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New comprehensive review of 3D printing in oral and maxillofacial surgery

By Anisha Hall Hoppe, Dental Tribune International

BOSTON, US/KARAJ, Iran: The introduction of 3D printing in medicine has improved outcomes across surgical applications by decreasing costs, reducing surgical time and improving reliability of treatments. Researchers from the Harvard School of Dental Medicine and the Alborz University of Medical Sciences in Iran have created a handy summary of the current advances of 3D printing in the field of oral and maxillofacial surgery (OMFS) that offers clinicians a brief explanation of 3D printing and a broader look at how 3D printing can be used for specific purposes in OMFS.

Clinicians need not have a strong understanding of engineering or materials science to be able to utilise 3D printing in their treatment plans. Indeed, merely under-

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3D printing enables surgeons to create surgical plans, implants and protheses that are all tailored to the individual anatomy and needs of each patient while being cost-effective and reducing surgical time and complications. (Image: FOTOGRIN/Shutterstock)

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standing the differences between the various 3D-printing methodologies is an adequate place to start. Thanks to high-resolution imaging, the practitioner need only import image data and many 3D-printing software packages will process and render this information into a printable model, for which the clinician requires no CAD/CAM knowledge. In addition, clinicians can even outsource overall virtual surgical planning and surgical implant fabrication to the numerous companies now offering these services.

In their review, the researchers give a simple description of CAD/CAM's role in realising implants and surgical solutions bringing implants and surgical solutions to life. Computer-rendered 3D models and printed guides advance surgery for maxillofacial trauma and reconstruction, reducing surgical time by ensuring bones are repositioned correctly, for example. Printed cutting guides improve surgical results, and even before surgery, CAD programs can calculate symmetry in areas of bone defects for restoration with CAM devices.

The power of visualisation

3D-printed models significantly aid in patient education and communication, helping clinicians demonstrate the desired results of the planned procedure, particularly when the trauma or area of reconstruction is difficult to understand. CAD enables clinicians to even work with parents to prepare for needed corrections, such as for a known cleft palate, while their child is still *in utero*.

This ease of visualisation is particularly useful in complicated procedures such as those of orthognathic surgery. During the procedure, printed osteotomy guides ensure that bone segments are placed correctly, dental roots and nerves are avoided, and complicated asymmetric movements can be achieved when desired. Additionally, 3D printing of titanium plates that are completely customised to patient anatomy ensure ongoing stability and strength of the bone.

A safer option

3D printing has also meant that microvascular reconstruction is no longer necessary in cases of reconstruction, as bone harvesting and transplantation has become a thing of the past. In maxillofacial prosthodontics, the risk of infection and obstruction of anatomical structures, among other issues, are already challenging enough without having to deal with problems such as donor site morbidity and added patient pain. There are a number of 3D-printable materials available for various reconstruction purposes that are both biocompatible and cost-effective, and designated software can easily remodel defects or completely missing bone and other facial structures into a symmetrical, aesthetic and functional result.

Materials of incredible strength and durability are available for surgical purposes, such as for temporomandibular joint prostheses. Reconstruction of the fossa and mandibular component requires different materials that work together and provide enduring strength. The advent of 3D-printed guides has meant that are patients no longer subjected to multiple surgeries for a procedure such as a condylectomy and prosthetic replacement. The authors do note that more research needs to be done into the new procedures that utilise some device or scaffolding solutions, as there is still a lack of information on how patient-tailored prostheses affect muscle and joint function in the long term.

The use of 3D-printed surgical guides for dental implant placement is well documented and has been shown to dramatically decrease both the surgery time and the errors that may arise from freehand drilling. The fabrication of dental implants too using 3D printing is being increasingly investigated. Some studies on bone healing rates for a variety of structures and implant materials have indicated high rates of implant success, but long-term clinical evidence is lacking.

Bone tissue engineering has shown significant progress, researchers all over the world having developed scaffolding solutions that rely on various combinations of designs, cell sources and biomaterials, among others, all tailored to patient-specific anatomy. There is much more still to be done, and the authors note a bright future for research in regeneration of neural and vascular networks, ensuring mechanical properties and more. It is also a field without much medical regulation and one that would benefit from more clinical studies, particularly considering the advances expected in bioactive synthetic materials in the coming years. The authors cite the success in one study of a 3D-printed scaffold for a cleft palate restoration that utilised bone marrow stromal cells and achieved new bone growth in 45% of the defect volume after just six months.

