

# CBCT

CONE BEAM COMPUTED TOMOGRAPHY  
MAGAZINE

## pink issue

### **DIGITISATION IN HEALTH CARE: THE PARADIGM SHIFT**

**DR. SUNALI KHANNA**



### **THE EVOLUTION OF DIGITAL DENTISTRY: A PARADIGM SHIFT IN ORAL CARE**

**DR. PRASHANTHI REDDY**



### **ARTIFICIAL INTELLIGENCE IN DENTAL RADIOLOGY**

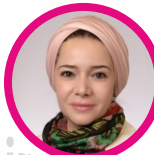
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### **BEYOND CLINICAL DIAGNOSIS, HOW ARTIFICIAL INTELLIGENCE CAN MAKE OUR JOBS EASIER.**

(Artificial Intelligence Solutions in Dentistry)

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### **XVI INTERNATIONAL CAI MEETING & 'PIONEERS COURSE' ATHENS 2023**



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Guest Editor  
**Dr. Sushma Jaju** BDS, MDS  
Conservative Dentistry  
& Endodontics (India)

## FROM THE EDITOR'S DESK

## FROM THE EDITOR'S DESK

Hello Readers of CBCT magazine,

I am honoured to be the guest editor for this exclusive issue - PINK issue, which is dedicated to all the female authors.

"Strong woman don't have Attitudes, we have Standards"

With ever changing landscape of dentistry, pioneering women have broken away from the traditional barriers for their gender and have raised the bar for their female successors who have chosen dentistry as their preferred path.

In the United States, Emeline Roberts Jones was the first practicing female dentist, having taught herself basic fillings and extractions in secret. She joined her husband's dental practice in 1855 and, after his passing, continued to practice on her own.

Dr Vimal Sood was also the first Indian woman dentist to pursue her post graduation in pediatric dentistry.

Today, studies show that in the majority of countries with available data, women graduates outnumber their male counterparts in dental schools, and this is certainly the case in Indian subcontinent.

About 50-60 % of students in all dental schools in India are female and about 15% deans in dental schools across the country are women.

Women working in oral health help shape a vibrant system that defines the future of the profession, promotes a more inclusive health policy, advances research, practice and clinical care.

We are proudly presenting you this special issue from our eminent female authors who are showcasing their work and sharing their valued experiences with our readers on various aspects of dentistry.

Guest Editor  
**Dr. Sushma Jaju** BDS, MDS  
Conservative Dentistry & Endodontics (India)



## DIGITISATION IN HEALTH CARE: THE PARADIGM SHIFT

**Dr Sunali Khanna**

Associate Professor  
Nair Hospital Dental College, Mumbai

She has authored 75 papers in reputed International and National Journals and has addressed 60 International Conferences and eminent national forums. She became the first and only candidate to qualify the D.N.B (Diplomate of National Board Examination) in Oral Medicine & Radiology till now.

**A**dvancement in Science and technology has without any doubt made our lives better than the earlier times. We cannot refute the fact that the life of each one of us is highly dependent on the modern-day technology. Such technologies have contributed to digitisation in healthcare thus transforming healthcare operations. From electronic health records, orders, digital x-rays to robotic surgeries, modern day health technologies and digitisation has enhanced the patient care.

Digital health or digital healthcare is a broad multidisciplinary concept that includes concepts from an intersection between technology and healthcare. These include changes related to documentation, contact, referrals, orders, upgraded therapies, technologies, improved screening and diagnosis and targeted treatment approaches with minimal ergonomic issues.

Digitisation has also impacted medical education. Young doctors today have multiple ways to learn, treat and get trained with minimal human interference. Things have become less labour oriented therefore decreased human errors. Better imaging and treatment modalities have brought better understanding of grey areas.

