Small device, big impact: Biosensors in oral cancer diagnosis

By Dr. Sahithi Kolli

Point-of-care biosensors can help in the early detection of oral cancers. Early-stage tumors are more likely to respond to therapy, ultimately leading to a higher rate of patient survival with greater preservation of functional oral structures.

Oral squamous cell carcinoma (OSCC), the most common type of oral cancer, is a serious issue for individuals worldwide because of its high mortality rate and metastatic spread to other body parts. Despite recent advances in biological research and treatment, early oral cancer identification remains critical in increasing survival rates.

Currently, the most popular methods for detecting oral cancer are visual inspection and biopsy, which are time-consuming, labor-intensive, and reliant on the investigator's competence and invasive [1]. On the other hand, the development of point-of-care biosensors for oral cancer detection has the potential to change how this disease is diagnosed. These techniques have the potential to aid in the development of effective treatments, ultimately leading to a higher rate of patient survival.

> *Biosensors can assess the number of biomarkers precisely and reliably, assisting in the correct diagnosis of OSCC during its development.*

A biosensor, by definition, is a self-contained analytical instrument that includes a biologically active substance in close contact with an appropriate transduction element for the goal of detecting (reversibly and selectively) the concentration or activity of chemical species in any type of sample [2].
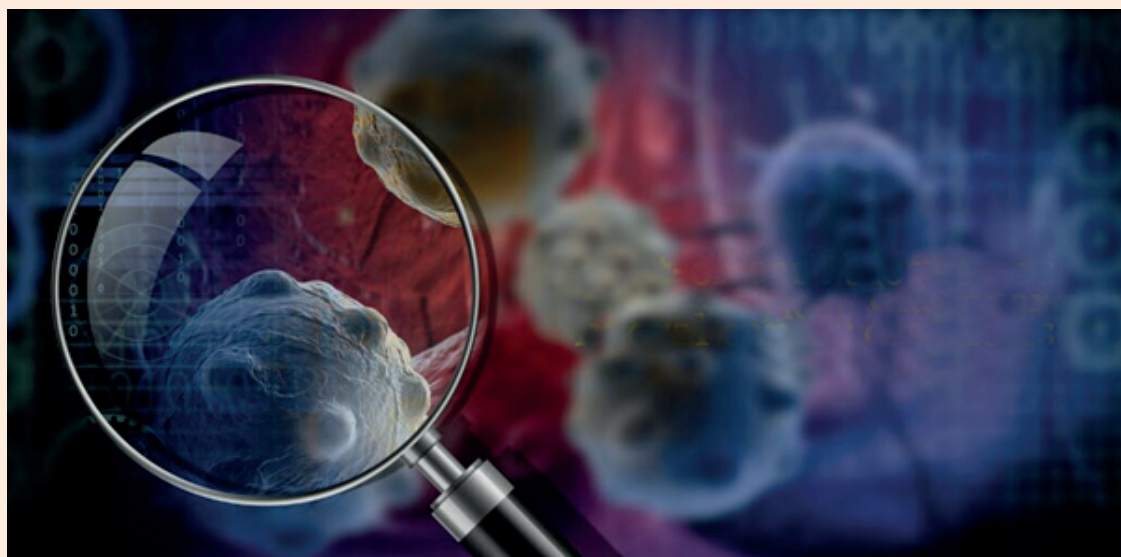
Point-of-care biosensors can help in early detection of oral cancer increasing the treatment success rate and patient survival rate. (Image: Canva)

Recent advancements in nanoscience and material design have resulted in the creation of point-of-care devices for biomolecule sensing and cancer diagnostics. With the growing acceptance and popularity of digital healthcare-based systems, several groups have spent more resources on creating and releasing proof-of-concept biological transmitting devices.[3]

The cell proliferation regulating inhibitor of protein phosphatase 2A (p90/CIP2A) has been identified as an OSCC biomarker. CIP2A is abundant in OSCC cell lines and dysplastic and malignant human oral epithelial tissues but not in normal controls[4]. CIP2A is present in most malignancies, including lung and gastric cancer, but it is more prominent in oral cancer.

