Dentures produced using 3-D printing versus casting and milling

Non-precious metal alloys (NEM) are enjoying increased demand in dental technology. Additive manufacturing with laser melting ensures the uniformity and accuracy of ceramic-veneered, non-precious metal restorations created from dust and light. Are the traditional manufacturing processes of dental technicians, such as casting and milling, making a comeback? We spoke with Master Dental Technician Dieter Spitzer of Unicim, a manufacturer of dental restorations based in Berschis in the Swiss canton of St. Gallen.

Fig. 1_Tailor-made dental technologies: Master Dental Technician Dieter Spitzer offers traditional manufacturing along with CAD/CAM methods, such as laser melting of metals for dental restorations.

All images courtesy of Concept Laser GmbH, Lichtenfels, Germany.

_Mr. Spitzer, you refer to Unicim as a digital production center. What do you mean by that?

Unicim combines traditional production methods with digital CAD/CAM manufacturing, such as metal laser melting or powder-based plastic laser sintering. With rapid manufacturing methods, you can select the most functional and affordable dental prosthetic solution based on your customer's needs, be it crowns and bridges, frameworks, primary and secondary structures or implant supra-constructions.

_Can you give us an idea of the process for creating dental restorations out of metal by using the additive manufacturing technology?

Once the 3-D CAD data is complete, the support structures are set up with the help of a data processing software. Various software solutions are available for this purpose. One of the most common is CAMbridge, which requires license fees.

Alternatively, there is AutoFab Mlab, which is license-free and allows you to assign specific measurements. With Concept Laser systems, the customer is able to choose freely and is not bound by any software. The processed data is then transmitted to the machine via the network or USB port and the construction job is started. With this process, you can finish a project fully automatically overnight. Once complete, the components are removed from the building board and refinished. After manually removing the support structures, the surface is then microblasted with aluminum oxide and, in the case of bridges, the crown edges are thinned down.

_Will milling and casting soon be a thing of the past in dental prosthetics?

Milling and casting will remain part of the standard repertoire of dental laboratories for training and application. Additive manufacturing options will offer many advantages in the future and reduce production risk enormously. Unfortunately they are still far too rarely seen in practice by dentists and dental technicians. Some of this has to do with the old school mentality of doing everything manually. The dental laboratory of the future will be more of a hybrid: milling and casting where desirable but with additive manufacturing as a top alternative. "Add on versus take away," I like to call it. In summary, the casting process, from creating the cast object to the finished product, is usually very time consuming and can lead to distortion, especially with large-span restorations. With additive technology, we achieve contour accuracy more easily than with milling. Our workplaces in dental technology are also cleaner thanks to CAD/CAM: less dust, less bonding agent, glue and outgassing. Ultimately, the deciding factor is quality. Compared to casting and milling, additive printing processes are creating entirely new ways of thinking in terms of production, workflow and the products themselves.

_How are these changes expressed?

We need to look at different levels here. First is the transition from manual craftsmanship to high-precision, high-accuracy industrial CAD/CAM production. Milled non-precious metal restorations have significant disadvantages due to material consumption: high production costs and system-related lower quality in terms of fit and shape retention. During casting, we also encounter disadvantages in terms of low material density, mold costs, production time and rework. Nearly all of these disadvantages disappear with laser melting. By using proven materials like remanium star CL and rematitan CL from Dentaurum with our Mlab cusing R, we have been very satisfied with the quality of our system-manufactured products. In the case of large-volume restorations, any excess tension that arises can be alleviated through subsequent heat treatment, thus avoiding any potential distortion. Of course, the same applies to cobalt-chromium alloys or titanium.

_You mentioned changes in the products. What changes were you referring to?

I'm quite optimistic. I'll describe a couple of them. First, the geometric flexibility of prosthetics is enabling a new way of looking at shapes or functions. In the future, imagine restorations with channels into which medications can be fed. The dentist or orthodontist can provide treatment, and the patient won't have to deal with temporaries. The second major change is the selective density of a component made possible by the process. Thus, for example, bridges with more than ten sections can not only be manufactured in a one-step process tension-free, they can also be increasingly applied in heavily utilized areas, such as cantilevers, edges or brace elastics. In model casting, that's not always an easy problem to solve. Geometric freedom is a genuine plus for us, as it opens up new possibilities for restoration design. For example, brace elements can be made much finer while retaining sufficient mechanical properties.