Digitisation has also made patient care easy and straight forward. The most significant upgrade is "placing patients' health in patients' hands". In this way, patients are given the right in decision making regarding their treatment. In coming years, patients will be able to access all the treatment options and details of their health condition in their phone, thus seeking control over their management. This will help to achieve "patient-centred care" as the cornerstone of medical practice. Recent developments in e-health/digitisation have made continuous and comprehensive healthcare easy and largely automatic. This is further refined by automated reminders to follow up, refill orders, timely follow up, comprehensive care and social support. It has also improved patient privacy due to better and

upgraded encryption codes along with collection, storage, exchange and retrieval of patient information.

Telemedicine is an integral part of digitisation and a step towards shrinking the world of healthcare. It benefits the accessibility of healthcare services. It meets higher demands of health care for the population who do not have access to tertiary hospitals. There are several applications in play store that has made telemedicine possible in India. Few examples are Tata MG, Pharmeasy, Sabka dentist, Toothsi, Practo. However, there is a downside to this. Lack of clinical examination, connectivity problems, patient's belief in the systems, misuse of online generated prescriptions, lack of appropriate investigations, high cost of equipment to name a few. However, there are some significant obstacles before complete consolidation of telemedicine.

In 2007, World Health Organisation adopted the broad description of telemedicine: "The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for the diagnosis,



Digital developments in multiple areas are causing massive shifts. Digital transformation can speed up healthcare by reducing costs and improving services. Digital technology is utilized to healthcare innovation as in other fields. However, digitisation in healthcare has multi-dimensional problems and is therefore in its teething phase.

In modern society, national borders are irrelevant because cyber space business across multiple industries have received new opportunities with the shift of their business models incorporating the use of digital technologies. The digital revolution has taken business sectors to a new height through the advancement of technology. The healthcare sector also embraced digital technology to facilitate technological change from mechanical and analogue electronic devices to the digital technology that is available today. Many medical advances have been and gone over millennia; and none has impacted digital technology.

Networking and computer innovations have enhanced the spectrum of medical therapies and changed how doctors work. But, like every coin has two sides, the massive transformation in health care sector comes at high investment and maintenance prices. Despite the

high cost, benefits like huge reduction in plastic and other wastes, have contributed to the environmental conservation. Digitisation in healthcare is one of the bold steps towards a sustainable ecosystem.

For instance, India and other developing countries across the world have always struggled with population dividend and unequal distribution of healthcare services and health disparities. The tertiary hospitals with sophisticated diagnostic and treatment modalities are an asset to the healthcare infrastructure.

To facilitate changes, healthcare industry has an integrated, equitable and comprehensive model over the years. Patient outcomes can be improved with customized care by which individual needs will be prioritized. Therefore, the incorporation of digital technology serves comprehensive healthcare by focusing on individual needs. In developing nations, digital health systems have the potential to improve healthcare performance and make it easier to accomplish strategic objectives.



# THE EVOLUTION OF DIGITAL DENTISTRY: A PARADIGM SHIFT IN ORAL CARE

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## ABSTRACT

In recent years, the field of dentistry has witnessed a transformative evolution through the integration of digital technologies into various aspects of oral healthcare. This paradigm shift, often referred to as digital dentistry, has not only revolutionized traditional dental practices but also significantly impacted the realm of oral medicine. This article explores the definition, historical development, and the pivotal role of digital dentistry in both dentistry and oral medicine. Furthermore, it sheds light on the future of digital dentistry in India and concludes by emphasizing its promising prospects in enhancing oral healthcare.

## INTRODUCTION

Digital dentistry has revolutionized the field of dental healthcare by integrating cutting-edge technology into various aspects of diagnosis, treatment planning, and patient care.[1] Digital imaging techniques such as cone-beam computed tomography (CBCT) and intraoral scanners allow for precise three-dimensional representations of the oral cavity, aiding in the detection of dental issues with unparalleled detail. This accuracy translates into better treatment outcomes, reduced errors, and ultimately, improved patient satisfaction. Furthermore, digital dentistry reduces the need for traditional, uncomfortable dental impressions, as digital impressions can be obtained quickly and painlessly. The integration of computer-aided design and computer-aided manufacturing (CAD/CAM) technology allows for the efficient creation of crowns, bridges, and other restorations, often in a single visit. This not only saves time but also reduces the inconvenience associated with multiple appointments. Overall, digital dentistry offers a plethora of benefits, including increased precision, enhanced patient communication, improved workflow efficiency, and a more comfortable and convenient patient experience. As technology continues to advance, the field of digital dentistry is poised to further transform the way oral healthcare is delivered and experienced. [2]

