Creating 3D printed denture frameworks that fit

By Frieder Galura

"Dentaurum Power Liquid is the key to success using the CAD Cast technique for cast partials... apart from a fine-grained investment material..."

When casting partial frameworks based on digitally produced designs created using 3D printing or milled out of resin or wax blanks, the main problem for many labs is the unsatisfying fit of the final denture. Normally, the framework is virtually designed on the scanned master model in a 1:1 ratio, however, the casting contraction is not taken into account in this processing step.

When working conventionally, the wax-up is made on a refractory model, which is already oversized due to the setting expansion of the investment material (By the way, you'll have the same problem when working with light curing waxes).

When working digitally, the CoCr casting contraction of 2.2% can either be compensated for by scaling the design in the software or by using an investment material with a higher rate of thermal expansion.

For this article, we will cast a series of 3D printed partial frameworks to develop experience on the "expansion" effect.

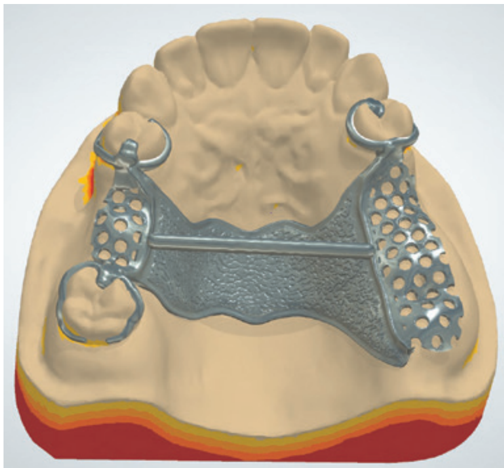

Figure 1. Screenshot of cast partial upper jaw.

The workflow

To begin, an upper jaw model Kennedy class 2 was scanned and the framework designed using 3Shape software. The framework design was stabilised with a transverse rod (diameter 2.5mm) (Figure 1). The STL data was then sent for 3D printing (Figure 2).

Figure 2. The 3D printed resin frameworks.

Figure 3. The fit of the resin framework.

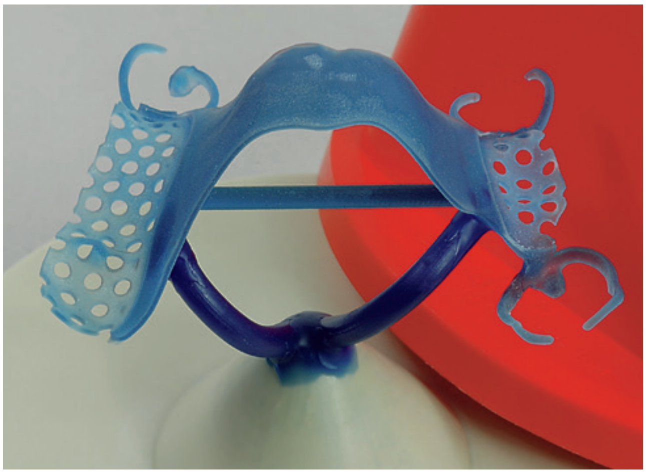

Figure 4. The resin framework on the ring base.

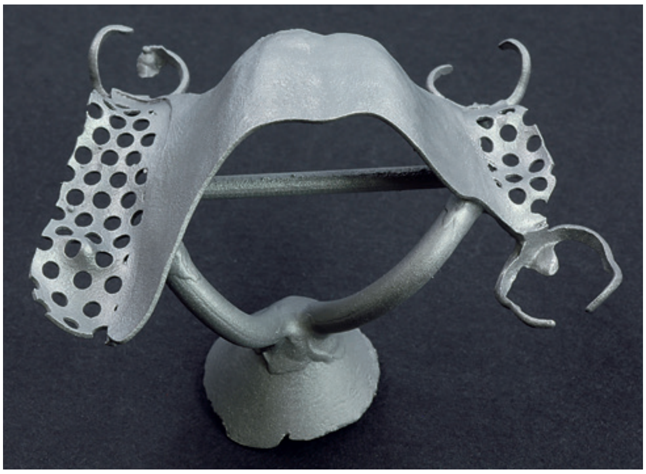

Figure 5. The cast.

Figure 6. A tight fit.

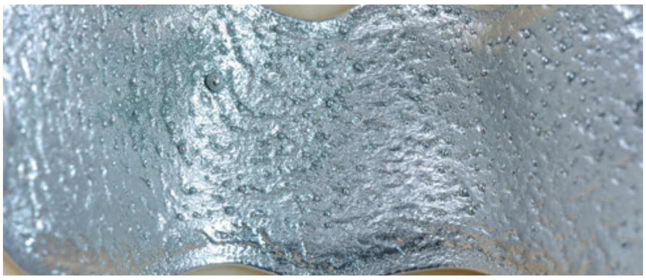

Figure 7. Micro-bubbles present on the stippled side.

