

# today

SHOW  
REVIEW

40<sup>th</sup> International Dental Show • Cologne • 14–18 March 2023



## Impressions

Over the course of five days, IDS offered visitors the opportunity to see and try out the most current innovations in dentistry.

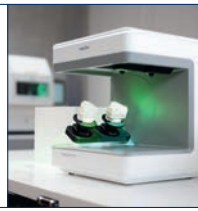
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## Aesthetic solutions

Austrian manufacturer edelweiss dentistry presented its newest development: the edelweiss CAD/CAM BLOCK at its booth.

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## Products in focus

Complete digital workflows, sustainability and artificial intelligence applications were some of the trends observed at this year's event.

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## IDS celebrates great comeback

Thousands attend centenary of the world's leading dental show.

IDS, which celebrated its 100<sup>th</sup> anniversary this year, was held from 14 to 18 March. According to organiser Koelnmesse, around 120,000 visitors from 162 countries attended, 60% from abroad. Like usual, attendance by EU countries, particularly Italy, France, the Netherlands, Spain, Belgium, Romania and Greece, was high. In addition, there were many visitors from Asia, South America, the US and Canada. In total, 1,788 companies from 60 countries exhibited at the show. These included 433 exhibitors from Germany.

A visitor survey showed that visitors' overall assessment of IDS 2023 was positive. Over 80% were very satisfied with the event, 83% praised the comprehensive showcase and almost 90% would recommend visiting IDS to their business partners. Furthermore, 84% of the respondents were satisfied with the IDSconnect digital platform and its additional offers.

Mark Stephen Pace, chairman of the board of directors of the Association of the German Dental Industry, commented: "IDS 2023 was a success across the board, and at the same time, it proved that even after 100 years it is still reinventing itself and developing further. IDS has once again confirmed that it is a world-leading trade fair. The quality of the visitors was sensational. Together with Koelnmesse, we will successfully lead IDS into the second century of the event's history with energy, ambition, creativity and vision. This year's slogan of '100 years of IDS—shaping the dental future' reflects the outstanding importance of the trade fair today and in the future."

Chief Operating Officer of Koelnmesse Oliver Frese added: "Over five days, we experienced an IDS that more than lived up to its claim as a leading international hub. This gives the global dental industry the necessary impetus for the coming months and, at the same time, underlines the global appeal that emanates from IDS. The result of the event is all the more remarkable as the geopolitical framework conditions are currently a challenge."



nates from IDS. The result of the event is all the more remarkable as the geopolitical framework conditions are currently a challenge."

The overall feedback from the exhibitors was very positive too. Fred Freedman, vice president of member services at the Dental Trade Alliance and president of International Dental Manufacturers, stated: "IDS is the largest and best international dental meeting in the world. The 2023 IDS can be summed up in one sound bite: IDS is back. With the enormous crowds and thousands of international distributors and visitors, this is a must for all US manufacturers and companies looking for new international business."

Simon Campion, president and CEO of Dentsply Sirona, concluded: "It was important for us as a company to be back on-site and meet our customers in person because that makes a difference. Under the motto 'United for better dentistry', we offered our visitors a programme with 40 hours of live demonstrations and hands-on training. In addition, we made clear statements on the topics of digitalisation and sustainability with our panel discussions. We can positively impact the lives of millions of patients. We can only do this through mutual exchange and closer collaboration."

In an interview with Dental Tribune International, Stanley Bergman, CEO and chairman of the board of Henry Schein, mentioned that "one of the highlights in attending IDS is the opportunity to tour the exhibit hall, preview the vast array of new technologies and products being showcased and meet with many of our Team Schein members representing our businesses across the Europe, Middle East and Africa region. Attending IDS also provides an opportunity to meet with our supplier partners and to speak with our customers—dentists and other dental professionals—and together discover the latest innovations and advancements in the field".

He continued: "Many of these products and technologies are designed to make dental procedures easier and more efficient, leading to better patient care and satisfaction. This includes

easy-to-use clinical digital workflow solutions fostering open architecture and product interoperability, advancements in 3D printing and resources to enhance workflow management, systems and product integration. That's why it is so motivating to experience first-hand the reaction of dental practitioners to our company's rich line-up of activities promoting technology advances in dentistry, a wide range of value-added services and educational insights from industry and professional thought leaders."