The need for updated curriculum

The review also highlights the overarching benefits of utilising 3D-printed models in clinician education, particularly because realistic, easy-to-access models can be printed anywhere and can be customised to virtually any training situation or patient model. 3D printing using both soft and hard materials can produce a lifelike cleft lip and palate model in a single print, for example. Researchers are constantly re-evaluating model creation based on surveys of tactile and haptic feedback and how realistic a model is compared with the real thing.

In addition to a list of materials and their associated applications across OMFS, the authors include some associated risks with 3D printing, including need for further classification of devices. They also note that clinicians should take the time to educate themselves on not only the associated costs of 3D printing but also the technology that they specifically will require. Not every material is compatible with every printer, and skilled technicians are essential for the various steps of the 3D-printing process. 3D printing itself involves the risks of exposure to chemicals, possibly lasers or other sources of injury and should really be undertaken with proper assistance. Though clinicians should not feel hesitant in adopting 3D printing, it is not as simple as printing and implanting. There are a myriad of sources on the topic and a number of companies specialising in helping clinicians use 3D-printed surgical solutions immediately, safely and with efficacy.

The study, titled "The impact of 3D printing on oral and maxillofacial surgery", was published online on 14 April 2023 in the *Journal of 3D Printing in Medicine*, ahead of inclusion in an issue.

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Ultradent introduces J-Temp temporary resin

By Ultradent Products

Ultradent Products, Inc., a leading developer and manufacturer of high-tech dental materials, today released its newest product, J-Temp temporary resin, a premixed, light-cured temporary resin designed for multiple use cases and maximum ease of use—for dentists, by dentists.

Engineered for maximum usability—offering four solutions in just one product syringe, dentists can utilize J-Temp temporary resin for everything from bite ramps and temporary occlusal buildups, to build structure for isolation clamping, for temporary restorations, and for splinting between implant copings.

On developing J-Temp temporary resin, Ultradent's vice-president of clinical affairs, Dr. Jaleena Jessop says, "J-Temp Temporary Resin started because there was always a need for something that didn't exist. The more I used J-Temp temporary resin for different procedures, the more I found that it is really nice to have one product that can cover a gamut of different needs, versus needing five of six different materials that may expire before you use them next."

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(Image: Ultradent Products)

For more information about J-Temp please contact sophia.yadi@ultradent.com.

Artificial intelligence: A gift to dentists

By Dr Kyle Stanley, USA

The May 2019 edition of *The Atlantic* magazine contained an article titled "The truth about dentistry". In it, the author visualised dentists—not a particular dentist but dentists in the abstract—as sinister authority figures looming over the helpless patient's recumbent form, drill in hand. Mistrust permeated the scene like swamp fog. "When he points at spectral smudges on an X-ray," the author pleads, "how are we to know what's true?"

Then there was the Dustin Hoffman movie *Marathon Man* with its Nazi dentist-cum-torturer, and the famous—or, if you're a dentist, notorious—1997 *Reader's Digest* article by a writer who visited 50 dentists in 28 states, picking them at random out of the Yellow Pages, and was given treatment plans ranging in cost from under US$500 to nearly US$30,000. That one really hit a nerve, so to speak.

Dentists have had their share of bad rap, but still, the experience of the *Reader's Digest* writer was probably not terribly far from the truth. It was borne out, with eerie accuracy, by a 2021 Dental AI Council study intended to quantify the suspected inconsistencies in dental diagnosis and treatment. The same set of full-mouth radiographs was presented to 136 dentists, and they were asked to provide tooth-by-tooth diagnoses and a treatment plan. A person with confidence in the scientific basis of dentistry might naturally expect a limited amount of diversity among the responses and would assume that the commonalities would far outweigh the differences. Not so. Not once did more than half of the participants agree about the diagnosis for a given tooth. The variety of estimated costs was almost comical, ranging from US$300 to US$36,000—figures strikingly similar to those cited by the *Reader's Digest* author. Worse, the range of cost estimates did not present as a bell curve, the majority of responses clustered together and only a few outliers at the extremes. Instead, the distribution was more or less at; the frequency of a cost estimate of US$1,000 was about the same as that of a cost estimate of US$10,000.

Other studies have found that dentists' interpretation of radiographs—the very foundation of diagnosis—was far from reliable. Estimates of cavity depth and recognition of radiolucencies were wrong as often as they were right. In another study, three dentists examined several thousand radiographs; their interpretations were in full agreement only 4% of the time.

Houston, we have a problem

How should we account for this lack of precision in a medical field? Is it due to dishonesty? To greed? To variations in skill? To honest differences of opinion? Whatever the reason, it gives dentistry a bad name. But there is a remedy. It comes in the form of a powerful new technology that is already transforming many aspects of our lives: artificial intelligence, or AI for short.

