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3D printing

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case report
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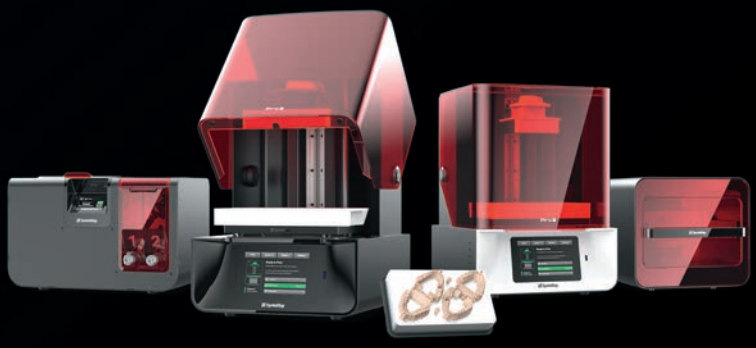

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Dr George Freedman

Editor-in-chief

It is time to embrace the future

This year brings new promise and fresh hope. The world has passed through the dark clouds of pandemic and uncertainty; the bright future beckons. We have lost much: family, friends, time, opportunity and, most of all, confidence. Whereas we were once certain that our established knowledge, techniques and experience could deal with anything that might be thrown at us, we have clearly seen that achieving survival and future success typically involves radically disruptive concepts and indirect approaches.

From a historical perspective, the dental profession experiences a major directional shift every 20 years or so, roughly once in a generation. In the 1960s, the high-speed handpiece mainstreamed dental access by leveraging productivity. In the 1980s, bonding and composite materials awakened the public interest in appearance, and cosmetic/aesthetic dentistry made dental care desirable and popular. The 2000s ushered in the routine delivery of implants and implant-borne restorations, providing full function and form to those who had no teeth to restore.

The 2020s herald the advent of chairside 3D-printed dental rehabilitation, under the continuous and comprehensive management of the dental practitioner, encompassing virtually every dental treatment and material. The wide range of clinical 3D-printing applications is most often grouped according to treatment category:

– *Fixed prosthodontics:* permanent and provisional indirect restorations (crowns, onlays, inlays, bridges)
– *Removable prosthodontics:* complete and partial dentures that incorporate digital occlusal design
– *Restorative dentistry:* direct custom monobloc restorations
– *Implant dentistry:* surgical guides to facilitate ideal implant positioning and biomimetic bone segments that accurately replace missing segments, minimising stress transfer to the remaining tissue
– *Orthodontics:* aligners
– *Maxillofacial surgery:* custom-designed bone grafts
– *Periodontics:* 3D-printed guides that relieve and retract gingival margins.

It is reasonable to forecast that the 3D-printing dental revolution will be significantly more transformative than the other paradigm shifts of the past century; each of the earlier developments affected a small portion of existing procedures or initiated innovative new ones. Additive 3D dentistry affects and enhances every dental procedure. In fact, we can envision that in the very near future, the standard direct restoration will be printed extra-orally and then bonded on to the prepared tooth rather than being inserted *in situ* by relatively unpredictable layering. 3D printing is typically a same-day service, eliminating patient waiting time and laboratory transportation costs.

3D printers are high quality, high precision, accurate and significantly lower in cost than conventional treatment options, readily affordable for the single practitioner. That in itself will drive their mainstream adoption by the profession. The vast potential of dental 3D printing provides the impetus for its key role in dentistry's coming paradigm shift.

3D printing embraces the future of dentistry, the future of our practices and the best for our patients.