Researchers from the University of Florida and National Yang-Ming Chiao Tung University in Taiwan present a breakthrough hand-held biosensor that enables speedy and accurate detection of oral cancer in the *Journal of Vacuum Science & Technology B*, copublished by AIP Publishing and AVS.

> *A readily available and developed CIP2A biosensor with excellent sensitivity and a shorter sensing time could be of major utility in advancing oral cancer screenings in the office [5].*

As part of a modular biosensor system comprised of a Si-MOSFET digital reader and externalized cartridge sensor strips functionalized for the SARS-CoV-2 virus, a low-cost sensor similar to a glucose detection strip was developed. The device makes sensor strips with an Au-plated electrode out of easily accessible glucose test strips. The modular biosensor system has been functionalized to detect CIP2A. The sensitivity has been checked using CIP2A protein dilutions and tested with HeLa cancer cell lysate.

The biosensor developed by the group comprises a sensor strip similar to a glucose strip and a circuit board (a hand-held terminal similar to a glucometer) for detection. Typically, test fluid is introduced into a small liquid channel on the tip of the sensor strips. A few electrodes are placed within the liquid channel, and their surfaces contain antibodies to specific proteins found in human oral cancer lesions.

During detection, short electrode pulses are sent across these electrodes, and the circuit board module analyzes this signal and generates a four-digit number according to its concentration. Thus, helping in detecting cancerous lesions.

The researchers mention that they will now concentrate on increasing the performance of this biosensor. They will also run additional studies to see if the device can detect other oral cancer-related indicators.[6]

Developing a tool for better and early detection of oral cancers is absolutely critical for advancing. Early-stage tumors are more likely to respond to therapy, and patients are more likely to retain more of their normal oral structures, limiting the functional deficits caused by treatment. There is immense potential for advancement in this area of diagnosis since, to date, we are still relying on conventional resources.

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Artificial intelligence and machine learning in dentistry

Artificial intelligence and machine learning have been emerging as powerful tools in dentistry. (Photo: Canva)

By Dr. Rewant Chauhan &
Dr. Saumya Tiwari

Artificial intelligence (AI) and machine learning (ML) have emerged as powerful tools for improving diagnosis, treatment planning, and patient monitoring in dentistry. This article provides a comprehensive overview of the current state of AI and ML in dentistry, including their applications in caries diagnosis, oral radiology, implantology, surgery and periodontal treatment. The benefits and challenges of AI and ML in dentistry are discussed, as well as prospects and opportunities for innovation and development. This article also concludes that AI and ML have great potential in dentistry but that more research is needed to overcome the challenges and fully realize their benefits.

Introduction

AI and ML are transforming various aspects of modern society, including healthcare. AI and ML have shown great potential in dentistry to improve patient care, diagnosis, treatment planning, and disease prevention. Dentists are harnessing the power of these technologies to optimize workflows, reduce errors, and increase the accuracy of dental procedures. This paper explores the role of AI and ML in dentistry, including the current state of the art, benefits, challenges, and prospects.

Overview of artificial intelligence and machine learning

AI refers to algorithms and technologies that mimic human intelligence, including reasoning, problem-solving, decision-making, and perception. AI models can learn from large amounts of data and derive insights that can be used for prediction, object classification, or identifying patterns. AI and ML have shown great potential in dentistry, including diagnosis, treatment planning, surgical procedures, and patient monitoring. By leveraging these technologies, dentists can improve the accuracy and speed of dental procedures, reduce errors, and improve patient outcomes.

Diagnosis

One of the most important applications of AI and ML in dentistry is the diagnosis of oral diseases and conditions. AI models can detect abnormalities, identify caries and predict the risk of periodontal disease by analyzing images such as radiographs, CT, and intraoral photos. For example, a study by Khanagar et al. used a model from ML to analyze panoramic radiographs and predict caries risk in children.1 The model achieved 93% accuracy, outperforming traditional caries risk assessment methods.