### Trends in 2023 and beyond

Two topics stood out at this year's IDS: completely digital workflows and sustainability. Furthermore, a considerable number of companies showcased artificial intelligence (AI) applications.

Straumann, for example, introduced a new software solution for its Virtuo Vivo intra-oral scanner which will improve the speed and accuracy of digital impression taking. Intra-oral scans are the entry point for digital workflows and will be automatically connected to the Straumann AXS platform and various services in the future.

Following its recently established partnership with Smilecloud, Straumann launched its smile design and centralised collaboration platform developed by dentists for dental professionals in selected European markets. Smilecloud allows clinicians to design virtual mock-up smiles for patients.

Straumann also launched its first dynamic surgical navigation system to perform implant treatment in a fully digital workflow. Straumann Falcon will be available in select European countries.

ClearCorrect launched an array of new innovations to help dentists treat complex cases. Included in the launch were improvements to ClearCorrect's aligner via an enhanced end-to-end workflow that allows dentists to efficiently treat patients who have missing or erupting teeth with pontics, bars and guides. In addition, ClearCorrect launched the ClearCorrect







Sync mobile app, allowing dentists to quickly set up patient profiles to create new cases.

In addition, GC announced the launch of two new solutions during IDS: the next generation of the company's dedicated dental laboratory scanners—the Aadvia Lab Scanner 3—and the new Aadvia IOS 200 intra-oral scanner.

GC says that it has set new standards in digital workflows with the introduction of the Aadvia IOS 200, which uses a new stereo matching technology known as four-dimensional regression and has been designed specifically to help dental clinicians overcome scanning challenges such as reflections, saliva and translucencies. According to GC, the technology provides a strong and robust method for calculating 3D images.

Because the Aadvia IOS 200 uses stereo technology for its 3D measurement, a much slimmer, smaller and lighter scanner handpiece, weighing just 120 g, is possible. This results in enhanced ease of use for the dentist, greater comfort for the patient and easier access to not only areas difficult to reach—such as the distal molar region—but also paediatric dentition and dentition in patients with limited mouth opening. The autoclavable tip (weighing about 30 g) assures full cross-infection control compliance.

With AI-based object recognition, the new Aadvia Lab Scanner 3 identifies what has been placed in it and automatically makes the necessary adaptation for an optimal scan without any user handling. Its AI system-guided automated workflows aim to provide greater peace of mind.

In addition to these features, the scanner is equipped with two high-resolution cameras and an advanced 3D sensor that contribute to optimal data acquisition and ensure a high accuracy of 4 µm and an extremely fast scanning time of 12 seconds for a full arch (measured with deactivated colour scanning).

AI software creator Pearl announced during IDS that it would be bringing its Practice Intelligence AI solution to Europe soon. This software uses dental radiographs and treatment data

of a practice's patient population to offer actionable insights, in addition to an array of reporting tools and performance analytics.

Practice Intelligence improves clinical productivity and performance by analysing and optimising existing dental practice operations. CEO of Pearl Ophir Tanz commented, "In bringing the full breadth of AI's capabilities and benefits to more dental practices around the world, we proudly continue to serve our mission of revolutionising the standard of dental care on a global scale."

Based on the extensive upgrade and rebranding, Imagoworks plans to expand its business to include implant crowns, bridges, inlays, onlays and dentures. Additionally, Imagoworks aims to strengthen its cooperation with global dental enterprises such as Medit to achieve a fully integrated AI-driven digital dentistry workflow employing 3D scanners and processing equipment.

Youngjun Kim, CEO of Imagoworks, remarked: "Dentbird Crown is the result of the passion of our AI software experts who worked endlessly and sought advice from dentists and den-



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The announcement of the international expansion of Practice Intelligence follows the global success of Pearl's real-time pathology detection software, Second Opinion. In 2021, it received clearance as an assistive tool for use in dental radiology from Australia's Therapeutic Goods Administration and New Zealand's Medicines and Medical Devices Safety Authority. The software has also received US Food and Drug Administration clearance.

After a large-scale update, Imagoworks released Dentbird Crown (formerly 3Dme Crown) at IDS 2023. This online AI-based automatic crown design software has been trained through deep learning of high-quality clinical big data. The recent update focused on improving the shape of the crown based on this training data. Various new features for enhanced usability and convenience were also added, including a modification feature, server expansion, interface improvement and CAM software interoperability. Users can now experience a faster and more intuitive crown design workflow than ever before.

tal technicians." He added: "We are excited to have improved the intuitive and automated workflow, from uploading scan data to crown design and CAM. Imagoworks will be very attentive to our users so that dental professionals around the world can provide more convenient and accurate treatment to patients."