## DEFINITION

Digital dentistry encompasses the utilization of advanced digital technologies and computer-based systems to diagnose, plan, and execute dental treatments effectively and efficiently. It comprises various aspects, including digital radiography, intraoral scanning, computer-aided design and computer-aided manufacturing (CAD/CAM), three-dimensional (3D) printing, and virtual treatment planning. Digital dentistry serves as a bridge between traditional dental practices and modern technological innovations, offering improved precision, patient comfort, and workflow efficiency. [3]

## HISTORY

The journey of digital dentistry dates back to the mid-20th century, with the development of the first dental radiographic imaging systems. The advent of digital radiography revolutionized dental diagnostics by providing immediate, high-quality images with reduced radiation exposure for patients. Over the years, the field expanded to encompass various digital tools and techniques. [4] The introduction of intraoral scanners in the late 20th century marked a significant milestone. These devices replaced traditional impressions, which were often uncomfortable and time-consuming for patients, with digital impressions that are more accurate and less invasive. Subsequently, CAD/CAM technology emerged, allowing for the fabrication of dental restorations such as crowns, bridges, and veneers with exceptional precision. [5] The incorporation of 3D printing technology in dentistry further enhanced treatment possibilities. It enabled the production of customized dental implants, prostheses, and orthodontic devices with unparalleled accuracy and speed. Today, digital dentistry has become an integral part of dental practices worldwide, facilitating comprehensive patient care. [6]

## IMPORTANCE IN DENTISTRY

Digital dentistry has significantly impacted the field of dentistry in multiple ways, making it indispensable for modern dental practices.

### Enhanced Diagnosis:

Digital radiography and 3D imaging have improved diagnostic accuracy by providing detailed views of oral structures, aiding in the detection of dental caries, periodontal disease, and dental anomalies.

### Precision in Restorations:

CAD/CAM technology allows for the creation of precise, aesthetically pleasing dental restorations in less time, reducing chairside adjustments and enhancing patient satisfaction.

### Efficient Workflow:

Digital records and treatment planning streamline administrative tasks, improving practice efficiency and patient management.

### Patient Experience:

Intraoral scanning eliminates the discomfort associated with traditional impressions, enhancing the patient experience and increasing compliance with recommended treatments.

### ● **Teledentistry:**

Digital tools enable remote consultations and treatment planning, making dental care more accessible, especially in remote or underserved areas.

### ● **Orthodontics and Digital Dentistry:**

Digital dentistry has transformed orthodontics through the introduction of 3D imaging, digital treatment planning, and clear aligner therapy. Orthodontists can visualize the movement of teeth and plan treatments more accurately using digital models. Patients benefit from the convenience of removable clear aligners and shorter treatment times compared to traditional braces.

### ● **Implantology:**

Implant dentistry has greatly benefited from digital workflows. CBCT imaging, guided implant surgery, and computer-aided implant planning enhance the precision and predictability of implant placement. Digital technology also allows for the creation of patient-specific surgical guides, reducing the risk of complications.

