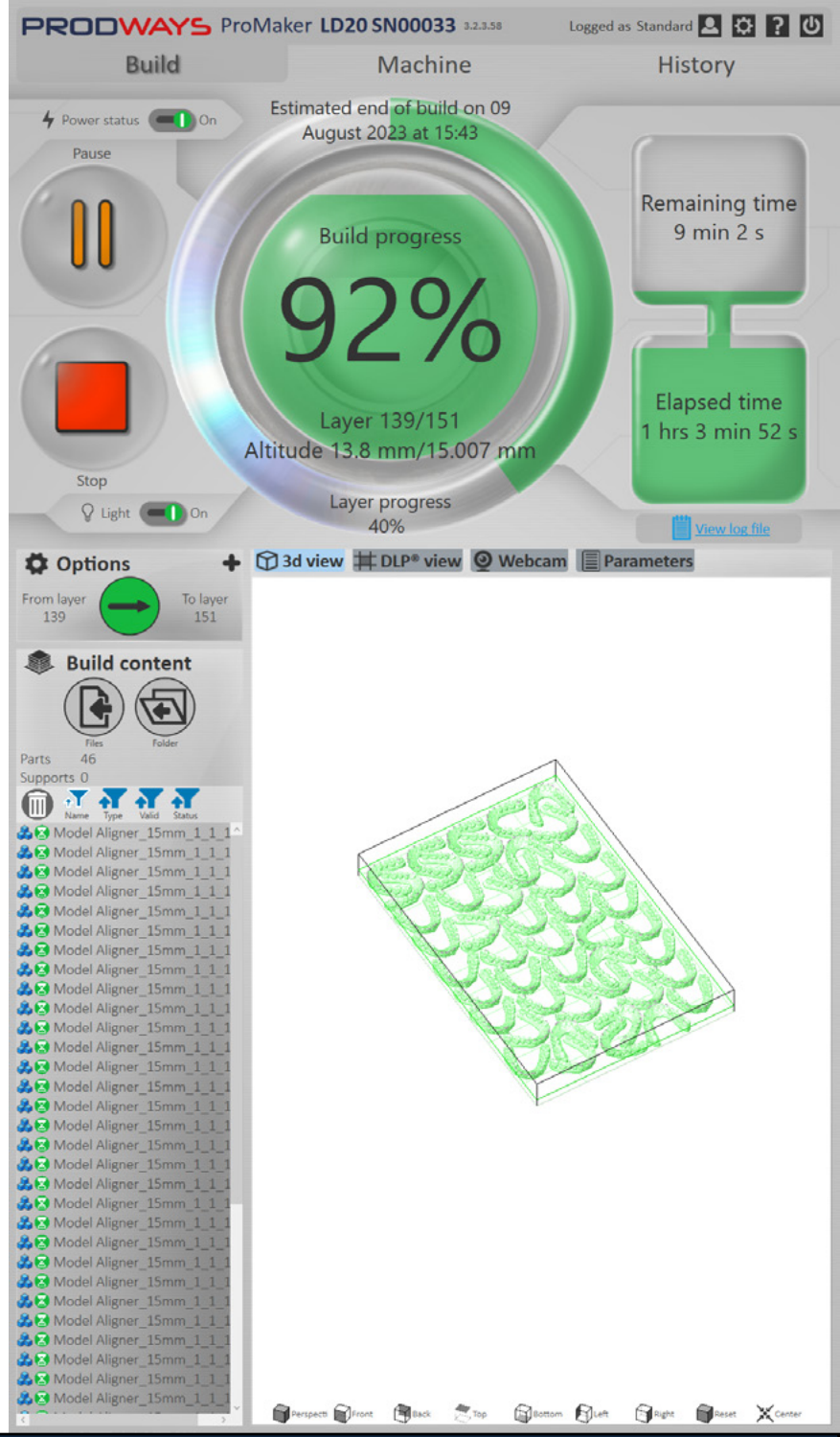
Digital Dentistry Advancements

for Dentists & Orthodontists

The interoperability compatibility of an all-digital workflow used during the various stages of clear aligner production is necessary to guarantee an optimal result. Additive manufacturing technology (3D printing) can produce on-demand aligners for the exact requirements of each individual dentition problem. It's an undeniable advantage for dentists and orthodontists.