Dr George Freedman
Editor-in-chief

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Cover image shows
UltraCraft A3D printer.
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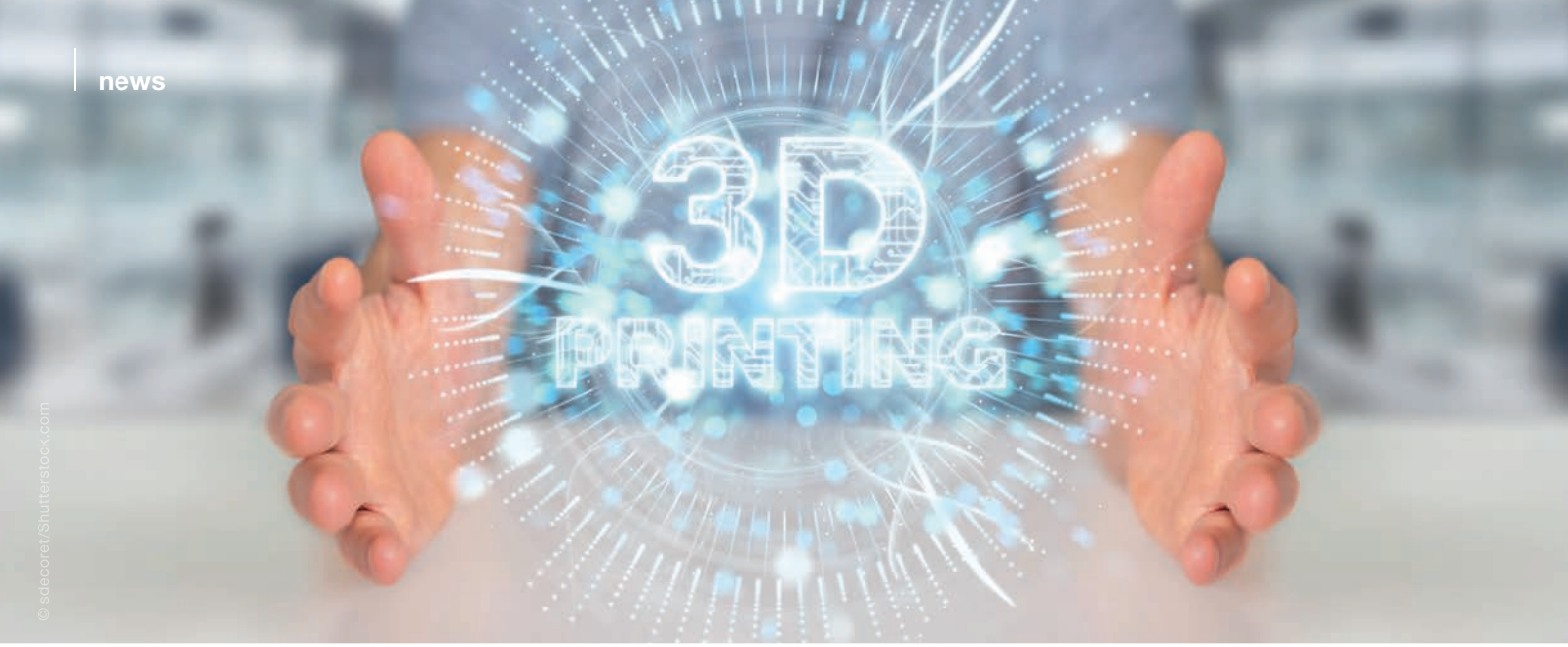

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3D-printing start-up promises 100-fold reduction in print times

By Anisha Hall Hoppe, Dental Tribune International

After raising an astounding US$1.3 million (€1.24 million) in a seed funding round, Vitro3D will take its place as a commercial rival in the increasingly competitive 3D-printing market. A start-up grown out of the University of Colorado Boulder and the Colorado Life Sciences Incubation Program, Vitro3D offers revolutionary improvements to traditional 3D printing and claims to be able to 3D-print pieces up to 100 times faster than is done using existing methods.

Should the company be able to make good on its claims, its process would take additive manufacturing to a whole new level, making the current printing speed of nearly every other 3D-printing solution on the market virtually obsolete. By utilising a cartridge-based design, there is no resin handling involved. The company also states that the goal is to design parts that require far less post-processing than is currently necessary in production, and this applies to the printing of dental aligners as well as the scaffolds used in tissue engineering.

Though these seem to be lofty goals, if Vitro3D is successful in expanding the current capabilities of volumetric printing, the entire dental 3D-printing market would be turned on its head. The plan is to continue to tackle both speed and detail to ensure accuracy is always maintained. Doing so would mean production times across a number of industries would be reduced.

Dr Camila Uzcategui, CEO of Vitro3D, attributes the company's proprietary volumetric 3D-printing technology to specific algorithms, carefully designed hardware and material science knowledge. She says that, because the company is now funded, it can "demonstrate the power of [its] revolutionary 3D-printing technology, which offers the potential to change the way complex structures, including intricate custom medical products, are manufactured".