### ● **Facial scanners and software packages:**

have the potential to digitize and replace conventional extraoral records, analog facebow, occlusal analysis, and diagnostic wax-ups. The development of collecting a facebow record, tracking the mandible, and digitally constructing a smile-all of which can be used to make a virtual patient will be discussed in this section. This virtual patient's information enables the dentist to digitally arrange therapy for a variety of dental specialties, including smile design, orthognathic surgery, maxillofacial prosthodontics, and prosthesis and implant rehabilitation. This system provides information that facilitates digital communication between providers, patients and laboratory technicians in order to achieve a more predictable end result. [14]

### ● **Virtual articulators and digital facebows:**

Virtual facebows would be used to orient digital models within virtual space with respect to a reference plane, after which the models would be articulated with respect to one another. Various methods for transferring the virtual facebow have been published in the literature, including facial scanning with reference points, pictures, and stereophotogrammetry. Virtual facebows and articulators have the advantage of avoiding common problems associated with traditional manual articulating procedures, such as material distortion, inaccuracies during orientation and positioning, and difficulty modelling patient data in 3D. Eliminating these obstacles could boost productivity and reduce difficulties during prosthesis delivery.[14]

### ● **Smile designing:**

Smile designing: In order to streamline the design process and increase predictability of the outcomes, digital smile design protocols and methods were developed to be used in conjunction with Keynote, PowerPoint, or other specialised programmes. The patient's face features are captured digitally in digital workflows with facial scanners, and conversions that were formerly performed by hand can now be done virtually, preventing the introduction of those error.[14]



## ● **Shade matching:**

Shade guides are another name for shade-matching devices. Value, chroma, and hue are chosen in that order when choosing a shade. Color matching should be done in a systematic way that ensures accuracy, uniformity, predictable results which are absolutely important in esthetic dentistry. [15]

## ● **Forensic dentistry:**

Digital forensics could be defined as the "application of computer science and investigative techniques for a legal purpose involving the analysis of digital evidence." The use of digital forensic investigations is becoming more widespread as a result of technological developments and the identification of root causes, particularly in cases involving large-scale catastrophes like terrorism, aviation, tsunamis, and earthquakes. Additionally, after a suspect has been tentatively identified, dental radiographs are crucial in the identification and age estimation processes by comparing antemortem (AM) and postmortem (PM) data. The problems in interpretation or inaccurate identification that could occur with conventional radiographs in the current period have been greatly decreased by the use of digital radiography. [16] Using the manual cast approach during bite mark analysis may present challenges since it increases the risk of unintentional damage to the evidence. Using optical surface scanners, often referred to as fringe pattern protection scanners, such as the Gom ATOS III (Gom, Braunschweig, Germany), which display high-resolution results without causing any harm to the evidence.[17]

# ● **IMPORTANCE IN ORAL MEDICINE**

Beyond its impact on traditional dental procedures, digital dentistry plays a crucial role in the field of oral medicine. Oral medicine encompasses the diagnosis and management of various oral and maxillofacial diseases, including oral cancer, oral mucosal disorders, and temporomandibular joint disorders. Digital dentistry contributes to this field in the following ways:

## ● **Early Detection of Oral Pathologies:**

Digital radiography and 3D imaging enable the early detection of oral lesions and abnormalities, improving the chances of successful treatment and reducing morbidity.

## ● **Non-Invasive Methods for Diagnosis of OSCC:**

Optical detection systems i.e. VELscope, Optical coherence tomography (OCT), Artificial intelligence.

## ● **Precise Treatment Planning:**

CAD/CAM technology aids in the planning and execution of complex oral surgeries, ensuring optimal outcomes for patients with conditions like oral cancer or temporomandibular joint disorders.

## ● **Monitoring Progress:**

Digital records allow for the systematic monitoring of patients with chronic oral conditions, facilitating ongoing care and treatment adjustments as needed.

## ● **Research Advancements**

Digital technologies provide valuable data for research in oral medicine, contributing to the development of new diagnostic tools and treatment modalities.

- Digital imaging techniques, such as cone-beam computed tomography (CBCT) and intraoral scanning, have become essential tools in oral medicine. CBCT provides three-dimensional images with lower radiation exposure than traditional CT scans, allowing for more accurate diagnoses of complex conditions like temporomandibular joint disorders and impacted teeth. Intraoral scanners facilitate the creation of precise digital impressions, reducing patient discomfort and enhancing the accuracy of prosthetic restorations.

