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DIGITAL TECHNOLOGIES IN DENTAL LABORATORIES

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Abstract: *Development of new software, production technologies and materials offers new possibilities to dental technicians nowadays. More and more products can be produced in dental laboratories using digital technologies. Modeling of framework for a removable partial denture and a framework for composite veneered bridge are described in the following article. The finished digital products can be produced on different additive manufacturing machines such as 3-D printers, stereolithography or selective laser melting.*
Key words: *digital dentistry, removable partial denture, framework for composite veneering*

1. INTRODUCTION

The way of work in dental laboratories has started to change with the introduction of new digital technologies in past years. The expectations for the future are even more positive with the upcoming intraoral scanners, new technologies and materials. However a big step must be done also in our thinking to switch to all the novelties and to take all the advantages these technologies can offer. New generations of dental technicians will have a completely different way of work surrounded with PC's and high productivity machines.

2. WORKFLOW IN DENTAL LABORATORIES AND HOW CAN BE IMPROVED BY USING NEW TECHNOLOGIES

This paper was mainly written to encourage dental technicians to use new technologies such as digital work flow to facilitate and to fasten the procedures in dental laboratories. A job of a dental technician is very individual and time consuming. Since some years ago it was a completely artisan job. Most steps in the creation of a dental prosthesis were manufactured by hands using materials like plasters for models, wax and metals for casting techniques, ceramic and PMMA or composite materials for veneering and denture finishing. As in every artisan job dental technicians tried to fasten their work flow with use of prefabricates for different applications. For example wax pontics or pre modelled occlusal surfaces are available to facilitate a wax modelling for metal casting of crowns and bridges.

All this prefabricates are nowadays available in forms of databases in different dental software. Final users are not only allowed to choose between many different types of teeth all stored in their PC's database, but have the possibility to change size shape and do corrections as they are used to. Although most of technicians that use digital technologies in dental laboratories use them especially for modelling frameworks for ceramic, I would like to showcase that there is software that can be used for modelling of frameworks for removable dentures and frameworks with retention pearls for a later composite veneering with the combination of different software.

3. EXISTING SOFTWARE AND TECHNOLOGIES FOR DENTAL LABORATORIES

There are different software available for use in dental laboratories. Most of them were created for the design of substructures for a later ceramic veneering in fixed prosthetic. The final designed products were primarily intended to be milled out of non-metal materials like zircon oxide. In last years the software have evolved and offer different possibilities like full anatomical design, a reduction of a full anatomical design to a substructure for ceramic veneering, design of inlays, onlays, veneers, bars, telescopes and of course recently very popular design of substructures on implants. Of course the development of software and technology was followed by the development of new materials. Nowadays there are different materials for dental use available on the market. Especially for milling machines we can choose between PMMA, composite for provisional restorations and casting technique, different metal materials, usually chrome-cobalt and titanium alloys and a lot of non-metal materials like zircon, alumina and lithiumdisilicate for ceramic veneering or final restorations. The same digital design can be used also on additive manufacturing machines. One of the possibilities is to manufacture the object on a 3-D printer or stereolithography machine for use in casting technique. The second option is to have the object done directly of the final material. One of the technologies for this purpose is selective laser melting for metal frameworks. New composite materials for provisional prostheses are being developed also for 3-D printers and stereolithography.

4. DIGITAL REALIZATION OF FRAMEWORKS FOR REMOVABLE DENTURES AND COMPOSITE VENEERED BRIDGES

In first step I'll try to basically explain how to use the FreeForm software to design a framework for a removable denture. In the second step I'll show the result in modelling of a framework with pearl retentions for composite veneering. This kind of products are very common in daily practice in dental laboratories but are still done manually because there are only few software that allow such design capabilities and the production is only possible with an additive technology.

Plaster models of patient's mouth are used in a standard working procedure for the modelling of a framework for a removable denture in dental laboratories. All the undercuts in the insertion direction of the denture are fixed with wax and additional wax plates are positioned in areas where space for resin under the framework on the gingival area is needed. After this preparation step, the plaster model is dubbed with silicone or gelatine and a second model is made of investment material. On the second model the frame for the removable denture is modelled with wax and everything is once again covered by investment material in preparation to be casted.

Similar steps were used in the digital work flow for the modelling of a frame for a removable denture but with some advantages and time savings. The first step was the digitalization of the plaster model with a 3-D scanner. The software allows controlling the undercut areas in real time, thus allowing repositioning the model to obtain a desired insertion direction for the framework. The areas for additional resin space under the framework could be painted or defined with lines on the model and an offset of a desired thickness is obtained with just few mouse clicks. The complete model was translated along the insertion direction. With this procedure all the undercuts were fixed allowing an easy insertion of the framework. By doing so a second model was obtained, like the one made of investment material, but working on digital models offers additional advantages like measuring the undercuts between the two models, to define the areas with the desired undercut for retention clasps. The shape of the framework and retention areas is defined by lines on the second model and offset with the desired thickness. After the design is finalized the framework is simply removed from the model. The result of a digitally designed framework for a removable denture is shown in fig. 1.