Speed is a key advantage when producing clear aligners through digital dentistry. From the very beginning of the process, the intraoral scanner takes an impression of the patient's mouth easier, and more ergonomic. Digital impressions allow shorter, more comfortable visits.

The reduction in production times and speed of implementation ultimately translates into greater patient satisfaction who benefit from increased comfort and gain more control of their budget. As a result, the practitioner also benefits not only in terms of customer relations, but also through a modern and well-controlled practice, a simpler workflow requiring less manpower, and an increase in profitability.



Growth Driver for Dental Laboratories

As for dental labs, the use of highly automated machines operating with a consistent and integrated process produces significant economies of scale and responses that are adapted to market needs, including requests that are more aesthetic than medical. It is also a real growth driver, enabling the company to expand in a profitable and fast-growing market. With 3D printing, technicians are becoming more skilled and versatile, but this does not rule out the option to combine digital performance with the craftsmanship of traditional methods used for finishing dental appliances.

As soon as it becomes part of an integrated and controlled production chain - a key principle at Prodways - the additive manufacturing of aligner preforms becomes a major asset for the development of the professions operating in the sphere of orthodontics.

For laboratories, mastering 3D printing is also a formidable means of growth with an investment that quickly pays for itself.

Patient Side

Comfort, Satisfaction, Budget Control

Professional Side

Profitability, Precision & Quality, Faster Production Cycles

Chapter 3: End-To-End Workflow

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A Seamless Experience and a Scalable Production

Whether you are a new player in the production of clear aligners or wish to scale up to industrial production volumes, our ecosystem of validated partners will meet each of your needs providing the best return on investment.

With an integrated dental workflow, the manufacturing of clear aligners process provides higher consistency, accuracy, and precision at every stage of the workflow.

Intraoral Scan

It all starts with the intraoral scan of the patient's mouth to get an accurate impression to plan and design the treatment plan according to its specific goals. Prodways has partnered with 3Shape in this step of the digital workflow to innovate digital treatment planning and automation of the design and production preparation process with clear aligner software for an advanced dental solution easy to use.

3D Printer

Once the treatment plan is developed, we move on to printing the models for the clear aligners. Prodways ProMaker LD Series 3D printers use our unique MOVINGLight® technology specially built for dental applications to produce up to 55 clear aligner molds in one hour with repeatable and accurate results guaranteed.

Thermoforming

Thermoforming, the process of adding the film application to the model by applying heat and pressure to a plastic sheet which is positioned on top of the 3D model printed specifically for the patient, is the next step of the process. Hamer offers an automatic system for in-line thermoforming of dental aligners and also allows the possibility of integrating vision and laser marking systems, which are used in the final packaging to identify the aligners according to the treatment plan.

LAC

For the trimming of aligners, Prodways has partnered with Dental Axess' automated aligner trimming solution for a high-quality and comfortable final product. Their industrial-grade machinery and software integration can improve workflow quality, consistency, and eliminate the manual labor bottleneck. One technician can now produce 100 aligners per hour.

Manufacturing Execution System

To ensure perfect coordination of the clear aligner workflow, Prodways has chosen Oqton's cloud-based Manufacturing Execution System (MES). Oqton covers the entire manufacturing chain, from design to final post-print quality control, via a seamless and efficient process. Powered by AI algorithms, the software allows the system to learn continuously, improving efficiency and quality throughout the manufacturing chain, and also predicting how machines will behave.

