Are printed occlusal splints worth your time?

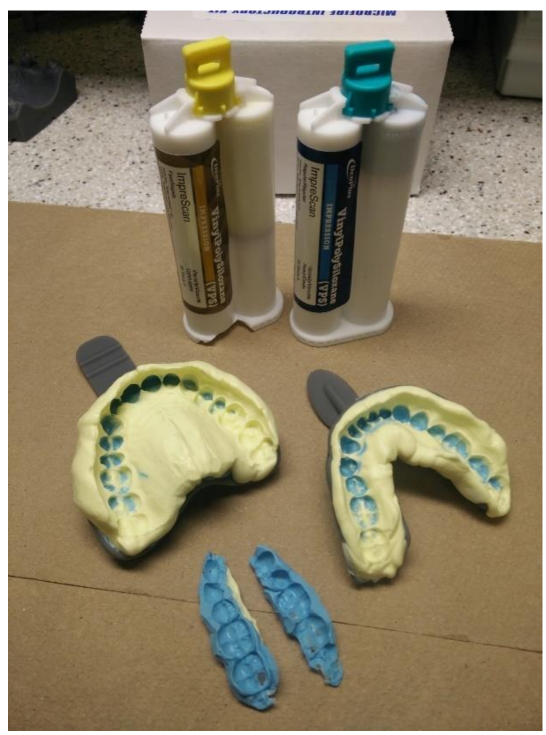
A step-by-step overview of the design and fabrication process By André Gaul, D.T.

While biocompatible 3D printable resins have been available in Europe for some time now, they are only slowly becoming legal for sale on this side of the Globe. One such product is **KeySplint Soft™** by Keystone Industries, which is intended for the manufacture of thermo flexible occlusal splints and nightguards. Since then, many of my fellow colleagues and clients are wondering if the end product is comparable to a traditionally made splint. I could take the manufacturer at its word and say "yes", but I like to see for myself and so does my employer. Since I have access to the product and equipment needed, I decided to give it a go and share my results. With myself as the test subject, I went ahead and made an occlusal splint, using the following tools and material: **Shining 3D's DS-EX** desktop scanners, **Flashforge's Hunter** DLP 3D printer, **Exocad's DentalCAD** software and **Splint module**, and for the printable material, the aforementioned **KeyPrint KeySplint Soft™** by **Keystone Industries.** What follows is an overview of the whole process, culminating in a finished product and my verdict.