Currently, methods such as digital light processing and stereolithography are at the forefront of dental 3D printing, but Vitro3D promises that its new technology will be even faster. Volumetric printing is completed incredibly rapidly because the printed object is not built layer upon layer. Instead, the printer uses images projected from various angles to solidify the object within a liquid suspension. The entire printed object is essentially formed all at the same time. Because the object is created by the intersection of lasers, it does not require the supports that are traditionally needed in 3D printing, and the resulting surface can be much smoother and the accuracy even better. Additionally, it saves a significant amount of time in post-processing. The separate machines and products dedicated to post-processing make up a large portion of revenue for most 3D printer companies. However, as other firms are already able to produce millions of aligners with cheap materials, it might take a considerable time for even the fastest technology to take hold, given potentially higher costs related to transitioning methodology, equipment and materials.

Vitro3D promises print times of under 1 minute owing to precisely controlled structure and mechanics, which also results in less waste. Only time will tell whether this latest entry into the field will prove able to compete against the currently dominating companies such as Align Technology, which, from 2021, has produced over 700,000 clear aligners per day. Vitro3D has also not specified whether it intends to be a centralised producer of aligners like Align or offer printing solutions for laboratories or offices.

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Dental students in Thailand have rated customised 3D-printed teeth as being more helpful in the learning process and preclinical training than extracted or typodont teeth.

Study shows 3D-printed teeth customised with deep caries are a good alternative for student training

By Anisha Hall Hoppe, Dental Tribune International

For teaching students the selective caries removal (SCR) technique, many dental schools rely on extracted teeth, but often the damage caused by caries is too extensive to provide any instructional value. Employing advances in additive manufacturing, researchers in Thailand have developed 3D-printed teeth customised with carious lesions for student practice and demonstrated that these exceeded typodont and extracted teeth in providing quality practice for students. The majority of students surveyed agreed that the 3D-printed teeth created a more realistic opportunity for practice.

Mimicking complex tooth structures has become cost-effective through 3D printing, enabling the recreation of accurate occlusal anatomy and pulp based on actual patient scans. According to the Thai researchers, however, a major challenge is reproducing the appearance of deep carious lesions over the pulp chamber. By using dental wax to simulate dental pulp and placing a caries layer created from resin-modified glass ionomer cements in the deepest portion of occlusal and proximal cavities they designed in 3D-printed teeth, the team was able to mimic deep caries in teeth. The created caries was covered with a nano-filled resin composite in the occlusal cavity, but proximal caries was not covered to ensure that it was visible as a shadow on the marginal ridge.

In order to assess whether these 3D-printed teeth superseded typodont or extracted teeth for training, the

researchers had students remove the caries using the SCR technique and evaluate their learning experience via a self-administered questionnaire. An instructor then assessed the students' prepared teeth.

The results showed that most of the students preferred the 3D-printed teeth for SCR practice over extracted or typodont teeth and found them easier to handle than their typodont counterparts. However, the students noted that the hardness of the 3D-printed enamel was not as hard as the enamel layer of typodont teeth and that the tactile feeling experienced during caries removal was not always comparable to the experience of caries removal in patients. Being able to differentiate between carious lesions and sound tooth structure was also somewhat of a challenge in these 3D-printed teeth. The researchers noted the need for adjustment to the levels of hardness in the various layers and components of the 3D-printed teeth in further research.

Most of the students said that using these 3D-printed teeth helped them feel motivated to hone their SCR skills compared with other model or extracted teeth options, as well as enhanced their practice and control of fine motor movements of their fingers. The researchers found that the students most often correctly performed proximal caries removal once they had concluded a practice session on the occlusal cavity and attributed this to experiential learning.

> "... 3D-printed teeth offer the advantage of customisation, such as adjusting the size and location of caries."

The researchers said that 3D-printed teeth offer the advantage of customisation, such as adjusting the size and location of caries. Caries can also be changed in colour to make it more apparent for students who are learning how to identify caries. Their study demonstrated that this can be done in-house using commonly available dental materials.

Editorial note: The study, titled "Assessment of 3D-printed tooth containing simulated deep caries lesions for practicing selective caries removal: A pilot study", was published in the first January 2023 issue of the International Journal of Environmental Research and Public Health.

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