Treatment planning

AI and ML can also help dentists plan treatment by analyzing patient data and recommending the best action. By integrating patient data such as medical history, radiographs, and clinical findings into an ML model, dentists can create a personalized treatment plan tailored to the patient's needs. A study by Kohalaka et al. used an ML model to predict dental implant success based on clinical and radiographic data.2 The model achieved 94% accuracy, highlighting the potential of AI and ML in dental implantology.

Surgical procedures

AI and ML can also be used to improve the accuracy and precision of surgical procedures in dentistry. By analyzing 3D models of the patient's teeth and jaw, AI models can simulate the surgical procedure and guide the dentist. Also, a study by Bayrakdar et al. used a deep-learning algorithm to analyze 3D models of the patient's jaw and predict the optimal implant position for dental implantology.3 The model achieved 90% accuracy, demonstrating the potential of AI and ML in guiding dental implant procedures.

Monitoring the patient

AI and ML can also help dentists monitor patient outcomes and predict disease progression. By analyzing patient data such as periodontal measurements, radiographs, and clinical findings, AI models can predict the risk of disease recurrence and recommend appropriate treatment options. A Novel study by Troiano et al. used a model from ML to predict the risk of periodontitis recurrence based on clinical and radiographic data for molar loss over ten years.4 The model achieved 90% accuracy, demonstrating the potential of AI and ML for periodontal disease management.

Benefits and challenges of AI and ML in dentistry

The use of AI and ML in dentistry has several advantages, including:
• Increased accuracy and precision in diagnosis and treatment reduce errors and variability in dental procedures, leading to greater efficiency and cost-effectiveness.
• Streamlining workflow and reducing administrative tasks, allowing dentists to focus on patient care
• Facilitating personalized treatment plans based on individual patient data
• The ability to analyze large amounts of data and identify patterns that are not immediately apparent to the human eye

Challenges of AI and ML in dentistryDespite the many benefits of AI and ML in dentistry, there are also some challenges to overcome, including:
• Privacy and security concerns, as patient data must be protected and secured
• Lack of standardization in data collection and analysis can affect the accuracy and reproducibility of AI and ML models
• Difficulty interpreting the results of AI and ML models, which can make it difficult for dentists to make informed decisions
• The limited data available in certain dentistry areas may make training AI and ML models difficult

Prospects

The future of AI and ML in dentistry is promising, with many opportunities for innovation and development. One promising area of research is the integration of AI and ML with robotics, which may lead to more precise and efficient dental procedures. Another area of research is the development of AI and ML models that can predict the progression of dental diseases such as caries and periodontitis based on genetic and environmental factors. In addition, using AI and ML in teledentistry and remote patient monitoring can improve access to dental care in underserved areas.

Conclusion

AI and ML have shown great potential in dentistry for diagnosis, treatment planning, surgical procedures, and patient monitoring applications. By leveraging these technologies, dentists can improve patient outcomes, reduce errors, and increase the efficiency of dental procedures. However, some challenges need to be addressed, including privacy and security concerns, lack of standardization in data collection and analysis, and difficulties in interpreting the results of AI and ML models. Nevertheless, the future of AI and ML in dentistry is promising and offers many opportunities for innovation and development.

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About:

Dr. Rewant Chauhan

Dr. Rewant, BDS from Govt Dental College & Hospital, Mumbai, is well-versed in a variety of computer platforms and advanced software packages that can assist dental practitioners. He has experience in digital dentistry workflows and CAD-CAM software, which he uses to improve the accuracy and efficiency of dental treatments.

Dr. Rewant holds a patent for an AI model in dentistry. This innovation has the potential to enhance the precision and effectiveness of dental treatments, which could lead to better patient outcomes.

Dr. Saumya Tiwari

Dr. Saumya, BDS from Govt Dental College & Hospital, Mumbai is a professional content writer with a strong interest in business and marketing.

ITI announces new consensus statements and clinical recommendations for implant treatment

Participants from all over the world at the seventh ITI Consensus Conference in Lisbon in Portugal in May. (Image: ITI)

By ITI International Team for Implantology

BASEL, Switzerland: The International Team for Implantology (ITI) once again convened leading experts in implant dentistry and related fields to review the latest literature and establish implant dentistry guidelines for the coming five years during its seventh ITI Consensus Conference, held in early May. The findings were presented at the organisation's annual conference, also held in Lisbon in Portugal in the same week.