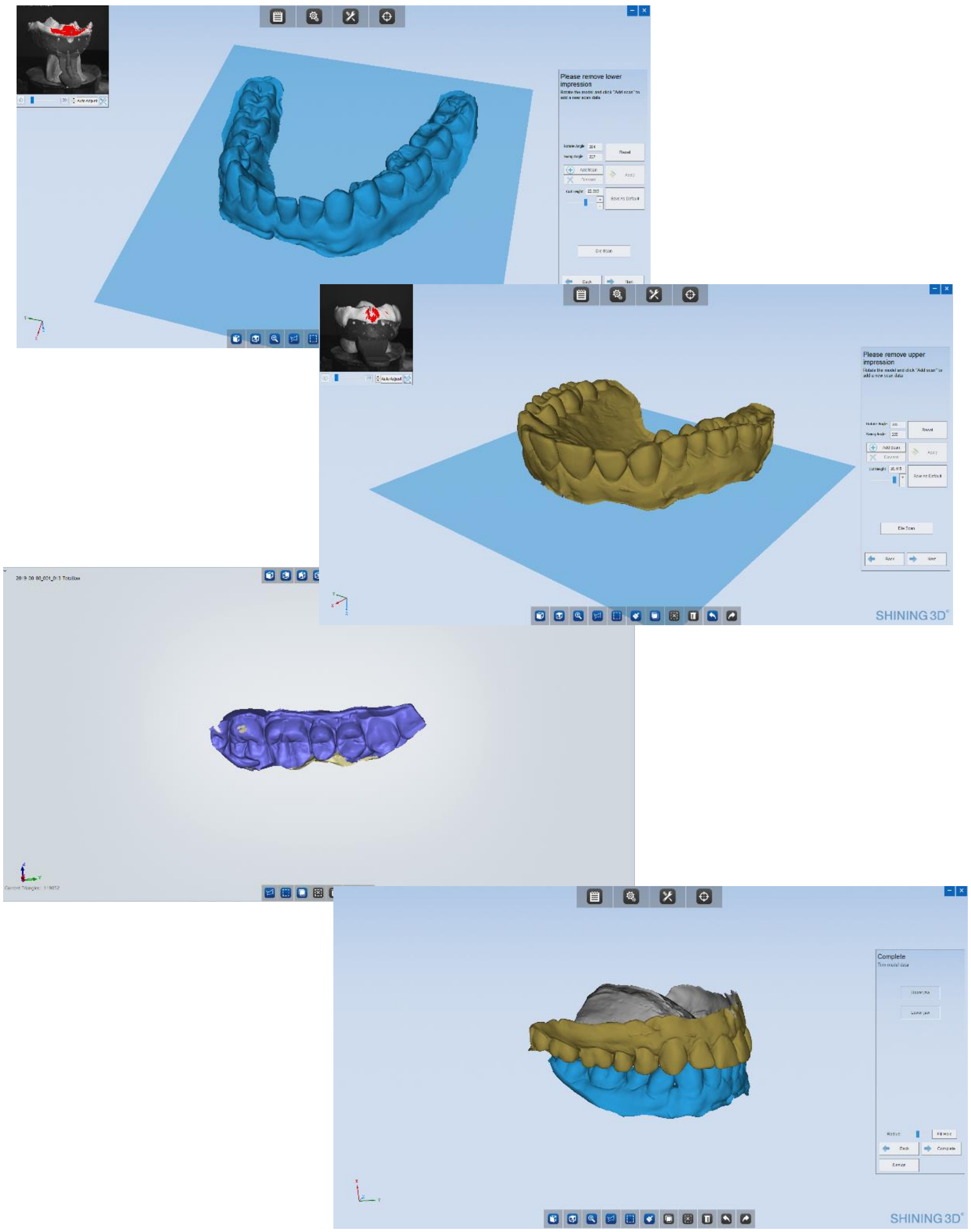
I began by taking my upper and lower impressions along with a bite registration using **Imprescan**, a scannable VPS impression material by **DenPlus Inc**.

I didn't manage to get my 3rd molars in there so the splint will end at the distal of the 2nd molars, no biggie.

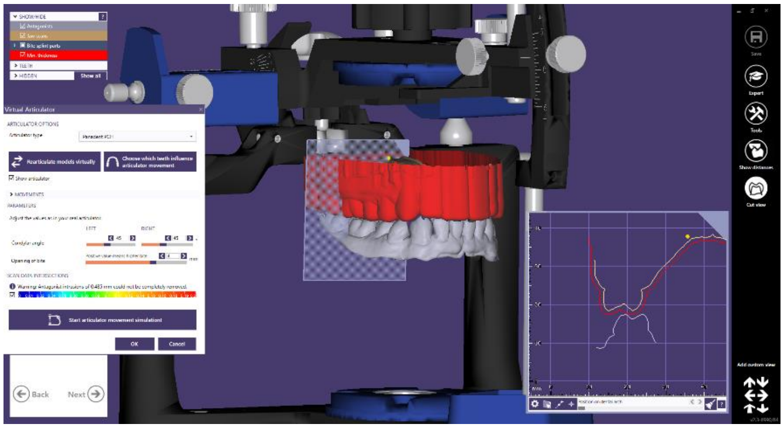
From there, we could either go straight to scanning or pour the models in stone and scan them, on or off an articulator. In the latter case, the models could be set in static occlusion or with the splint gap pre-set with the incisal needle, the **DS-EX** scanner can handle both. I opted to scan the impressions and bite record since my goal is to test the complete digital approach. I still intended to pour models in dental stone, but only to see the difference in the fit of the splint between stone models and printed models.