## FUTURE IN INDIA [9, 10]

In India, digital dentistry is rapidly gaining traction and holds great promise for the future of oral healthcare. Several factors are driving its growth in the country:

- **Technological Advancements:**  
India's growing tech industry and access to cutting-edge digital technologies are facilitating the adoption of digital dentistry practices across the nation.
- **Increased Awareness:**  
Increased Awareness: Both dental professionals and patients in India are becoming more aware of the benefits of digital dentistry, leading to its wider acceptance.
- **Cost-Effective Solutions:**  
As digital dentistry becomes more prevalent, the cost of digital equipment and services is expected to decrease, making it accessible to a broader segment of the population.
- **Teledentistry for Rural Areas:**  
Digital dentistry, including teledentistry, has the potential to address oral healthcare disparities in rural and underserved areas, where access to dental care is limited.
- **Academic Integration:**  
Dental education institutions in India are increasingly incorporating digital dentistry into their curricula, ensuring that future dental professionals are well-versed in its applications.  
The future of digital dentistry in India is bright, with the potential to revolutionize the oral healthcare landscape, improve patient outcomes, and reduce oral disease burdens across the country. [12]

## CONCLUSION

Digital dentistry has emerged as a transformative force in both dentistry and oral medicine. Its ability to enhance diagnostics, treatment planning, and patient experience has made it an invaluable tool for dental professionals. In the context of oral medicine, digital dentistry facilitates early disease detection and precise treatment planning, ultimately improving patient outcomes. Looking ahead, India is poised to embrace digital dentistry with open arms, leveraging its technological prowess and expanding access to high-quality oral healthcare. As digital dentistry continues to evolve and become more accessible, it will undoubtedly play a pivotal role in shaping the future of dentistry and oral medicine, ultimately benefiting patients and dental professionals alike. With ongoing advancements and increasing integration, digital dentistry promises to usher in a new era of excellence in oral healthcare, positioning India as a leader in this innovative field.

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# ARTIFICIAL INTELLIGENCE IN DENTAL RADIOLOGY

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## ABSTRACT

This review's purpose is to examine the creation and application of AI technology in literature while assisting radiologists in comprehending the lingo and fundamental ideas behind this technology, which will soon be included into clinical workflow.

## INTRODUCTION

Artificial intelligence is an area of computer science that enables machines to emulate intelligent human behavior through software-based algorithms. Two eminent scientists, Alan Turing and John McCarthy, established the principles of artificial intelligence in the 1950s. The artificial intelligence winter, which took place between 1973 and 1980 and 1987 to 1993, historically hampered the progress of the field, even though the groundwork had been done long before. Following Deep Blue's victory over Garry Kasparov, the artificial intelligence program created by IBM started to acquire popularity around the end of the 1990s (1-4).

The four pillars of artificial intelligence techniques are genetic algorithms, expert systems, fuzzy logic, and artificial neural networks. Rules-based systems called "expert systems" are developed using the knowledge or opinions of a specialist. On the basis of the stated rules and based on the cause-and-effect relationship, a conclusion is anticipated to be reached. Blurred logic is a rule-based system once more, but rules are not binding directives. You can use the ambiguous rules we apply in daily life as an example of muddled logic. A pattern of neurons in the brain serves as the foundation for artificial neural networks. Neurons and their connections are essential for learning in humans. Artificial neural network learning is accomplished using the same modeling. Today, artificial intelligence methods are of interest to many researchers in the fields of design, biomedicine, and medicine (3-6).



Digital imaging techniques, such as cone-beam computed tomography (CBCT) and intraoral scanning, have become essential tools in oral medicine. CBCT provides three-dimensional images with lower radiation exposure than traditional CT scans, allowing for more accurate diagnoses of complex conditions like temporomandibular joint disorders and impacted teeth. Intraoral scanners facilitate the creation of precise digital impressions, reducing patient discomfort and enhancing the accuracy of prosthetic restorations.