Latest ITI consensus statements defined and presented

Three days of intensive exchange by more than 90 professionals at the consensus conference culminated in the distillation of a new set of ITI consensus statements and clinical recommendations based on the latest available evidence. These were presented in a concentrated day of lectures at the very well-attended annual conference.

The ITI holds its consensus conferences every five years to review the latest literature. The discussions at the most recent edition covered five main areas: surgical techniques, technology, oral medicine, patient benefits, and implant placement and loading protocols.

ITI President Dr Charlotte Stilwell said, "Evidence-based implant dentistry is a key part of the ITI's DNA. Our regular ITI Consensus Conferences and the resulting statements and in particular the clinical recommendations ensure that

the implant dentistry community can apply the latest treatment approaches with confidence."

To ensure that the consensus statements are available to as broad an audience as possible, they will be published online in an open-access supplement to Clinical Oral Implants Research later this year. The statements will also be available on the ITI website.

ITI honorary fellowships for 2023

Each year, the ITI takes particular pleasure in distinguishing long-serving ITI fellows for their outstanding achievements in the field of implant dentistry and on behalf of the organisation. At the annual dinner after the annual conference, this lifetime honour was awarded to Dr Luca Cordaro (Italy), Prof. Christoph Hämmerle (Switzerland), Dr Frank Higginbottom (US), Prof. Hideaki Katsuyama (Japan) and Dr Dean Morton (US).

After eight years as chair of the ITI Education Committee, Prof. Daniel Wismeijer (Netherlands) has rotated off the committee and the board of directors. He is being replaced by Dr Nikos Mattheos (Hong Kong), whose strong background in education, particularly as an early adopter of digital education approaches, makes him the ideal choice for this position.

Dr Mattheos commented, "This is a position of responsibility, but also one that offers personal growth and an opportunity to introduce and test ideas, influence future directions and explore new pathways for ITI education and implant dentistry in general."

New ITI sections

Sections represent the ITI's global scope and strength in countries and regions around the world and play a pivotal role in achieving the organisation's collective aspirations. An ongoing process of decentralisation gives sections full freedom to select, adapt and implement educational concepts with the aim of achieving the greatest possible local impact. With the establishment of two new sections, in Colombia and Peru, the ITI now has 36 sections.

New ITI Education Committee chair
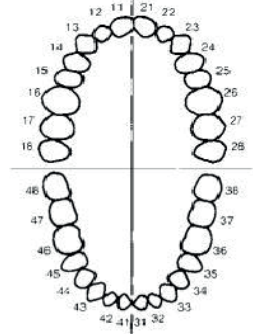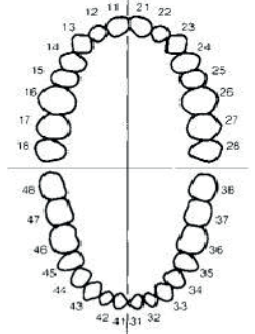

Dr Nikos Mattheos. (Image: ITI)