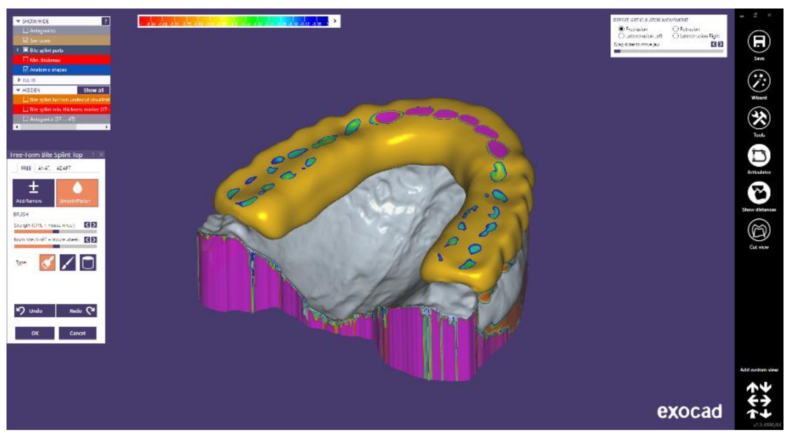


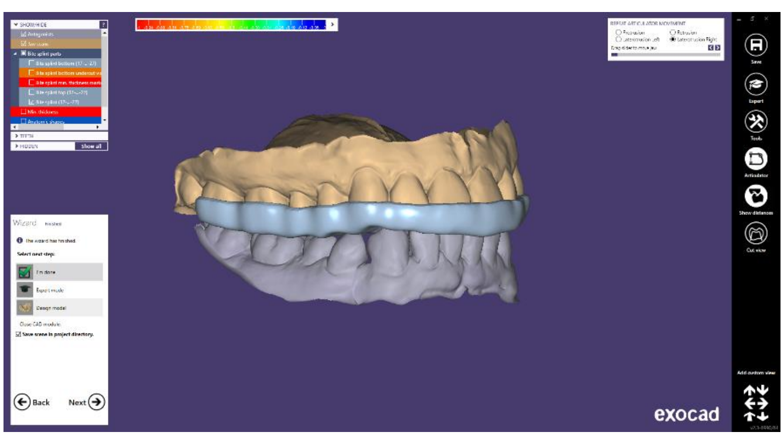
The scanning workflow for two impressions and a bite record is straight forward with the **DS-EX**'s **Clinic Mode**. It essentially consists of scanning all three in a row and ends with the software performing the automatic alignments of both impression scans with the bite record scan, resulting in both models in occlusion.



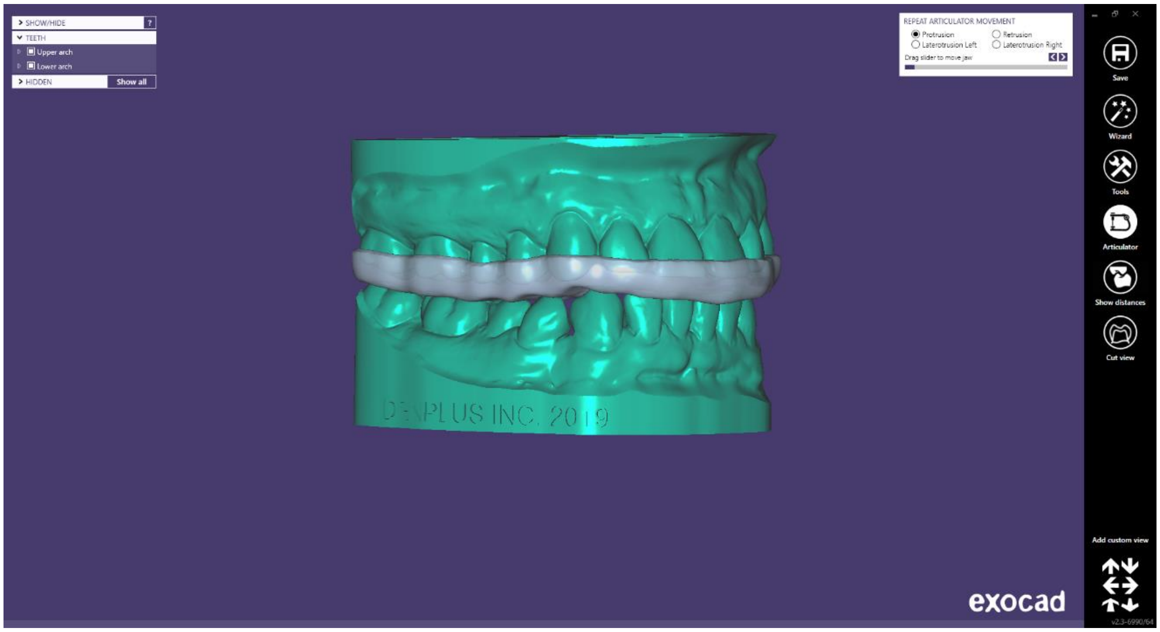
To design the splint, I used **Exocad's Splint** and **Virtual Articulator** modules. The latter allows to mount the case on a virtual articulator of your choice, in this case, a Panadent PCH, and perform the jaw movements to insure the prescribed guidance.