Companies frequently employ artificial intelligence applications to offer services to society today, and they do so in a variety of ways. Security screen systems that recognize faces and voices, spam messages that are sent to mailboxes, autonomous tools, and firm recommendation notifications have all become commonplace. As it is employed in various industries, artificial intelligence has found usage in medicine and dentistry. Artificial intelligence has grown to be a crucial part of many healthcare applications, including drug development, remote patient monitoring, medical diagnostics and imaging, risk management, wearable technology, virtual assistants, and hospital administration. Knowing the fundamentals of AI, such as machine learning, deep learning, and neural networks, is important to comprehend current AI applications (Figure 1) (7-11).

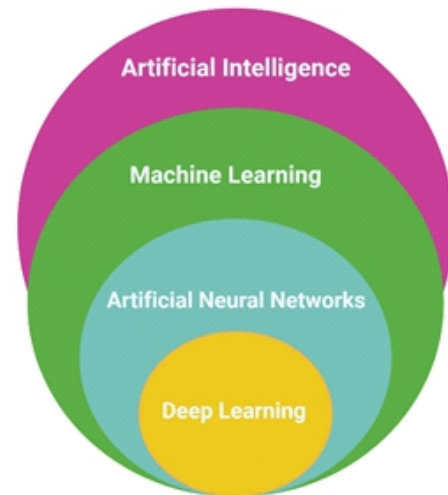


Figure 1. Key elements of artificial intelligence systems

## MACHINE LEARNING

A subset of artificial intelligence, machine learning is a computing program created to replicate human intellect. It develops by learning from its surroundings. The underlying challenge of machine learning is "How do we make machines that solve problems or how do we enable machines to program themselves?" Machines are now permitted to display many samples and identify different samples rather than utilizing conventional formulations. Then, through prior learning, it is anticipated that the machine will distinguish the samples from the random samples it encounters. The machine learning-based methods created with this logic have found success in a variety of sectors, including pattern recognition, computer vision, spacecraft engineering, finance, entertainment, computational biology, and biomedical and medical applications (7-11).

## DEEP LEARNING

Machine learning has a subset known as deep learning. It is technically regarded as a far more significant advance than artificial neural networks. Deep learning involves building neural networks with numerous layers, each of which uses the outputs of the previous layer as its input. In essence, it is made up of an input layer, an output layer, and numerous hidden layers in between. The various hidden layers that make up the algorithm structure (Figure 2) are the source of the word's use (7-11).