Prodways' Validated Ecosystem
for Industrial Production

3D Model Construction
The Scanner

Dental scanners are an increasingly common tool used in many dental practices. They are a useful complement to conventional radiography and can quickly capture a three-dimensional image. This process is easy and requires no special preparation, making it minimally invasive for patients.

The captured image is not only a comprehensive information tool but also a digital model that can be immediately transferred to the laboratory. This can help prepare procedures or assist in the manufacture of prostheses.

To use the scanner, the practitioner inserts it into the patient's mouth and manipulates it to capture images from all possible angles. On-screen video feedback allows the operator to check that all the necessary images have been taken, and graphic software assembles the images to build a 3D model.

This 3D model can be manipulated on the screen through all three axes, zoomed in on details, and archived for future use. It is particularly useful in the manufacturing process of aligners, where the 3D scan can be immediately post-processed for interpretation by business software.

Alternatively, a conventional impression can be taken using a tray filled with a special hardening filler. This mold is then scanned to produce a digital reference model, which can be used by orthodontists to carry out their treatment plans.

For aligner production, Prodways recommends 3Shape professional software programs that are optimized to work with its ProMaker MOVINGLight® 3D printers.

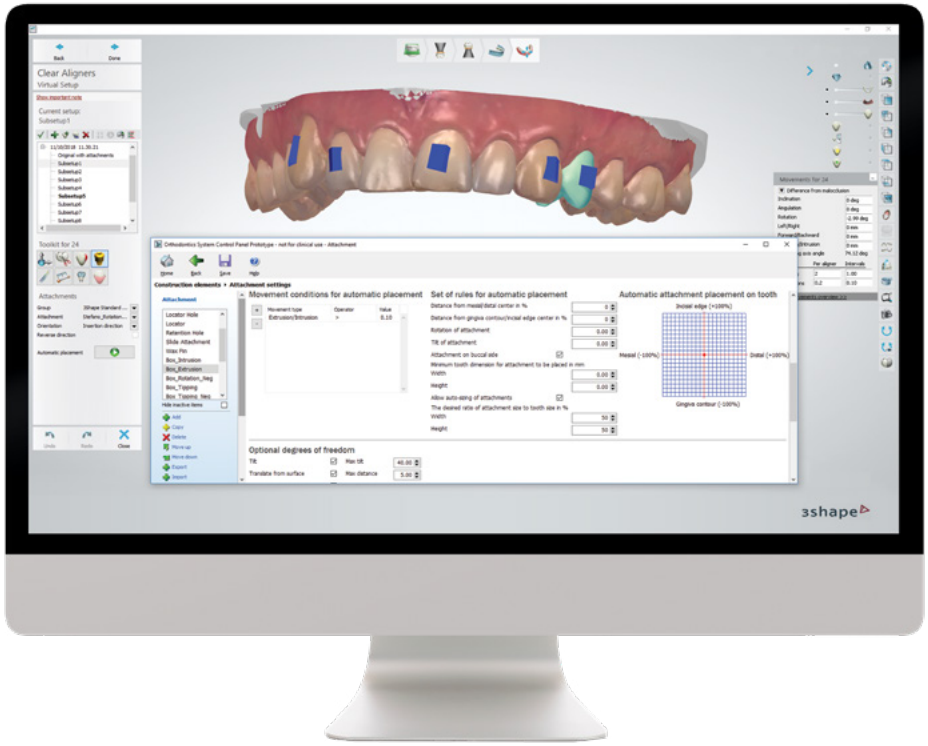
Professional
Software

Once the three-dimensional model is completed, the orthodontic treatment plan is prepared and will subsequently be used to schedule the production of aligners.

Beforehand, the model can be used to visually explain to the patient in before/after mode what his or her teeth will look like at the end of the treatment.

The 3D file generated by the scan is transmitted to the specialist, who is a dental professional but who may also be a specialized technician employed in a laboratory for the production of aligners. At this stage, the specialist will implement professional software that will potentially be used to merge the 3D file from the scanner with the digital X-rays taken from the patient's teeth in order to enhance the reference model.