AI is an umbrella term covering a wide range of computing techniques. They range from "general AI"—intelligence indistinguishable from that of a human being, in all circumstances—to "narrow AI", specialised programs whose expertise is limited to a particular class of problem. Most make use of a programming technique called a "neural network" by loose analogy to the structure of the human brain, and all have in common the property of trainability. They learn by taking in vast amounts of data of a certain type—say, photographs of faces or samples of text— and extracting commonalities. Once trained, an AI program can pick out a particular face in a crowd or write an essay or a love poem as well as or better than you can.

General AI is the darling of science fiction writers, but is very far from realisation. No AI system has anything like the broad knowledge of all aspects of the world that a human being has, and so, for the time being at least, we do not have to worry about being taken over by independent-minded and malevolent robots like the notorious HAL of 2001: A *Space Odyssey*. Even the comparatively limited task of safely operating a car in an urban environment has not yet been mastered, despite years of effort and oceans of investment.

Narrow AIs, however, already easily match or surpass human abilities, and they have become the tools of choice for performing many exacting tasks. Many of these involve computer vision, the analysis and recognition of objects or imagery. More than a decade ago, it was found that a trained AI could recognise and categorise nodules in radiographs of cancer patients' lungs as accurately as a panel of oncologists could, and much faster. Computer vision and AI are now familiar parts of the oncological toolkit, and they are being applied to a widening array of medical fields. One of those is dentistry.

Dr Kyle Stanley.

Dentists are in an excellent position to take full advantage of AI. There exists, to start with, a virtually limitless supply of dental radiographs for training. The radiographic image is the coin of the realm in dentistry; patients are accustomed to having their pathologies explained to them with reference to the "spectral smudges on an X-ray" evoked by *The Atlantic's* reporter. The range of pathologies to be detected is relatively narrow, and the AI program can not only identify them but also quantify them with greater than human precision. The dental radiograph is, therefore, an ideal application for the sharp focus of narrow AI.

The second opinion—so to speak—provided by an AI program is directly valuable to the practitioner. The computer is hypersensitive to subtle greyscale gradations; it may detect something the human reader has overlooked. More importantly, it is never tired, distracted or rushed and so is not prone to the types of mistakes and oversights that people routinely make simply because they are human. The AI program may in many cases simply duplicate the perceptions of the human, in which case nothing is gained but confirmation, but it may add information overlooked by the human or differ in its interpretation, leading to a re-examination and re-evaluation of the evidence.

Even if these benefits may seem minor to an experienced practitioner confident in his or her abilities, there is another side of the AI experience to consider: the patient's. The results of the AI program's analysis are presented to the patient in vivid, intuitively understandable form. The radiograph no longer consists merely of spectral smudges, but has become graphically compelling, having highlighted areas, colour-coded outlines and explanatory labels. For a patient, the enhanced display conveys a heightened sense of precision, clarity and objectivity. The diagnosis is no longer just the opinion of one person, whom a cynic might suspect of ulterior motives. It need not be taken on faith; it is supported by the unbiased authority of a digital computer.

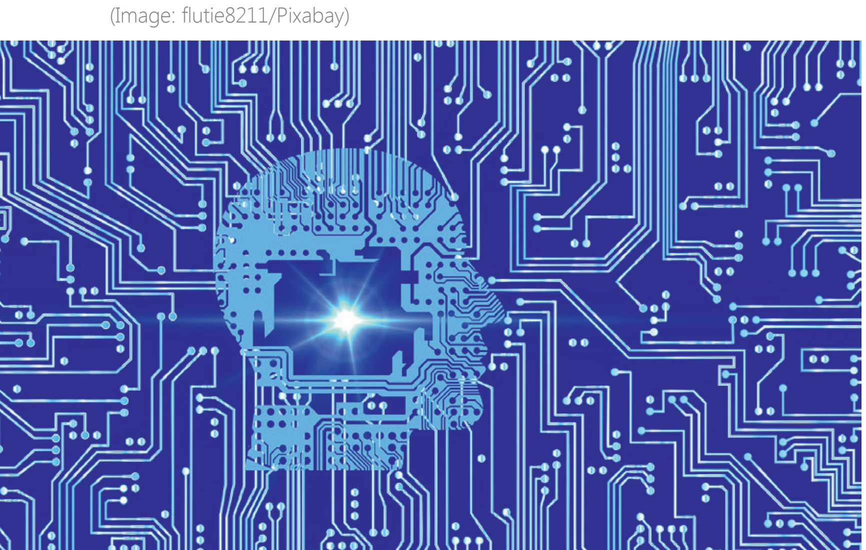
While the graphic presentation of a computed analysis may impress a patient as something more than human, the practitioner should be aware that the AI program is an assistant, not a supervisor. Even though the accuracy of AI's radiographic analyses in various medical fields has been shown to be indistinguishable from that of human interpreters, the AI program actually knows much less about teeth (or lungs or livers) than the trained and experienced practitioner does. What it does know, and knows very well, is how a large number of specialists have interpreted a very large number of radiographs. Its findings are, in effect, those that hundreds or thousands of dentists would make if they were to vote on the content of a given radiograph. Where there is not unanimous agreement, majority opinion prevails, or findings are presented in terms of probabilities. The practitioner using the AI program remains entirely free to form a different opinion or to disregard the advice the program gives, but has the benefit of knowing what a large group of peers would have made of the radiograph in question.