Researchers use generative artificial intelligence to design realistic dental crowns
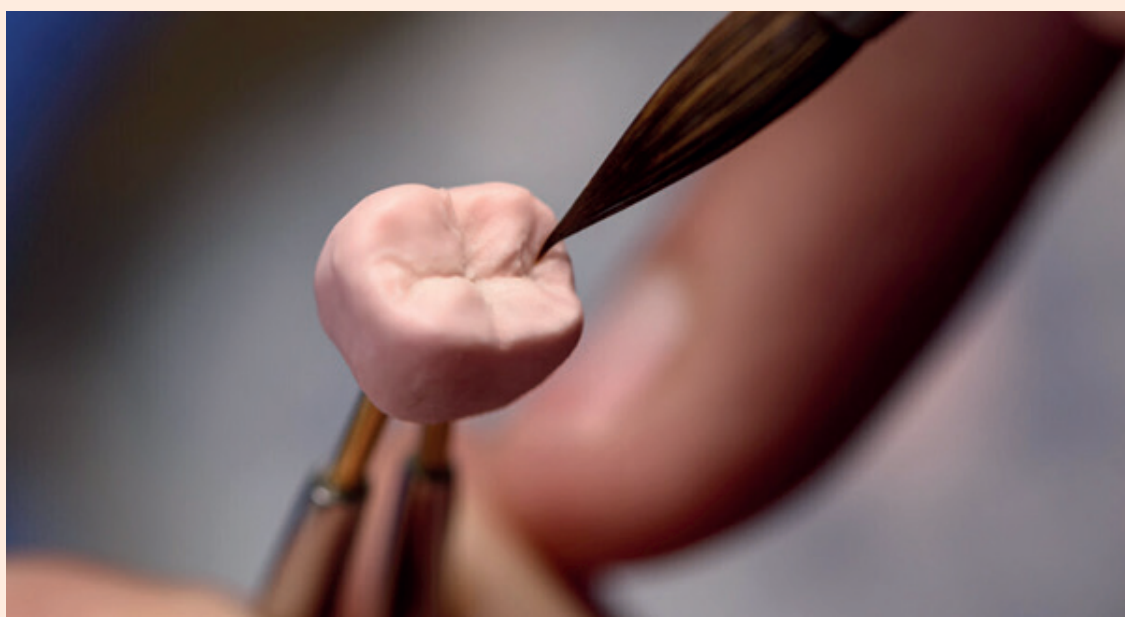
A recent study has reported that thicker lips were considered less attractive by respondents after augmentation. (Image: Kourdakova Alena/Shutterstock)

By Iveta Ramonaite,
Dental Tribune International

HONG KONG: CAD/CAM technology has greatly improved the productivity of dental prostheses but still has its drawbacks when it comes to the design of crowns. Using an artificial intelligence (AI) learning method, researchers from the Faculty of Dentistry at the University of Hong Kong have created an algorithm for personalised dental crown design of high accuracy to produce crowns that resemble the morphology and biomechanics of natural teeth.

According to the researchers, the CAD/CAM workflow has significantly improved dentistry, but is still labour-intensive and time-consuming, particularly because of the need for customisation for each patient, despite CAD software using a tooth library to assist in generating prosthetic designs, and it generates health and environmental hazards during the 3D-printing and milling processes. CAD/CAM remakes are often necessary because of marginal misfits, and design can affect the biomechanical performance and thus the fatigue lifetime of the crown. For this reason, a means of crown design that addresses these issues is needed.

In the study, the researchers trained the algorithm on 600 sets of digital casts of mandibular second premolars and their adjacent and antagonist teeth and tested it on an additional 12 sets of data to generate 12 crowns. They then compared the natural second premolars with the designs created by their algorithm, using CEREC software and by a technician using a CAD program. They looked at morphological parameters of 3D similarity, cusp angle, and number and area of occlusal contact points. They also subjected the designs realised on computer in lithium disilicate to biomechanical fatigue simulations based on physiological occlusal force.

"During the training process, natural teeth morphological features were learned by the algorithm, so that it can design dental crowns comparable to a natural tooth—both morphologically and functionally," lead author Dr Hao Ding, a postdoctoral fellow in applied oral sciences and community dental care at the university, said in a press release.

The generative AI-designed crowns had the lowest 3D discrepancy, closest cusp angle and similar occlusal contacts compared with natural teeth. In lithium silicate, the AI-designed crowns were found to have an expected lifespan similar to that of natural teeth. According to the researchers, the other two methods of designing dental crowns produced crowns that were either too large or too thin and failed to reach the same lifespan as that of natural teeth.