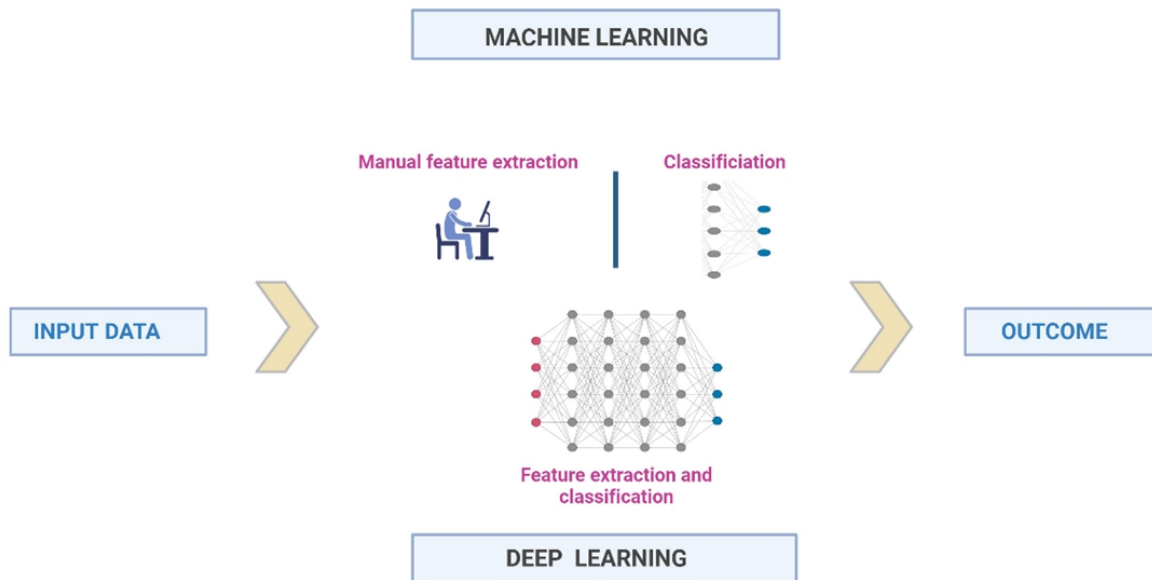


Figure 2. Schematic presentation of deep learning

Deep learning has expedited advancements, particularly in computer vision, making it possible to analyze medical images, such as by segmenting them. Deep learning is currently used in the fields of image recording, image combinations, image descriptions, computer-aided diagnosis (CADx) and prognosis, lesion/local detection, and microscopic image analysis. A few technological advancements are crucial to deep learning's success. The availability of vast amounts of data (big data), the development of learning algorithms, and advances in high-tech product-centric central processing units (CPUs) and graphics processors (GPUs) are essential components of the success of deep learning, as learning requires the processing of vast amounts of data by computers (11-13).

## NEURAL NETWORKS

Computer systems called neural networks are modeled after the biological nerve networks that make up the human brain. Without being coded with particular rules for the activity, these systems frequently learn to do tasks by taking examples into account. This consists of a network of interconnected computer processors that can learn from previous experiences, interpret nonlinear data, handle erroneous data, and allow the model to be applied to other types of data. The most frequently used algorithms for image processing nowadays are neural networks (6).

## ORAL RADIOLOGY AND ARTIFICIAL INTELLIGENCE

Because it can identify and classify lesions that the human eye might miss, computer-based diagnosis is becoming more and more common in clinical settings. The digital storage of medical imaging data has undergone a revolution in the last 20 years thanks to advancements in imaging technology and related research. In order to maximize compliance and patient outcomes and improve the accessibility and effectiveness of the current healthcare system, this data must be processed in a form that can be utilised with AI (14).

Due to its special ability to learn, AI may be included into imaging systems like digital radiography, KIBT, ultrasound (USG), and magnetic resonance imaging (MRG) in the field of head and neck imaging to detect slight deviations from normality that can go unnoticed by the human eye. By handling patient appointments as well as data archiving, retrieval, and reporting models, AI supports the workflow of oral radiology. The usage of these programs for diagnosis and treatment planning is growing in popularity as intelligently created programs that extract data from vast data clouds (shared storage) become more widely available. It is now simpler for artificial intelligence to access medicine thanks to radiology's capacity to create digitally encoded images that can be more easily translated into computer language (14).

The use of artificial intelligence in dentistry is expanding because it helps practitioners by enhancing patient care and makes complicated protocols simpler by ensuring a predictable result. By identifying periapical bone abnormalities from dental radiographs, Mol et al. (15) made the first dental use of artificial intelligence in 1991. AI has been applied to dental radiology to enhance picture interpretation. Since most of the imaging techniques used in maxillofacial radiology are based on X-rays, most of the AI models that have been suggested in studies have been created to address clinical issues

with teeth and jaws. The capacity of AI diagnostic models to properly find root canal openings, identify vertical root fractures, and identify proximal caries has received excellent feedback from numerous preclinical studies. Convolutional neural networks, which are capable of image categorization, detection, segmentation, registration, creation, and augmentation, have been the key tool employed in recent research on artificial intelligence in dental imaging (15-19).

In the realm of radiology, artificial intelligence systems have been created for image analysis, image quality enhancement, and radiographic diagnosis. To get good results, significant amounts of data must be collected, and oral radiologists' participation in research is crucial for gathering reliable and consistent data sets (20,21).