These new options also increase the longevity of dental product. In casting or milling, we have to deal with cost, material waste and lower material density; in casting especially, we have oversized dimensions and much lower material densities. With cast restorations, breakage is always an issue. But it doesn't have to be that way. Another benefit is the ability to create combinations through module or multicomponent construction methods. Base elements implanted into the jawbone are used as primary structures. An additively manufactured foundation element is then put into place as a secondary structure, onto which a secure, durable veneer such as HeraCeram is applied. Another aspect relates to new materials, such as non-precious metal titanium...

_Titanium would be hard and biocompatible...

Titanium is the ideal material for allergy sufferers, for example. In combination with laser melting and veneering, we can maximize its biological benefits. From a visual standpoint, titanium restorations offer a risk-free silver-gray luster. Manufacturers of non-precious metal alloys have spread pseudoscientific criticism regarding its aesthetics.

Low-dose fluoride in toothpaste or mouthwash, for example, has no impact on appearance. We can't deny the reality that titanium has not only caught up to non-precious metal alloys in importance, it has surpassed them. This is precisely why, in 2012, Unicim invested in a Mlab cusing R system for titanium applications from Concept Laser, which allows us to process reactive titanium material in a closed system. The unit can be used with dental materials certified under the German Medical Devices Act, such as rematitan CL from Dentaurum. Because of the high amount of material waste, milling-based processing of titanium is too expensive and casting is highly impractical.

_What are some of the problems that arise in the casting of titanium?

The reaction of titanium with oxygen causes a so-called alpha-case layer to form on the outside. This leads to embrittlement of the surface and

Fig. 2

Fig. 3

Fig. 2_Crowns and bridges manufactured using laser melting technology.
Fig. 3_Cast parts manufactured with LaserCUSING.

must be removed. If not removed, it can leads to problem with the adhesion of veneering. With LaserCUSING, no alpha-case layer forms. This makes laser melting with titanium powder excellent for processing. The very fine-grained microstructure of the laser-fused parts of this titanium alloy allows greater firmness than with conventional castings. The dentist receives a high-performance, long-life alternative that's easy to work on and more affordable than a precious metal solution. Finally, dentists and patients can benefit from a quality product that is both durable and natural in appearance.

_How does titanium compare in terms of price?

The price of the Dentaurum titanium powder we use is currently around 595 euros per kilogram; a 4-unit bridge weighing 4 grams thus costs EUR 2.40 in materials alone.

_Why has laser melting been so slow to catch on in the dental industry?

The reasons for this are many. The process is relatively new, so the learning curve is enormous. The fact that the quality of laser-fused products is better than conventionally manufactured dental restorations remains largely unknown. Its reputation continues to be tarnished by ignorance or misconceptions. Keep in mind, too, that dental technician training takes four years in Switzerland, and theoretical instruction is slow to incorporate new technologies. In addition, Swiss dental labs are very small.

The Association of Swiss Dental Technicians estimates some 1,200 centers, many of which operate with just 1 or 2 people. Therefore, investments in laser melting are carefully considered. Unicim, as a digital production center, acts as a service provider, supplying other laboratories. Right now I see it as more of an outsourcing topic while we wait for it to take hold in the market.

_What is the position of dentists regarding this issue?

Interest is undoubtedly growing, not least because it's impossible to ignore the technical, time-saving and affordability benefits. But we also need to look at the process chain. To prepare the data for manufacturing, the STL format is required. STL data from different scanners can be processed using the CAMbridge or AutoFab Mlab data processing software available from Concept Laser. Nowadays, conventional dental impressions form the basis for CAD data. The accuracy of the data depends on the preciseness of the work performed the dentist. Higher accuracy is essential. A high-quality intraoral scanner costs dentists today about 20,000 Swiss francs (CHF). If we had complete data migration from the dentist to the dental laboratory, we would be one step further. In the long term, however, that is unavoidable. Quality assurance and documentation needs will make open, manufacturer-independent data transfer an increasingly critical requirement. Especially in terms of affordability, the topic of laser melting is becoming more important._

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