The technician will then develop a detailed treatment plan according to the medical recommendations that were previously transmitted. The software first separates the teeth from their gums, which are distinguished by their difference in density, enabling individual canines, molars, and incisors to be "rotated" in order to virtually correct their implantation.



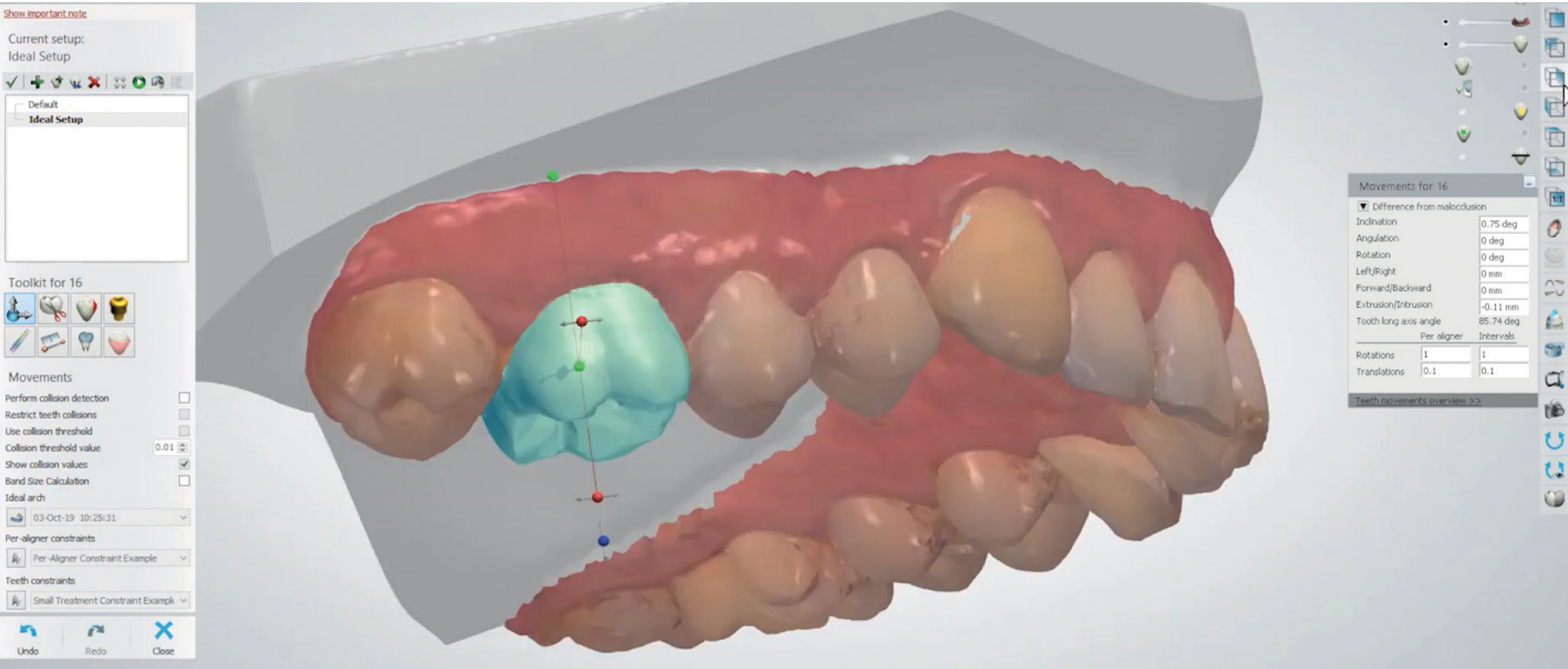
The technician does not necessarily have to be a qualified orthodontist because he or she is assisted by professional software that applies rules and settings acting as a reference and "safeguard" with the final medical approval required before proceeding to the next step.

