Adjusted occlusal splints made by 3D printing

A report by Dr. Michael Leckel (consultant dentist), Ali Ilani and Theo Grimm (dental technicians), Heidelberg

Occlusally adjusted splints are non-invasive and reversible therapeutic adjuncts that are an integral part of the clinical management of temporomandibular dysfunction.

Producing these splints in the laboratory has always been associated with different levels of technical sophistication. The simplest method consisted of thermoforming thermoplastic films (possibly with the additional application of autopolymerizing resin to obtain an adjusted occlusal surface). A more elaborate approach to splint production – which provided the added stability so beneficial for bruxism patients – was the spray-on technique, similar to the fabrication of orthodontic appliances.

The spread of CAD/CAM technology has provided two additional options. Both these options begin with an on-screen splint design step (Fig. 1). In the following step, the object is either milled from a PMMA block or additively produced in a 3D printer.

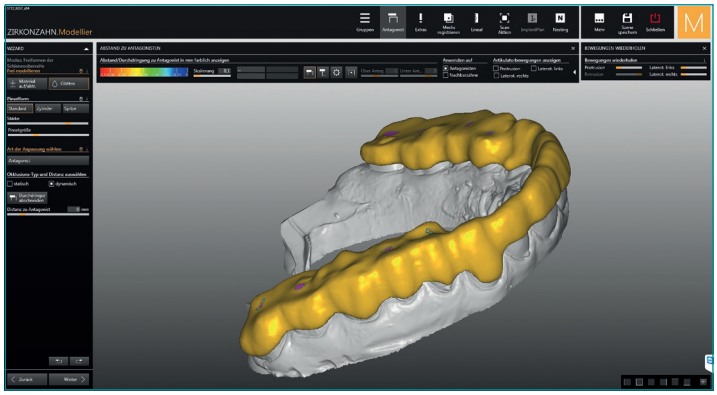

Fig. 1 On-screen splint design.

The present article will primarily address 3D-printed splints, but add a few concluding remarks about milled splints in terms of efficiency and other economic aspects of their production.

To fully leverage the benefits of the high precision associated with a CAD/CAM-based process, exact procedures are advocated already during the various clinical stages of treatment. This would include, for example, the use of silicone- or polyethylether-based precision impression materials, taking a centric relation record as close as possible to the intended thickness of the splint, and the use of a facebow if minor adjustments to edge-to-edge relations in the articulator are required. Experience has shown that this will shorten the time required for intraoral adjustments of the occlusal splint this obtained.

Once the casts have been are articulated, the situation is scanned according to the specifics of the scanning system used, followed by the on-screen splint design. Whether or not any supplementary modules are required for designing splints or fabricating casts will depend on the make and model of the scanner and CAD/CAM system, but these models are usually already present on the system, so no additional software has to be procured. The completed files will generally be saved in the widely used .stl format, avoiding conversion problems.

The design of a printed splint is in many respects similar to the design of a milled splint. The values for all relevant parameters, such as seating and splint dimensions, must be matched to the printing material and the 3D printer itself.

Depending on the manufacturer and the size of the printer, a varying number of splints can be printed concurrently. The Freeform PRO 75 UV by ASIGA (Sydney, Australia), for example, can used to produce seven splints at once. Each splint is printed in 50-μm increments. If a reduction of the printing time is desired while still obtaining a decent surface quality, 75-mm increments can be selected (Fig. 2).

An economic approach is to design the splints during the day and print them overnight, facilitating speedy delivery in cases where splint therapy becomes necessary on short notice, such as in acute TMD distress.

Fig. 2 Splints in the 3D printer.

The splint material is the transparent clear Freeprint® ortho UV by DETAX (Ettlingen, Germany), which has been approved as a class IIa medical device for the manufacture of drilling and x-ray templates as well as occlusal splints.

After printing, the splints are removed from the carrier plate and cleaned twice for three minutes in an ultrasonic cleaner filled with pure isopropanol. The pre-defined time for the preliminary and main cleaning cycles must not be exceeded (Fig. 3).

The supporting structures are separated and light-cured to final hardness using the Otoflash G171 xenon flash-curing device by NK-Optik (Baierbrunn, Germany) (Fig. 4). This requires 2 × 2,000 flashes of light while rotating the object in an protective atmosphere (nitrogen 5.0). This is a crucial step to ensure biocompatibility and to avoid the formation of an inhibition layer on the splint's surface.