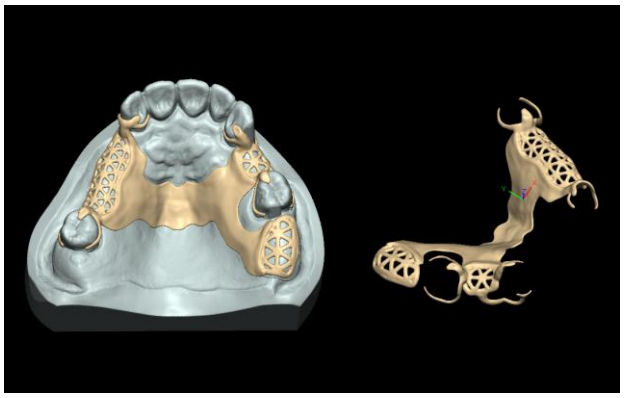

Fig. 1. Framework removable denture, design Renato Makovec

The second digital product is a framework for veneering with composite materials. It was modelled using a combination of dental and professional software. After the scanning of the plaster model 3shape's dental designer was used to define the teeth preparation lines and to design a bridge frame as it is usually done for ceramic. The frame was exported as stl file and imported in Sensable's FreeForm modelling plus software. For the tooth shape I used PoliDent's Primodent stl files because I had the possibility of working in the creation of the database, but also databases included with the 3shape's software would work fine. While keeping the internal part of the crowns untouched many changes were done on the outside of the framework. The bucal surfaces were carved to make room for composite material. This can be done really exact especially on the pontics because the internal material can be removed by offsetting it and the result is the same thickness of the wall all over the pontic that can be never achieved with manual wax modelling. The creation of the retention bar and retention pearls is really a piece of cake when using the free form's haptic device with the sense of touch especially for dental technicians with good manual skills. The finished result of the bridge framework is shown in fig. 2.

5. USE OF ADDITIVE MANUFACTURING TECHNOLOGIES

In both cases the finished products were made using digital work flow eliminating some time consuming steps such as dubbing of the plaster model with silicone and creation of a new one with investment material in the first case and saving time on modelling by using teeth out of a database in the second case. Both products have a high grade of design complexity and therefore can be produced only with additive manufacturing machines. There are some bigger dental laboratories especially in the united states that make use of Sensable's software to design frameworks for removable dentures. The products are than produced with 3-D printers or stereolithography machines and are casted in metal.

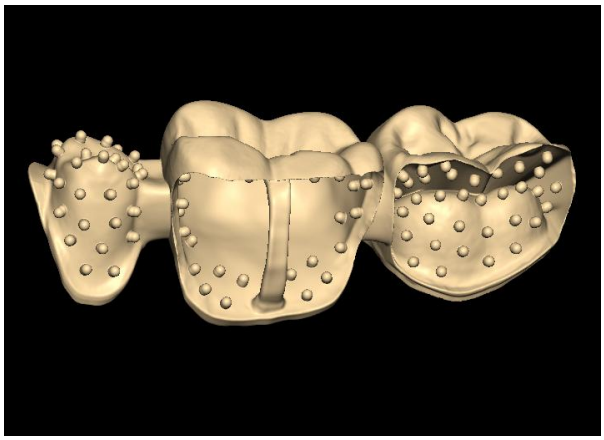

Fig. 2. Bridge framework, design Renato Makovec

Personally I don't know anyone modelling bridge frameworks for composite veneering in a digital way. The framework was printed on a 3-D Solidscape's dental printer and the fitting on the model is really OK. Other technologies like stereolithography or selective laser melting could be used for the production of the framework. With the last mentioned technology steps of investing and casting are eliminated. The digital design and 3-D printing allowed rational use of metal because of thinner surfaces that could be achieved with use of this technologies. This is useful especially when frameworks are casted with expensive metals.

6. HOW CAN DIGITAL TECHNOLOGIES CHANGE THE WORKFLOW

As mentioned in introduction note there are big expectations from final users to facilitate their workflow with the use of new technologies. Latest versions of dental design software has introduced the possibility to import a prepreparation scan and aligned it over the preparation scan. Hopefully there will be an option to automatically fit the restoration in the preprepared scan in the near future. This would be especially useful in combination with intraoral scanners where the initial information of the before preparation could be kept till the end of the restoration and the restoration could really be an exact copy of patients teeth. The development of new composite materials for 3-D printers like Nanocure presented by EnvisionTEC will open new fields in digital dentistry, and hopefully it will be supported with software that will allow multiple layers design for multicolour restorations. I bet we will be able to see frameworks for removable partial dentures with smooth surfaces produced on selective laser melting machines and hopefully sintered non-metal structures in the near future.

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