A Treatment Plan with Micrometric Precision

Between the initial state of teeth and the simulated final positioning, the professional software will define several gradual stages, from less than 10 to 50 or more per jaw. This requires the production of as many aligners as the patient will successively need to wear, on average up to 20 hours a day.

The aligners also have the advantage of being able to show the patient the final configuration of his teeth after treatment.

The most advanced working methods are also beginning to integrate artificial intelligence, which, based on thousands of memorized cases and on this “deep learning”, defines rules of procedure for the manipulation of the digitized teeth displayed on the screen.



From Treatment Plan to Production Plan

Once formulated and medically validated by an orthodontist, the treatment plan has to be transformed into a production plan. This will serve as a guide for the additive manufacturing machine or 3D printer.

MOVINGLight® is a unique, highly reliable, ultra-high precision technological solution that makes Prodways the undeniable leader in the 3D printing industry for dental.

- **Build plate up to 55 aligners**
- **Print in a flat position with no supports, to save material and reduce post-processing time.**
- **42 µm native xy resolution**
- **Unparalleled speed & high throughput**

Industrial Production of Clear Aligners

Prodways ProMaker 3D printers have a mobile platform that can support up to 55 models for thermoforming. They use an ultra-violet light source to project an image from a 3D model onto a photosensitive resin. When the resin is exposed to the light, it hardens and takes shape on the parts that are irradiated.

The printers have a unique XY resolution that allows for precision parts that meet high expectations for dental applications. Each model is identified with a unique code and built in successive phases until it becomes a replica of the half dentition at one stage of its treatment.

To optimize the manufacturing process, Prodways creates and produces its own resins that are perfectly suited for the layers and UV polymerization method. This is the only material needed for this stage of production.

Up To 55 Models in less than an hour

The resin dispenser, the construction plate, and the mobility of the projector are three components that allow the Prodways ProMaker machines to serve as fully automated tools. These tools ensure high productivity as they can create about fifty preforms in less than one hour. In addition, Prodways 3D printing guarantees the repeatability of the entire process with extreme precision and flawless quality, regardless of the technician's specific expertise or dexterity.

The principle of the mobile HD projector also allows Prodways to be the only industrial player to offer a resolution of 42µm over such a large manufacturing area.

Mass production in limited times is in fact essential to meet the requirements of this market, as the delivery times requested are generally rather short and the treatment of each patient may require the manufacture of up to several dozen models of aligner. As a result, the use of high-productivity 3D printers is a necessity to maintain good levels of profitability and customer satisfaction.

Guaranteeing this very high resolution without compromising the productivity of the machine is a determining factor and gives the practitioner and the operator the assurance that the patient will not feel any discomfort since the aligners will be adjusted to the shape of his or her teeth with micrometric precision.