"This demonstrates that [the algorithm] could be utilised to design personalised dental crowns with high accuracy that can not 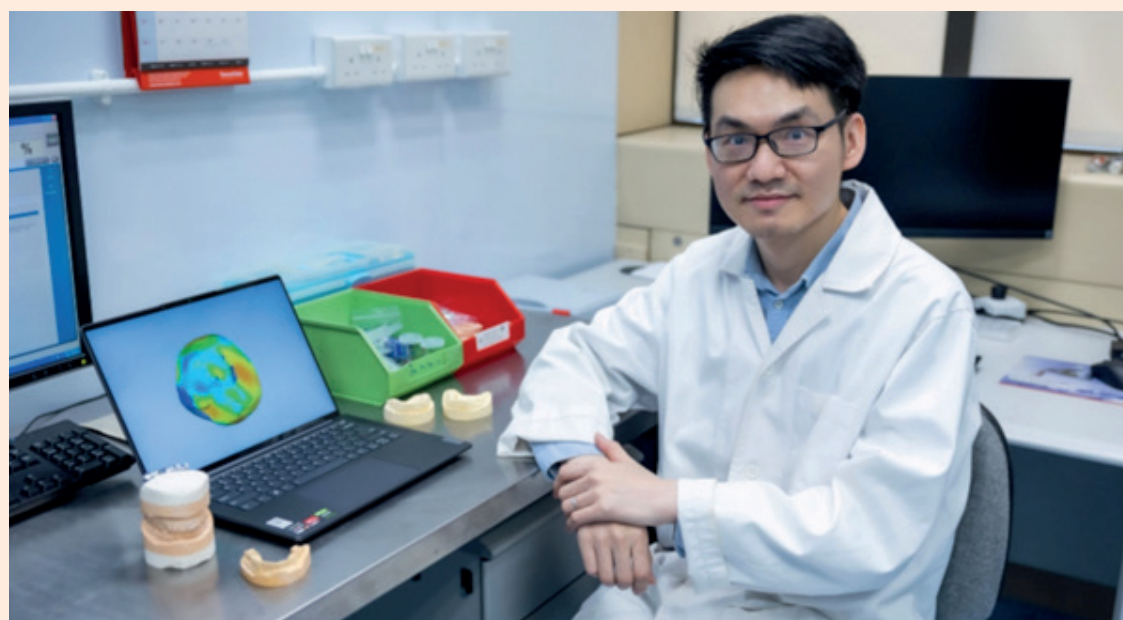only mimic both the morphology and biomechanics of natural teeth, but also operate without any additional human fine-tuning, thus saving additional costs in the production process," added senior researcher Dr James Tsoi, an associate professor in dental materials science at the university.

> *"Many AI approaches design a 'lookalike' product, but I believe this is the first project that functionalises data-driven AI into real dental application"*
> —Dr James Tsoi,
> *University of Hong Kong*

"Many AI approaches design a 'lookalike' product, but I believe this is the first project that functionalises data-driven AI into real dental application. We hope this smart manufacturing technology will be the stepping stone for driving Industry 4.0 in dentistry, which is vital to meet the challenges of an ageing society and lack of dental personnel in Hong Kong," Dr Tsoi stated.

Clinical trials for using the generative AI for dental crowns are underway. Additionally, the researchers are working to expand the applicability of the tool to other dental prostheses, such as partial and complete dentures.

The study, titled "Morphology and mechanical performance of dental crown designed by 3D-DCGAN", was published online in the March 2023 issue of *Dental Materials*.

Lead author Dr Hao Ding. (Image: University of Hong Kong)

DENTAL TRIBUNE
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Greener Dentistry toolkit helps dental practices get accredited

*Dr Davinder Raju.
(Image: Davinder Raju)*

Greener Dentistry aims to promote sustainable dentistry & eco-friendly dental practices. (Image: Canva)

By Dr. Rajeev Chitguppi

Dr Davinder Raju is the lead dentist at Dove Holistic Dental Centre in Bognor Regis in the UK and the founder of Greener Dentistry, an online platform that helps dental practices become more environmentally conscious and reduce their carbon footprint. This article shares a press release about the new toolkit from Greener Dentistry that helps practices go green and achieve accreditation.

Greener Dentistry is dedicated to making the dental profession more sustainable and is excited to announce the launch of its new comprehensive toolkit for greener dentistry. This innovative toolkit provides dental professionals with practical, easy-to-implement eco-initiatives to help reduce their environmental impact.