"It was a pleasure to experience the breeze of innovation blowing at IDS," Pace summed up. "The huge driving force of [the German industry's] research and development departments was demonstrated here. Direct comparison at the leading product show of the dental industry is providing them with a tailwind and pushing them to new spheres. I am already looking forward to IDS 2025."

The 41<sup>st</sup> IDS is scheduled to take place from 25 to 29 March 2025. ◀

All images courtesy of Koelnmesse.





Find out more about digital dentistry with the Ceramill DRS system and how it can help you make patients into fans. ↗

# Flawless single visit restorations

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• 1 Crowds gathered to check out Renfert's latest 3D-printing and Plug & Print technologies. • 2 Florian Mack, managing partner of SAM Präzisionstechnik, presented AxioSnapMount system. (© Robert Strehler) • 3 Curaden presented its comprehensive range of oral care products. • 4 Ivoclar turned 100 at IDS 2023, celebrating a century of innovation. (© Robert Strehler) • 5 The minilu booth and products were a colourful departure from the clinical feel of the fair, delighting attendees. • 6 Visitors could examine, test and consult on DETAX's one-stop-shop. (© Robert Strehler) • 7 Under the motto "THE BEST, BY DESIGN—intelligent & sustainable solutions", Dürr Dental showcased sustainable products and solutions based on artificial intelligence for everyday practice. • 8 A visitor to COLTENE gets a hands-on demonstration. • 9 Exocad presented new software releases. • 10 Rapid Shape provided clinicians the chance to see models produced with their materials in various stages of production. • 11 Dr Robert Gaudin (middle) of Charité—Universitätsmedizin Berlin in Germany received a NeoScan 1000 intra-oral scanner for outstanding achievements in dentistry. The scanner was awarded by Dental Tribune International's CEO Torsten Oemus (left) and Neoss CEO Dr Robert Gottlander (right). (© Robert Strehler) • 12 SprintRay's global brand ambassador, Usain Bolt, an Olympic champion and world record holder in the 100 m sprint, joined the company's press conference. (© SprintRay) • 13 Dentaaurum showed that when it comes to making and scanning models, clinicians have some novel options. • 14 Visitors gathered from across the globe and represented all specialties within and quite a few adjacent to dentistry. • 15 GC encouraged visitors to try their products as part of their preferred workflow. • 16 Few industry conferences provide attendees the opportunity to experience procedures first hand, but EMS made it happen. • 17 Over 120,000 people attended IDS in 2023. (© Robert Strehler) • 18 Orangedental presented its open chairside workflow for professional practice laboratories.





• 19 Visitors were treated to a live intra-oral scan demonstration by 3Shape during the fair. • 20 ACTEON created a completely futuristic setting that drew many visitors at IDS. • 21 One of the benefits of visiting IDS is the opportunity to discuss products in depth as this visitor to Planmeca is doing. • 22 VOCO was an established presence at IDS, proudly sharing its “made in Germany” materials. (© Robert Strehler) • 23 This year’s event marked the 100<sup>th</sup> anniversary of IDS. (© Robert Strehler) • 24 Standard procedures like intra-oral imaging are taken to the next level with technology by Straumann. (© Robert Strehler) • 25 Swiss dentists and sisters Drs Haleh and Golnar Abivardi, founders of vVARDIS welcomed visitors curious about their biomimetic technology. (© Robert Strehler) • 26 Experiencing virtual reality at IDS. (© Robert Strehler) • 27 There was no break in the crowds at the TePe booth. (© Robert Strehler) • 28 2023 saw the inclusion of even more environmentally friendly brands and products such as from Luoro Paperdent, which greatly reduce plastic waste. (© Robert Strehler) • 29 Herbadent gently combines the power of nature with modern dentistry and dental hygiene technologies to create a complete line of dental products made from herbs and natural ingredients for daily oral care.

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## “The edelweiss CAD/CAM BLOCK certainly created a buzz”

Optimal integration of function and aesthetics with solutions from edelweiss dentistry.