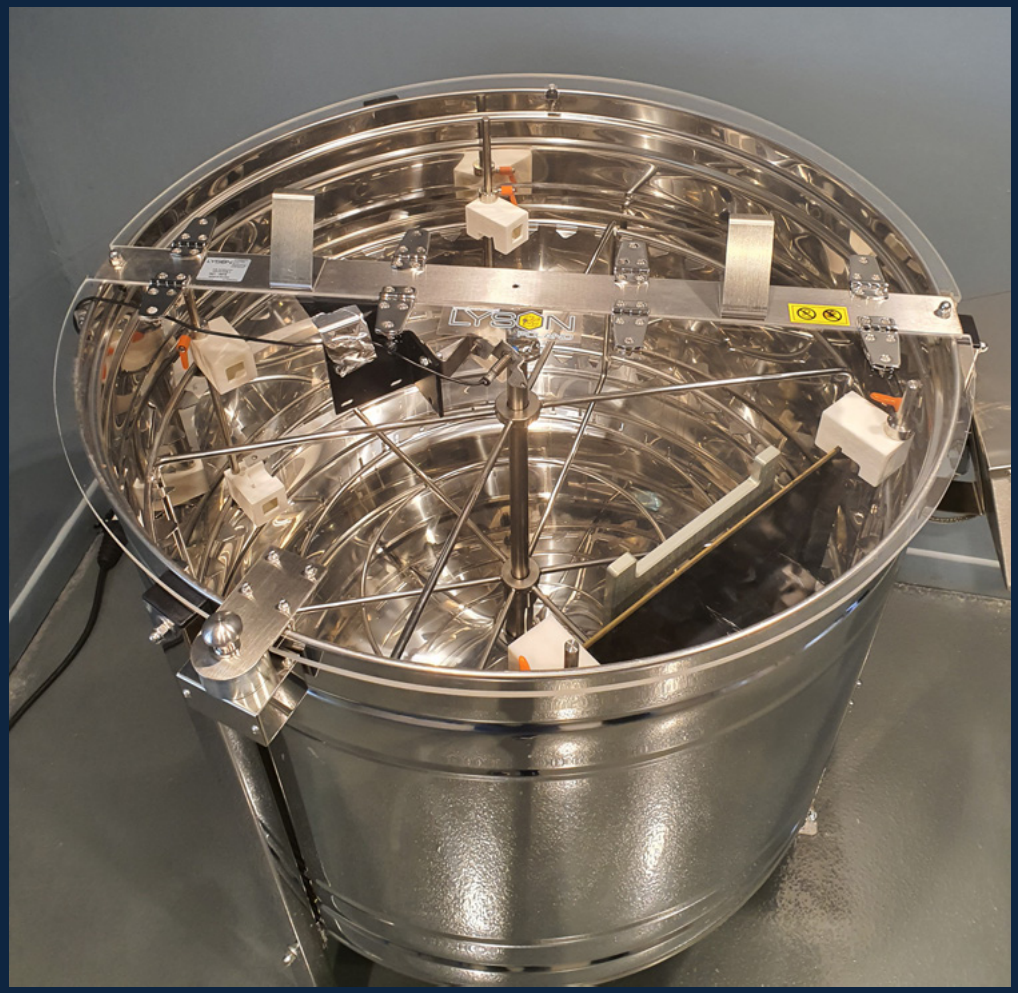
Preparation for Thermoforming

After 3D printing the shapes needed for clear aligners, the next step is to prepare them for the aligner production process. This involves taking the production plate out of the printer and finishing the shapes. First, the shapes are separated from each other.

At this point, a scanner is used to check the impressions and make sure they match the original digital model. This is usually done on a sample from the batch to ensure the future aligners fit perfectly on the teeth they are meant to straighten.

Prodways has engineered a spinner device to clean aligners without the use of isopropanol. A safer, more cost-effective device, the spinner uses no chemicals with less resin waste to achieve a smoother surface finish. Resin can be reclaimed in this process, which leads to significant cost savings.

1. **SAFE- No Chemicals**
2. **Cost Effective- Less Resin Waste**
3. **Smoother Surface Finish**
4. **Batch Processing**



Foil Application on the Production Tray

To make clear aligners, the shapes are placed on a tray and put in a thermoforming machine. This machine has a heating surface, film holder, and vacuum pump. The machine applies a thick, clear film to the shape by using air suction. The film fits tightly over the shape, including the teeth and gums, to make a perfect mold of the patient's mouth.

Different thicknesses of film are used depending on the patient's needs. The machine heats and cools the film for precise molding and hardening. The machine is easy to use and is digitally controlled. Large machines can produce up to 1,300 aligners per hour.

Traceability of Aligners is Imperative

Once thermoforming is complete, the molded plate, clearly identified to be associated with a patient record, is removed from the machine for finishing work.

The aligners must be marked beforehand as they are intended for a patient who will have to wear between 10 and 50 of them throughout his or her treatment. It is, therefore, necessary to precisely identify the name and the rank defined by the order of treatment without this information appearing too visibly when the person smiles or opens their mouth. The markings comply with the increasing MDR and FDA expectations in relation to U.D.I. (Unique Device Identifier) specific to medical products.