Figure 8. The casting result.

The manufacturer recommended the immediate investing of 3D printed frameworks after the removal of the wax support to avoid deformations. After 3D printing, the fit of the framework was OK (Figure 3). The resin frameworks were horizontally waxed on the funnel former of the base (Figure 4) with two sprues (diameter 3.5mm).

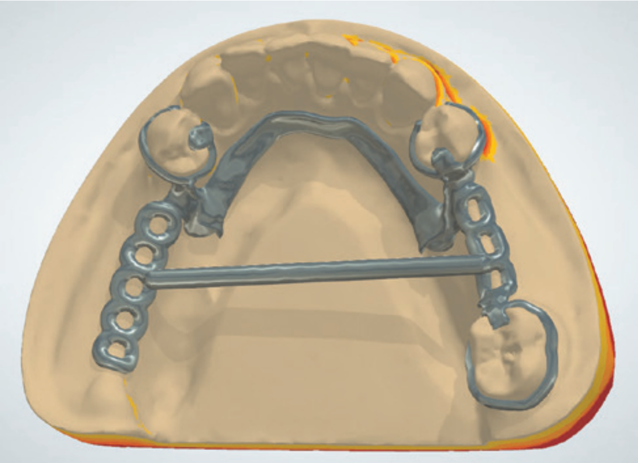

Figure 9. Screenshot of the lower jaw design.

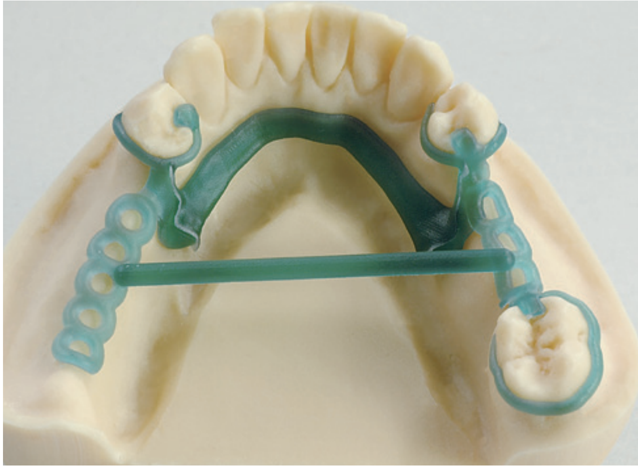

Figure 10. 3D printed sublingual bar.

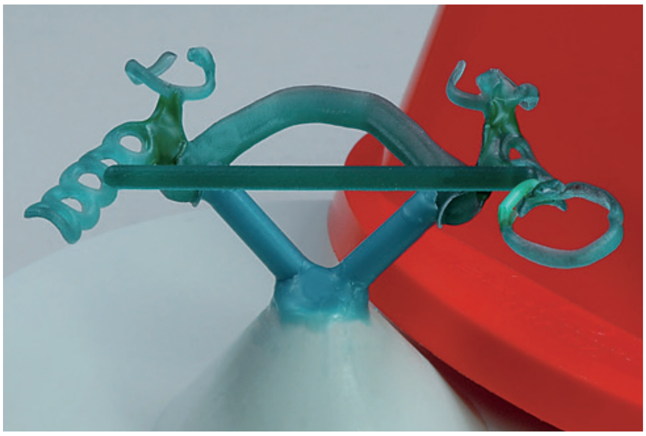

Figure 11. The lower jaw framework on the plastic base.

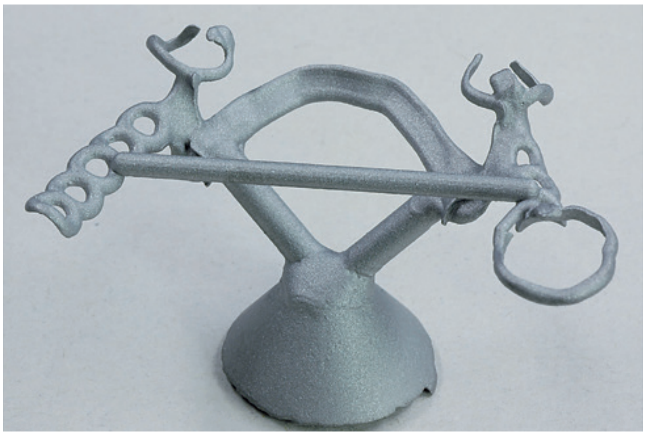

Figure 12. The cast sublingual bar.

Figure 13. The fit of the sublingual bar.

For the first casting series, the 3D printed frameworks were invested with Dentaurum investment material for cast partials such as rema® dynamic S, rema Exakt and rema Exakt F and cast with a cast partial denture alloy such as remanium® GM 800+. The surfaces of all the casting objects were very smooth (Figure 5).