The most significant impact of dental AI, however, is not that it necessarily brings a superhuman level of certainty to the data upon which diagnoses are based—although in most cases it may—but that it provides, for the first time, an objective and universally accessible standard of reference. Objective standards are precisely the thing that dentistry has lacked in the past, and their absence has given rise to suspicions about the candour and consistency of dental diagnoses. Look at the *Reader's Digest* writer: guided only by a phone book, he collected a bewilderingly large variety of diagnoses. If he had visited only dental offices using an AI assistant, he would have been given a much smaller variety, and the differences would have been due to small variations among the radiographs made by different practices rather than to the whims of individual dentists or the immediate financial needs besetting them.

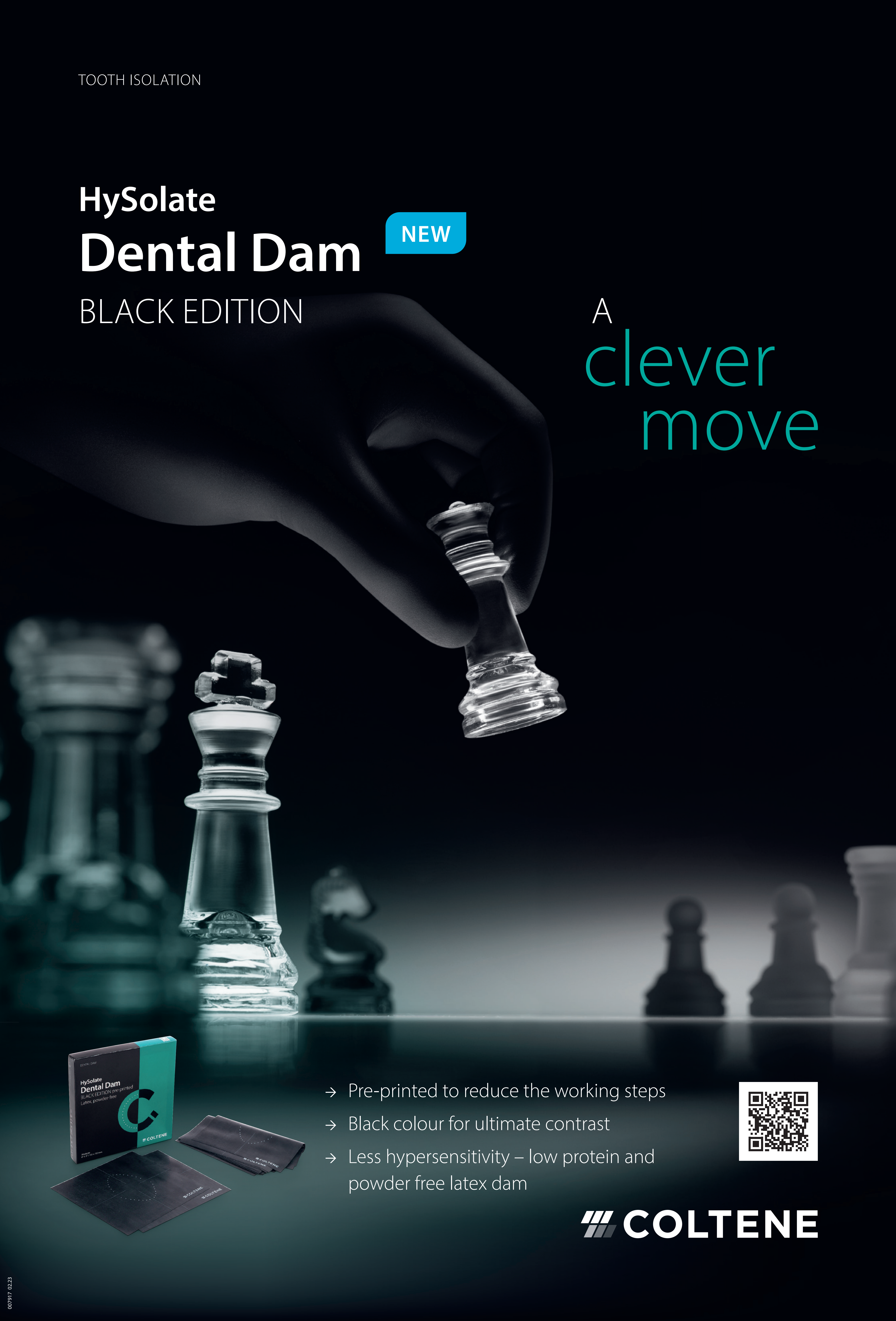
Consistency is not the only thing AI brings to dentistry. It also provides support for insurance claims and facilitates record-keeping, tracking of patients' dental health and comparison of performance among multiple practices in an organisation. It trains dentists at the same time as dentists train it. In the future, it may reveal connections between dental health and general health that we do not now suspect.