■ Pioneering Austrian manufacturer edelweiss dentistry presented its aesthetic solutions at this year's IDS and had a successful and interactive time at the trade fair. The company boasts the only biomechanical direct veneer system that overcomes the disadvantages of the organic fillers normally used in composite veneers and at IDS presented its newest development: the edelweiss CAD/CAM BLOCK, particularly its unique i-BLOCK for implant restorations. In addition, edelweiss dentistry showcased the edelweiss PEDIATRIC CROWN, the only natural-looking and minimal preparation crown on the market for use in children.

The edelweiss CAD/CAM BLOCK is a unique block that is created through a patented laser sintering and vitrification process to produce a single glass phase. The block has the aesthetics of pure glass ceramics, the strength of particle-filled ceramics and the resilience of natural dentine.

The edelweiss CAD/CAM BLOCK has several advantages compared with other blocks on the market. Owing to the material's glass-like property, the final restoration only needs to be polished with a linen buff, significantly speeding up finishing and polishing. No additional firing or glazing is needed, saving time and money.

“This newest block from edelweiss dentistry was one of the highlights of IDS 2023. Many industry representatives, dentists and dental technicians milled the edelweiss CAD/CAM BLOCK on-site and couldn't believe the ease with which it can be milled. Manufacturers of milling units were amazed by the ease of polishing and the strength of the product. The edelweiss CAD/CAM BLOCK certainly created a buzz and was a talking point at IDS 2023,” said Dr Stephan Lampl, CEO and founder of edelweiss dentistry.

He added: “Its outstanding, long-lasting shine and strength make it currently the best option for both anterior and posterior CAD/CAM restorations. This block is setting a new



1 The edelweiss i-BLOCK with integrated screw channel. 2 The edelweiss DIRECT VENEERS and OCCLUSIONVD system.

trend in the dental industry and is certainly changing the future of CAD/CAM blocks.”

### The i-BLOCK ensures high aesthetics and exceptional strength

The edelweiss i-BLOCK has a screw channel built into it that fits into the titanium base over the implant. This allows for perfect design of the abutment with a perfect emergence profile, making it easy to restore implants especially in the case of immediate loading or custom abutments. The block has a unique shock-absorbing effect. Resin within the material gives the restoration the resilience to withstand any occlusal force.

This is particularly important to avoid transmission of forces to the periodontal tissue and the implant, making the edelweiss i-BLOCK a safe option for long-lasting protection of the implant.

### The PEDIATRIC CROWN mimics the properties of natural teeth

Another highlight at this year's IDS was the edelweiss PEDIATRIC CROWN, the only crown for children that mimics the properties of natural teeth, is highly aesthetic and requires minimal tooth preparation, since stainless-steel crowns are less aesthetically pleasing and zirconia crowns require excessive removal of



tooth structure. “It is also easy to use and reduces chair time for the child,” said Dr Desigar Moodley, chief scientific officer at edelweiss dentistry. The edelweiss PEDIATRIC CROWN contains zinc oxide nanoparticles and fluoride for antibacterial properties. It is also free of bisphenol A, making it very safe for young patients.

The company works with several key opinion leaders, some of whom attended the fair to support edelweiss dentistry with their expertise. They were very pleased with the positive response to the products. Dr Nikola Podolsov, a dentist from North Macedonia and one of the company's key opinion leaders for Europe, commented: “It was fantastic to demon-

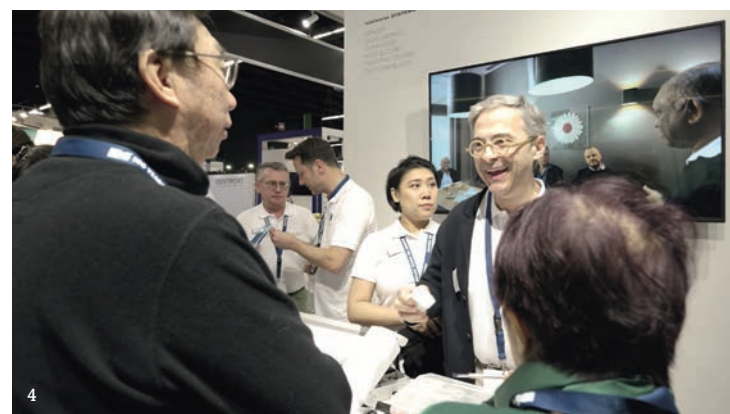
strate the edelweiss products live in front of so many dentists.” German dentist Dr Vesna Jelic, who is also a key opinion leader for Europe, said: “Being able to communicate with so many dentists, resulting in them learning from us, was very exciting.”