As expected, the casting results were much too tight, as can be seen by the mismatch of the separated clasp at premolar 24 (Figure 6). Also, the stippled side of the cast partial was covered with lots of micro-bubbles (Figure 7). This can be avoided by setting the investment for the ring under pressure with max. 1 bar.

A better fit was achieved in combination with "Power Liquid" (Dentaurum) in a concentration of 70-90% (Figure 8).

Further casting tests followed with printed sublingual bars in the lower jaw starting with the design (Figure 9). After the fabrication by a 3D printing process (Figure 10), the framework was provided with sprues and positioned on the plastic base (Figure 11). Figure 12 shows the sublingual bar with a smooth surface after the cast. The fit was very good by using Dentaurum Power Liquid in a concentration of 80% (Figure 13).

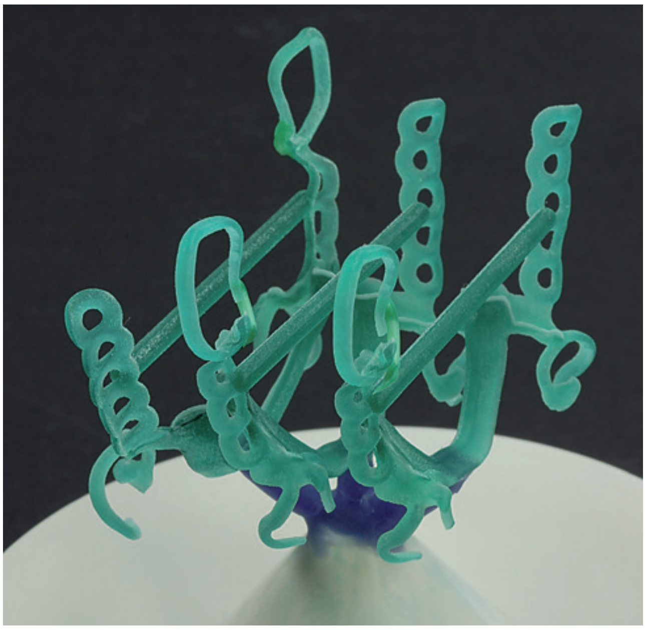

Figure 14. Test casts with several frameworks.

Figure 15. Casting objects with casting flashes.

Casting several frameworks inside one ring

Test casts were made with several frameworks inside one muffle. Three printed sublingual bars were invested (Figure 14). Due to the vertical positioning of the framework structures, only a very short sprue (diameter 4mm) could be attached in the middle of the sublingual bar. When working with several upper jaw constructions, a technically useful supply with sprues would be difficult.

In spite of a very thin layer of investment material on top of the invested frameworks, the total height of the ring was very high and would not fit inside most casting machines. It was conventionally pre-heated with a holding stage at 250°C and a heat rate of 5°C/min. The final temperature was 950°C/holding time 60 minutes.

The investment ring didn't show any external crack after the preheating. The devesting of the cast - especially the sandblasting - was of high effort. In the case of a complex sprue system, it would be difficult to cut off the sprues before sandblasting without risk of damage to the casting object.

Despite a slow preheating process, one could find some casting flashes after devesting because the investment mould had been cracked inside (Figure 15). Though the casting objects had been provided with only one sprue in the middle of the sublingual bar, the casts had no porosities in this space, but there were pits at the attached reinforcement bars. The surface was smooth.

For test purposes, a sublingual bar and an upper jaw plate had been invested with Power Liquid in a concentration of 80% for a "reduced speed-preheating". The muffle was put in the furnace after 20 minutes at 600°C. The investment material was totally unstable. Thus, a casting of several 3D printed frameworks can't be recommended. Due to the risk of cracking, it is advised not to make a speed-preheating in combination with Dentaurum Power Liquid.

Conclusion

Dentaurum Power Liquid is the key to success using the CAD Cast technique for cast partials, apart from a fine-grained investment material such as rema® dynamic S, which is also easy to devest.

When casting 3D printed resin frameworks, the following hints are recommendable:

- Use Dentaurum Power-Liquid for a higher thermal expansion;
- Invest under pressure (max. 1bar) for the avoidance of micro-bubbles;
- Heat rate 5°C/min;
- Holding time at 250°C/60minl;
- Invest exclusively single frameworks; and
- Don't use speed-preheating.

Prospects

The CAD/Cast technology is an alternative for the conventional cast partial fabrication. It would be preferable if the software producers offered a design program that would immediately show a digital pattern after the job order planning which at best should be corrected.

About the author

Frieder Galura trained as a dental technician in the Heidelberg University Dental Clinic. On completing his training in 1978, he worked in all areas of dental technicians in commercial dental laboratories. Since 2002, he has worked for Dentaurum as a dental technician in the prosthetic applications laboratory. He has been published in Germany, France, Spain, Italy, Japan and Australia on subjects including still life photography, ceramic gingiva, bolt technology and implant symposia.