This marking requirement presupposes extremely precise traceability of the trays throughout the production cycle and a discreet, indelible and invisible method of inscription. Several techniques are available, the most efficient of which is laser marking.

This can be done by means of special equipment integrated into the production line, at the end of the process, or in a finishing machine using various tools and operating automatically.

The 3D impressions, covered by the aligners, are then separated from each other. Then, piece by piece, the excess film is cut around each piece to free each gutter from the shape serving as a positive mold. This cutting can be done with a sharp tool, a small milling machine, or an automated multifunction system.

Similarly, the final polishing can be done on the disc with a precision portable electric tool or in a dedicated or multifunction machine. The choice of tool depends directly on the size of the manufacturing unit, its objectives in terms of production volume and the level of investment made to equip it. However, finishing work carried out by hand can be justified if the laboratory wants to offer a high level of service and quality for the final product, as well as a certain degree of customization, which involves having operators with great dexterity, a common qualification among prosthetists.

Packaging and Delivery

Once the aligners are marked, carefully deburred, polished, and cleaned again, they are ready for use. At this stage, some laboratories find it necessary to do a control scan again to make sure that the aligners processed are those intended for a clearly identified user.

But first, they must be packaged in protective packaging that clearly facilitates the identification of each tray in the exact order of use in relation to the treatment plan and schedule.

This document must not only list the items by their identifier but also indicate the length of each phase, i.e. the period during which each aligner must be worn.

The treatment period usually lasts from several months up to two years. For complex cases, patients are often assisted by their healthcare practitioner. At this stage, practitioners have a major educational role since they must make the patient aware that any inconsistency in the wearing of the aligners can undermine the treatment and render it inoperative.

In countries where the role of the practitioner is not considered as critical, the presentation of the treatment, in its informative packaging accompanied by its application schedule, is essential and must in itself encourage the patient to continue his or her treatment.

Chapter 4: Meeting the Challenges

Educational Support for Dental Laboratories

In recent years, dental practices have been revolutionized with the introduction of new techniques such as the use of 3D scanning or the additive manufacturing of prostheses, either on-site or in the laboratory. Traditional production processes that are too time-consuming and costly, and sometimes lack precision, have been supplemented or replaced by digitalized tools that improve manufacturing processes.

Easier and faster methods for dental technicians bring considerable benefits in terms of time and profitability.

Prodways implements a strategy that combines education and support to help overcome the obstacles that dental laboratories encounter.

This technical support must also support customers, who place orders, and dentists and orthodontists, to whom it is necessary to explain all the advantages of the new methods and solutions that must be implemented to meet these challenges.

To that end, Prodways offers its prospective customers the opportunity to develop personalized training and change management programs that involve not only management but also technicians, who must have a voice through direct participation in the process of selecting the right printer to receive their full support.

Chapter 5: Reasons to Embrace 3D Printing

Why Should You Embrace 3D Printing?

The objective benefits of embracing 3D printing for dental can be summarized in six fundamental points:

For Dentists & Orthodontists

1. Faster & simplified manufacturing times

2. Digital methods improve product accuracy, repeatability, and reliability.

3. Increated patient comfort & satisfaction.

For Dental Labs

1. Faster production cycles and improved product delivery times.

2. Precision & quality constraints are always respected.

3. A fully validated and digitalized workflow.

Return on Investment
Criteria to Consider

- Return on Investment
- The Cost of Materials & Consumables, and wear of the components
- The Production Cost Per Part
- The Performance of the Printer
- Integration of the Production Flow
- Salary of the Technicians & Operators
- Manufacturing Speed and the Quality of the Final Product
- Sales & Marketing Approach

Learn more in the production of aligner

Discover our eBook on the Hollowing Process

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