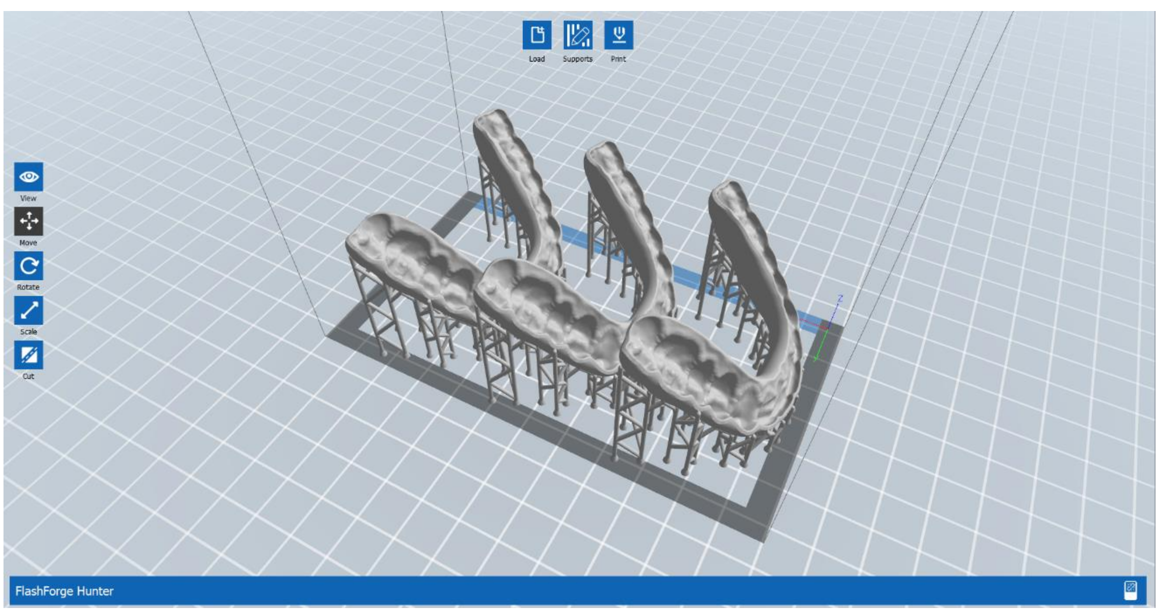




Once I completed the design, I went straight into **Exocad Model Creator** to build my models.



Next, I imported the splint file from the **Hunter**'s preparation or "slicing" software, **FlashDLPrint**, a simple yet powerful tool, included with the 3D printer. Because I wanted to test the printer's accuracy across its entire print surface, I laid out three splints.



At 100um layer thickness, this layout took 1 hours and 20 minutes to print, using the Hunter's Fast mode. Yes, the Hunter can print at 50um or 25um layer thickness, but for a splint, there's no real need for that since there isn't any fine detail. Reducing the layer thickness in this case would only double or quadruple the printing time. You may argue that the layer lines will be more visible and that the part will be less accurate. It is true that the layer junctions are more visible, but you need to be looking at it from extremely close to see them, and, keep in mind that, in the end, the splints are polished to a shine, effectively eliminating those lines. As for accuracy, a layer thickness of 100um should not adversely affect the printed splint’s fidelity to the digital design.

Below, our successful prints, still attached to the build plate. Everything looked good so far.

In case you’re wondering, each of these splints is worth around 5.10$can in resin.