“Attending IDS 2023 after years of the pandemic provided a valuable experience for the entire edelweiss team. The atmosphere of the event was busy and bustling with excitement, and the show gave us the opportunity to network with industry professionals from all over the world,” concluded Dr Lampl.

More information on the edelweiss dentistry products can be found at [www.edelweissdentistry.com](http://www.edelweissdentistry.com). ◀



3 The newly launched edelweiss CAD/CAM BLOCK showcased at IDS. 4 The edelweiss dentistry booth at IDS 2023.



5 IDS 2023 offered the edelweiss dentistry team the opportunity to network with industry professionals from all over the world.



6 Dr Marco Tufts, edelweiss dentistry key opinion leader from Belgium, said: “The excitement generated by the industry when shown the edelweiss CAD/CAM BLOCK was just amazing.”



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# Digital workflow for dental offices and laboratories—where are we now?

An interview with Niels Plate, group vice president of digital devices and equipment at Dentsply Sirona.



1 In an interview with Dental Tribune International at IDS, Niels Plate spoke about the present and the future of digital technologies in dentistry.

## Why should dental professionals go digital—and why would you recommend it?

I think that many dental professionals are already digital to some extent, whether they know it or not, because often they have very simple intra-oral cameras, which just take photos of the teeth, integrated into their treatment centres that take digital images. Many dental professionals have digital radiographic units too, and now many dentists also have 3D scanners, which are all digital.

Why should they go digital? Generally, this improves the treatment outcome and increases the efficiency of the practice. At the moment, in dentistry particularly, but also in many other industries, the key bottleneck is labour: we don't have enough dentists or assistants or receptionists or lab technicians. So all over the industry, there is a severe shortage of qualified people. Digital helps people to become more efficient, to produce reproducible results and to get better clinical outcomes, but also to focus on the core of the job, and this means the patient and the clinical result.

I can give one very simple example, the documentation of our new Primeprint Solution. It automatically documents each print and allows the dentist to simplify data storage in one PDF file. All necessary data can be summarised in one PDF file, which the dentist can then use to fulfil his legal obligations, eliminating the need to take any notes, to have any records and to do anything manually; all the work is done automatically. This is exactly what I mean. This is work which is a waste of qualified time for the dentist or assistant. This is where we can help.

## What are the latest digital devices and equipment Dentsply Sirona is showcasing at IDS 2023?

Dentsply Sirona is showcasing many new products at IDS, but let's go through them in the sequence they were introduced. The first one is Axano. It's a dental chair, but of course, it's much, much more, because it is built to ideally support the individual way of working of each dental professional. What does that mean? It means that as a dentist you can use three settings, but you can basically indi-

vidualise the whole workflow according to your requirements, working style, training and working preferences. This helps to save time. By pre-setting the dental chair regarding how you do an endodontic treatment or how you do a restoration, you don't need to set the value each time, allowing you to work fluently without taking your hands off the patient because all the functions of the dental chair can be controlled by foot. This allows you to switch smoothly through your preset menus. Of course, Axano has many other excellent features, like a massage function for the patient, but the most important is that it combines an efficient workflow with ergonomics.

The next product Dentsply Sirona is showcasing at IDS is the Primeprint 3D-printing system. This is our first 3D printer, and it was very important for us to have a fully digitalised workflow offering a complete solution for the dentist.

Primeprint Solution runs mostly automatically, employing a robotic arm that handles the printed object. It uses the patented cartridge system to keep the printed object enclosed so that no chemical fumes reach the user. The user then switches over to the post-processing unit by pressing a button, and that again proceeds fully enclosed and completely automated, producing the final washed object. Primeprint Solution is designed for all the common dental applications, which start with models, then also night guards, splints, surgical guides, temporary restorations and mock-ups.

But there is another product I'd like to mention, Primescan Connect, which is a version of Primescan, our high-performing intra-oral scanner now available in a laptop configuration. The laptop version was requested by many markets. This feature makes the workflow easier and more ergonomic.