Those are some of the collateral benefits. Above all, however, AI will give patients the reassurance of knowing that the condition of their teeth is not merely a matter of opinion.

(Image: flutie8211/Pixabay)



Dr Kyle Stanley is a specialist in implantology and a passionate advocate for mental health in the dental profession. He is founder and chief clinical of cer of Pearl, a company transforming patient care through arti cial intelligence. Dr Stanley maintains a private practice in Beverly Hills in the US, where he focuses on implant surgery and prosthetics.



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Choose the correct mask for your daily practice

By HuFriedyGroup

The spread of the pandemic over the last years has raised more and more awareness about the importance of wearing personal protection equipment such as gowns, gloves, caps, drapes and masks throughout daily routine in dental practices. During this difficult time, any type of mask was acceptable due to the emergency and the supply shortage, but now clinicians have the possibility to choose wisely the correct mask to wear based on the amount of fluid, spray, aerosol, splashing or spattering of blood generated and the length of each procedure: by doing so, they protect their patients, the dental staff and the community itself.

The ASTM classification in three different levels help identifying the right mask for a particular procedure and our full portfolio of Crosstex Masks covers all levels providing the appropriate protection to minimize the spread of potentially infectious diseases.

- ASTM Level 3 masks: provide high fluid protection and are ideal for procedures that generate moderate to high amounts of fluid, spray and aerosols, including complex oral surgery, crown preparation, implant placement, periodontal surgery and the use of ultrasonic scalers. **Crosstex Ultra Masks** are part of this group.
- ASTM Level 2 masks: provide moderate fluid protection and can be worn during limited oral surgery, endodontics, prophylaxis, restoratives, sealants and others. **Crosstex Procedural Masks** are level 2.
- ASTM Level 1 masks: provide light fluid protection and are ideal for patient exams, impressions and orthodontics. **Crosstex Isofluid Masks** belong to this group.

Apart from the choice based on the level of protection, which is nowadays an essential requirement for any infection prevention program within the dental practice, clinicians may choose our masks also thanks to their comfort: unlike the most common masks available in the market, Crosstex masks feature a soft, white medical-grade facial tissue inner layer that makes the mask comfortable, other than the highest quality meltblown filter for best filtration efficiency and breathability. The elastic, flat ear loops, also, minimize pressure to the ears and are attached to the outside of the mask to eliminate skin irritation and providing the most comfortable fit.

Last but not least, Crosstex masks have some additional characteristics, among which the most important one and award-winning: Secure Fit Technology's patented design features flexible aluminum nose and chin strips for a customized fit that eliminates dangerous gaps around any face shape. A special option for people with allergic sensitivity is also available: Ultra-Sensitive is an extra soft white hypoallergenic inner cellulose layer. The FogFree strip, lastly, block and absorb moisture, forming a strong seal preventing fogging of eyewear.

Some dental practitioners may be tired of wearing the standard white or blue masks and this is why we have listened to their request and decided to enlarge even more our portfolio, already full of colour options such as pink, yellow, lavender, blue, turquoise, sapphire, etc., with the new Ultra Earloop Facemask with SecureFit Technology, in Black! Belonging to the ASTM Level 3, they are ideal for procedures that generate moderate or high amount of fluid, spray and aerosols and now clinicians can feel safe during long and complex procedures while being cool with their new Black masks!

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* Patel RB, Skaria SD, Mansour MM, Smaldone GC. Respiratory source control using a surgical mask: An in vitro study [published correction appears in J Occup Environ Hyg. 2022 Jun;19(6):409]. J Occup Environ Hyg. 2016;13(7):569-576. doi:10.1080/15459624.2015.1043050

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