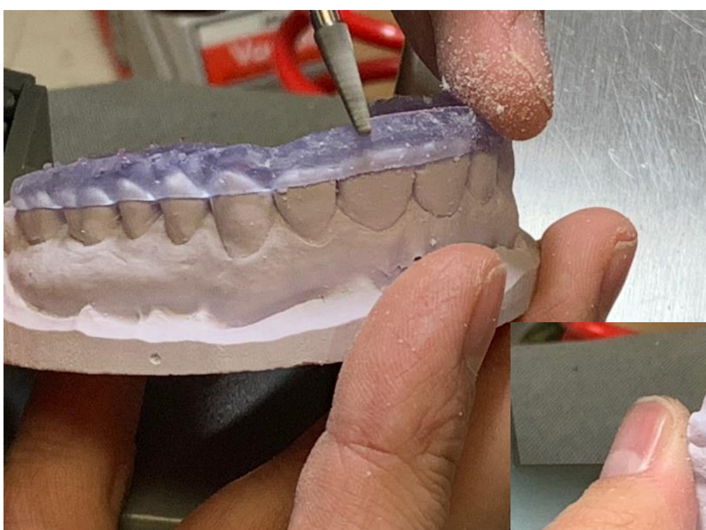
Below are the printed models. Normally, I would print models like these flat on the plate but, apparently, I have a big mouth and I couldn't fit them both in a flat position, so I angled them slightly. These models were printed hollow with a shell thickness of 2mm, and together amount to roughly 6.00$can in resin.

To test the difference in the adaptation, I also poured a set of models in dental stone. My initial prediction was that, since 3D printable resin shrinks a bit and dental stone expands, the splint would fit snuggly in my mouth, fit perfectly on the printed model and fit too tightly on the stone model. Was I right? We'll find out soon enough.

Next up was removing the parts from the plate, cleaning them in 99% isopropyl alcohol and post-curing them. The post-curing step is particularly critical for medical devices to ensure that any residual monomer is eliminated. In addition, the splints were submerged in glycerine during the post-curing. The reason behind this is that the curing of this type of resin is inhibited by oxygen. The glycerine acts as a barrier which allows the surface of the parts to fully cure under the U.V. light. If you've ever worked with polyester resin, commonly known as "fiberglass resin" you're probably familiar with this phenomenon. There are other, fancier curing chambers that employ a nitrogen blanket, but glycerine worked fine.

I used the **Eurolight UV LED curing unit**. Its tray is large enough to accommodate many parts at once, but since I only had a small container for the glycerine, I cured them one at a time. I also followed **Keystone Industries**’ post-curing recommendations.

With the splints fully cured, it was time to burr away the scaffold leftovers. To make them more visible, I rubbed some occlusion tape over the surface. As you can tell from the images below, I used the stone model that I poured up as a support base and, low and behold, the fit was great and not overly tight like I had predicted.



There was, however, a very minor give over the 2nd molars, on both sides, and on all three of the splints. This was easily rectified by submerging the splint in hot water for a minute to soften it a bit, placing it back on the model and holding it for a few seconds while it cooled down.

Now to check the contact points. For this task, I used the printed models. How was the fit you ask? Drum roll…like a glove! One thing to point out here is that, since I used a static articulator to join the models (the plastic disposable kind), and that my bite registration didn't have the 2 mm gap between the 2nd molars, I had to put the models in occlusion WITH the splint in place BEFORE locking the ball and socket joints with glue. Otherwise, if I did it the other way around, the mandible was slightly off from its correct relation to the splint. Not a big deal really since the models at this stage are only used for final checks. If this is of concern, rest assured that you can mount 3D printed models on a full articulator, if you prefer.

In all honesty, I was quite amazed at how little work was needed here, most of which I could attribute to my lack of experience in digital splint design. I reduced some of the stronger contact points, softened some of the contours I didn't like in my design and the splint was ready for polishing. Any tech that gets to do this daily would figure out how to knock them out much quicker.

The **KeySplint Soft™** printing material is polished the same way as acrylic resin: With pumice, polishing compound and a bit of elbow grease, but since the print surface was smooth to begin with, I expected the polishing to be quick and easy. Oh, and I should point out that despite being called “Soft”, this material is quite dense. I would say it is similar to **Impak™** resin.

Alright, I have a confession to make. By this time, I had already tried out the splints in my mouth. What can I say, my curiosity had gotten the better of me. But let's pretend that this case didn't need to go out until the following week, so I let the splints sit for four days, just to see if any dimensional changes would occur.

Four days later and the moment of truth had arrived. The fit did feel a bit tighter in the mouth than the first time I tried them, but, after softening in hot water, placing back in and biting down, the fit was once again nice and snug. It has now been an additional five days since doing this exercise and the splints fit just as well.

My final verdict: The digital approach to occlusal splints works! Like any new technique, there is a learning curve to overcome. If you're already doing crown and bridge work in CAD, this would be a cake walk. For those who have never worked in the virtual 3D environment, it does take some getting used to, but having mastered the traditional techniques means you've certainly seen worse!