"Traditional dental practices generate a significant amount of waste and consume a lot of resources," said Greener Dentistry founder Davinder Raju. „We wanted to create a toolkit that breaks down sustainability into manageable steps, so dental professionals can positively impact the environment without sacrificing the quality of care they provide to their patients."

The toolkit includes a range of eco-initiatives, from reducing water and energy consumption to minimizing waste and using environmentally-friendly products. Best of all, the entire toolkit is free for all dental professionals. For those who want to take their commitment to sustainability a step further, membership is available for only £12 per month.

Members who achieve a certain level of sustainability will be eligible for an accreditation award and a license to use the Greener Dentistry certification mark. This mark demonstrates a commitment to sustainable practices and can help dental professionals attract environmentally conscious patients.

"We believe that sustainability should be accessible to everyone, which is why we've made our toolkit free to use," added Davinder Raju. "We're excited to see how the dental profession will embrace these eco-initiatives and work towards achieving our accreditation award."

Greener Dentistry is committed to helping dental professionals make sustainable changes to their practices. Our comprehensive toolkit is the first step towards a greener future for the dental profession.

To learn more about Greener Dentistry and the Greener Dentistry toolkit, visit https://greenerdentistry global.

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Cheers to new beginnings: Celebrating oral tissue regeneration

The International Osteology Symposium 2023 offered participants a wide range of lectures, panel discussions and interactive workshops that covered various aspects of oral tissue regeneration. (Image: Osteology Foundation)

By Osteology Foundation

BARCELONA, Spain: The International Osteology Symposium 2023 was held in Barcelona from 27 to 29 April, and the event was a resounding success, drawing 2,400 participants from 80 countries. Organised by the Osteology Foundation, the symposium marked the foundation's 20th anniversary and provided expert researchers and practitioners with the chance to explore the latest advances in the field of oral tissue regeneration.

The event kicked off with with the symposium's workshop programme. A highlight of the three-day event, the fully booked Osteology workshops featured discussions on a comprehensive range of topics, including modern techniques in soft-tissue management using autologous and substitute materials, reconstructive procedures for peri-implantitis defects, and the latest in minimally invasive periodontal regeneration and recession coverage around

teeth and dental implants. The founding partners of the foundation (Geistlich, BioHorizons Camlog, botiss biomaterials, Dentsply Sirona and Straumann) were present, and they offered attendees a hands-on opportunity to experience special techniques and materials. Participants who missed out on places in the highly sought-after workshops had the opportunity to enjoy an exclusive pre-congress session in oral tissue regeneration.

Opening of the regenerative marathon

The symposium was officially opened at the end of day two by Prof. Frank Schwarz, vice president of the Osteology Foundation. Together with scientific chairs Dr Pamela K. McClain and Dr Istvan Urban, Prof. Schwarz set the stage for what promised to be an unforgettable event.

Over the course of the following two days, participants attended a wide range of lectures, panel discussions and interactive workshops that

covered various aspects of oral tissue regeneration. The topics covered included different strategies of hard-and soft-tissue augmentation around teeth and dental implants, prevention and management of complications and errors, and the pressing issue of peri-implantitis. These topics were complemented by lectures about innovative technologies and blood products for tissue augmentation, and regenerative approaches in interdisciplinary dentistry.

Bringing theory to life with live surgery

The programme boasted two remarkable live surgical demonstrations that were performed by the celebrated surgeons Dr Urban and Dr Sofia Aroca. The live surgery provided attendees with a unique opportunity to witness these masters of oral tissue regeneration in action as they performed complex procedures in real time. The surgeons' exceptional skill, precision and expertise were on full display, and they shared their knowledge and experience with

the audience in an immersive and interactive setting.