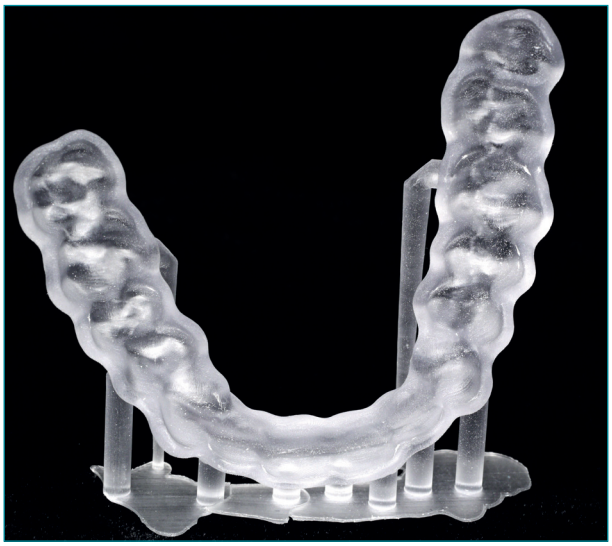

Fig. 3 Cleaned splint on a carrier plate.

The workpiece can now be returned to the cast. Given adequate experience in splint design and a proper fabrication approach, minimal – if any – finishing will be required. If the clinical procedure that resulted in the working materials and documents was performed diligently, the effort required to adjust the static and dynamic occlusion will be equally minimal.

Fig. 4 Otoflash G171 xenon flash-curing device.

The finished splint will have to be polished to a high luster in a conventional manner, using pumice powder (Fig. 5).

Any corrections requiring the application of additional material after delivery are performed using the light-curing transparent FreeForm® plast/fixgel resin (also by DETAX).

Some remarks on the economy and efficiency of the two approaches to computerized splint fabrication will be in order at this point. Our experience so far has been that there are no perceptible differences in terms of fit and, consequently, in terms of the time required at delivery.

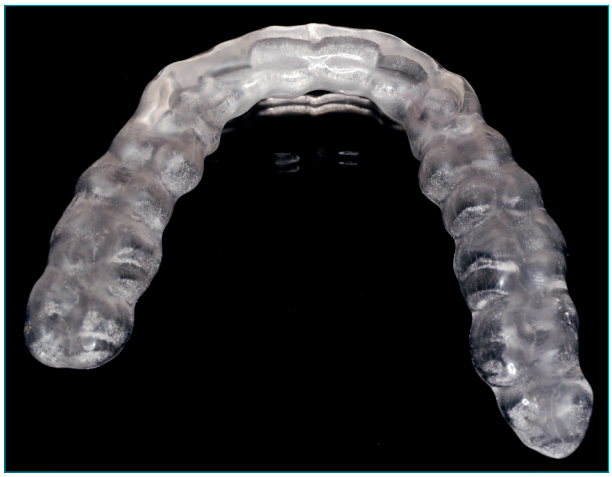

Fig. 5 Splint polished to a high luster.

A key issue, however, could be the materials' properties, for which adequate long-term evidence is still unavailable. While one type of splint is milled from a homogeneous block of material (subtractive procedure), the other type is built up layer by layer from a resin solution (additive procedure). To what extent this might influence any relevant properties of the material from which the splint is made, such as fracture behavior or long-term abrasion stability, remains to be determined by laboratory testing and clinical trials.

The scanning of the cast and the design and finishing process require about an hour of laboratory time for either approach.

Whichever of the two modes of fabrication is given preference, each represents significant progress in terms of system precision and material quality compared to conventional production methods – where keeping undesirable dimensional changes at the polymerization stage or the effects of material inhomogeneities at bay has always invariably required enormous skills and experience on the part of the dental technician.

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Devices used

ASIGA Freeform PRO 75 UV
NK Optik Otoflash G 171

Materials used

DETAX Freeprint® ortho UV
DETAX Freeform® plast / fixgel

In economic terms, the differences are more evident:

Milling:

- Each splint requires a resin blank (approximately 165 g, depending on the size), so the majority of the material goes to cutting waste
- Only one splint can be milled at a time

Printing:

- Low actual material consumption (about 10 g per splint), so the cost of the material amounts to less than €5 per workpiece
- Up to seven splints can be printed concurrently

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