Primeprint Solution and Primescan Connect are connected to DS Core, our cloud-based solution that provides up to 15 TB of cloud storage. Of course, DS Core can connect all services and data, including radiographs, clinical photographs and case files, and dentists can share all the data with some clicks or access it

from wherever they are. This data can be safely shared with partners, with labs and with the patient. In the future, DS Core will provide further solutions, because the possibilities of its use will continue to evolve.

Here at Dentsply Sirona's IDS booth all presented devices are connected to DS Core.

## Is Primeprint Solution designed exclusively for dental offices, or can it also be used in dental labs?

Our first intention with Primeprint was to have a chairside solution, but it is designed for both dentists and dental technicians, depending on the size and set-up of the dental lab. For a very big lab, then I would say that a more industrial type of product would be needed, but for the typical family-owned dental lab in Germany, Primeprint is a very good solution. The biggest advantage of Primeprint is that it is fully automated, so it can run the entire printing process, including post-processing, and safely deliver the final printed product, providing a chairside solution. This device meets so many high standards that you could even put it in your living room.

## What role does education play in transitioning dentistry to digital, and how is Dentsply Sirona fulfilling this role?

Education is very important to Dentsply Sirona and I think we have all learned during the COVID-19 pandemic that we can also digitalise education a little bit more. Dentsply Sirona offers education programmes through the Dentsply Sirona Academy. In our many international education centres around the world, the largest being in Charlotte in North Carolina in the US and in Bensheim in Germany, we provide the knowledge, skills and inspiration. Among the clinical educational material available on our academy platform, we have just published on-demand curricula.

We also offer more and more digital content on various platforms, like YouTube, where dental practitioners can get quick training on subjects of interest, especially on topics related to digital, or when they just want to get instructions on how to do something, how to maintain a device or

how to use certain functions. All this information is available online.

I believe that this is the way forward, because that is exactly how we behave in our non-professional lives. When I needed to change the battery in my car key, what did I do? I opened YouTube and searched for a video on how to do that. I didn't open the instruction manual; I found the information online.

Dental professionals also search for information in this way, and Dentsply Sirona is ready to provide them with the answers they are looking for where they are looking for it. Apart from that, we are putting a huge focus on user experience.

## The use of digital technology is a growing trend. What do you think the next five to ten years will bring in terms of new products or workflows?

Yes, I think that in the coming years the use of digital technology will still be a growing trend.

What we are now seeing is that digitalisation is moving quicker and quicker, producing a huge amount of data, and this will make it mandatory to move things into the cloud, same as we saw with office software or in many other industries. Moving to the cloud will give us not only unlimited storage but also unlimited computing power, which then, of course, will enable things like artificial intelligence in support of the dentist. I would expect then bigger breakthroughs in diagnostics to help the dentist to do an initial diagnosis and create a treatment plan to solve the problem identified.

I think that design of dental restorations will be much more automatised and that these services which are still done manually will become more and more generic. This biogeneric technol-

ogy is already known to CEREC users, but will evolve and become define a new standard way of working. Today, you can imagine that automation will move further and further and reduce the need for the dentist to amend the final design, making results reproducible.

I believe that another important area is outcome simulation. A very important part of dentists' work is communicating with their patients about the outcome of the treatment planned. We can see that very well at the moment for aligner treatments. A number of companies offer an outcome simulator, which shows patients how their teeth will look after aligner treatment. Of course, this has to be transferred to other treatments to enable dentists to show patients' their smiles after treatment and give them a treatment choice.

The last area I would like to mention is equipment efficiency to keep everything well maintained and to increase uptime and reduce downtime. Treatment management and remote servicing are other areas which we are actively working on. We can see the first results in DC Core already today, and this will reduce service costs significantly. We will increase the number of cases for which we can fix any issue remotely, without sending a service engineer to the dental practice, which means that the dentist can continue working. We will enable bigger structures, like dental service organisations, to manage their fleet and make sure that all their facilities are running and service their dentists well.

That is in a nutshell what I expect, but of course, there is much more. But there is also a natural limit to what can be done in a certain amount of time. ◀



2 Dentsply Sirona presented interactive events, exciting digital experiences and live demonstrations at IDS. 3 Trade show attendees experienced the digital universe at Dentsply Sirona's booth.



# Artificial intelligence: A gift to dentists

Dr Kyle Stanley explains the benefits of artificial intelligence technology in dentistry.



■ 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 flat; 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 exact-

ing 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.

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 grey-scale 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 high-

lighted 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. ◀

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