Further highlights of the programme included:
•	Research Networking Day and poster exhibition for young researchers, inlcuding research and ausdience awards;
•	a case session with six outstanding cases competing for the Osteology Case Award;
•	a lively debate on the treatment of intact and compromised extraction sockets, with a focus on immediate versus delayed implant placement;
•	proceedings from the Osteology DGI SEPA Consensus Workshop;
•	Osteology Partner Sessions from the American Academy of Periodontology and the Spanish Society of Periodontology and Osseointegration;
•	the practice-oriented wrap-up session "Oral regeneration in a nutshell", which covered various sub-topics; and
•	a jubilee evening as a platform for networking and exchange.

The International Osteology Symposium 2023 was an exceptional achievement, a true celebration of the foundation's 20th anniversary and a testament to its unwavering commitment to advancing oral tissue regeneration. The international community of professionals who attended the jubilee event left with a wealth of new knowledge and practical skills that will undoubtedly shape their daily practice in the years to come and with invaluable connections with like-minded colleagues gained during their time in Barcelona.

Visit the Osteology Foundation's website for more information on the annual symposium.

The International Osteology Symposium 2023 marked 20 years since the founding of the Osteology Foundation. (Image: Osteology Foundation)

The event took place from 27 to 29 April and featured 80 lectures and 14 workshops. (Image: Osteology Foundation)

Cheers to new beginnings. (Image: Osteology Foundation)

The venue, the Barcelona International Convention Centre, is one of the city's most recognisable architectural gems. (Image: Osteology Foundation)

Delegates arriving at the event. (Image: Osteology Foundation)

Dr Pamela K. McClain, scientific chair of the International Osteology Symposium Barcelona 2023. (Image: Osteology Foundation)


Morning with the Masters: Dr Giovanni Zucchelli of Italy held a presentation on soft-tissue augmentation around teeth and dental implants. (Image: Osteology Foundation)

During the symposium, Dr Frank Schwarz, vice president of the Osteology Foundation, succeeded Dr Christer Dahlin as the foundation's president. (Image: Osteology Foundation)

The Symposium programme featured numerous established as well as upcoming experts in the field of oral tissue regeneration. (Image: Osteology Foundation)
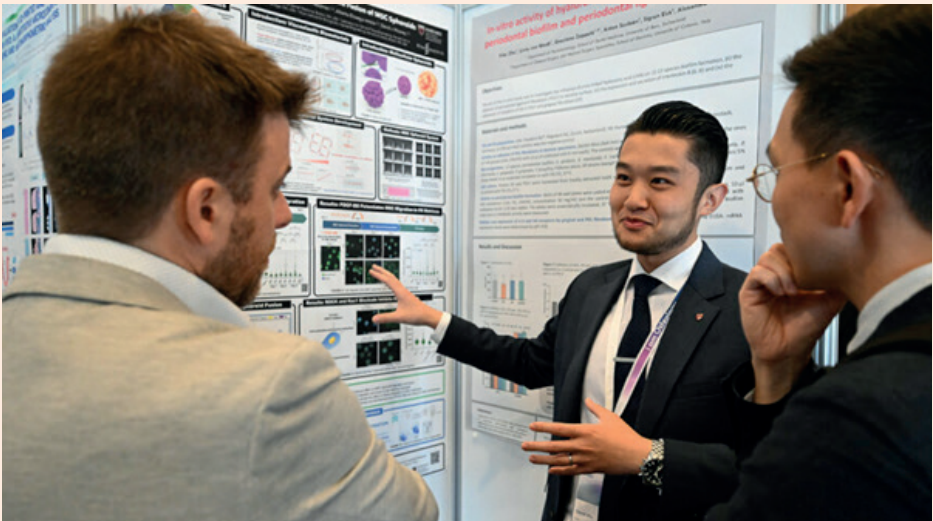
Dr David Wu (centre) during the event's poster exhibition and research networking day. (Image: Osteology Foundation)

The symposium provided young as well as experienced oral surgeons with the opportunity to deepen their knowledge of hard- and soft-tissue management. (Image: Osteology Foundation)

The programme boasted two remarkable live surgeries that were performed by the celebrated surgeons Prof. Istvan Urban and Dr Sofia Aroca. (Image: Osteology Foundation)
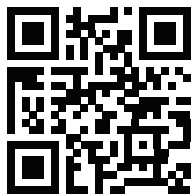
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