According to the literature, artificial intelligence studies have been carried out radiographically, most frequently with panoramic and CBCT images (Cone Beam Computed Tomography). Although studies in the field of general dentistry are often performed with panoramic radiographs, bite-wing and periapical radiographs are used for caries diagnosis; cephalometric radiograph for anatomical landmark determination. There are also studies using hand-wrist radiographs to detect orthodontic development (22-26).

Studies on the detection of tooth numbers by artificial intelligence have shown very good success rates in terms of diagnostic accuracy. Kuwada et al.'s research, which found the existence of extra teeth in the maxilla anterior region, obtained a 100% accuracy rate (19). Studies using panoramic radiography to diagnose extra-root and vertical root fractures similarly produced good accuracy (86.9%) and sensitivity rates (98.9%) (22).

The majority of studies in the field of radiology have used two-dimensional images, but the number of studies using CBCT sections has rapidly increased. Artificial intelligence algorithms are intended to be able to count teeth, identify root canal morphology, and separate pathological formations from anatomical features in CBCT sections. In CT sections, artificial intelligence was 95% successful in identifying teeth and tooth roots, according to Lahoud et al. (26). Setzer et al. (27) discovered that while the accuracy rate (93%) was high enough, the sensitivity rate (65%) was insufficient for detecting the presence of periapical disease.

Detecting lymph node metastases, identifying osteoporosis risk, diagnosing Sjögren's syndrome, and conducting mouth cancer screenings are more radiology applications of artificial intelligence algorithms. According to a study using computed tomography slices and convolutional neural networks, Sjögren's syndrome could be reliably identified 96% of the time. Using the deep learning technology, it was also possible to detect lymph node metastasis in computed tomography slices with high accuracy. Deep learning algorithms have been found to be just as accurate in identifying osteoporosis risk as skilled radiologists, with accuracy rates of 92.79% (28-31).

## CONCLUSION

It will be possible to diagnose problems at an early stage thanks to the algorithms that will be developed, as well as time and money savings in diagnosis and treatment services, thanks to the rapidly expanding artificial intelligence applications in all fields of dentistry. Artificial intelligence applications are anticipated to advance and spread to every patient in the near future, resulting in maximum patient happiness with the fewest mistakes and hazards.

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## ● **BEYOND CLINICAL DIAGNOSIS, HOW ARTIFICIAL INTELLIGENCE CAN MAKE OUR JOBS EASIER.** (Artificial Intelligence Solutions in Dentistry)

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**A** I has revolutionized the way we view, analyze, and manipulate our 3D dental images. In today's digitally driven dentistry, we are witnessing a boom of commercially available AI-based cloud platforms and apps aiming to facilitate the steps incorporated in today's dental digital workflow.

In their recent systematic review and literature analysis of "Where Is the Artificial Intelligence Applied in Dentistry?" (Thurzo et al., 2022), the authors state that "the majority of AI utilization is currently focused on and is also sourced from dental radiology. From the advances in 3D image processing with advanced AI algorithms, the benefits have spilled over into other dental specialties, such as orthodontics, maxillo-facial surgery treatment planning, or restorative dentistry, including caries diagnostics."

AI is used in dentistry to make the diagnostic tasks more accurate and efficient. Deep learning applications in dentistry is currently implemented in the detection and diagnosis of dental caries, vertical root fractures, apical lesions, salivary gland diseases, maxillary sinusitis, maxillofacial cysts, cervical lymph nodes metastasis, osteoporosis, cancerous lesions, and alveolar bone loss as well as identifying cephalometric landmarks and cephalometric analysis. Recent studies indicate that the performance of an AI based automated system is excellent, mimicking the precision and accuracy of trained specialists (Khanagar et al., 2021).

Commercially, the current available AI driven diagnostic tools are often presented as clinical decision support systems that assist and guide experts to make better decisions.

A clinical decision support system is defined as, any

computer program that has been designed to help health professionals in making clinical decisions, and also deals with the medical data or with the knowledge of medicine necessary for interpreting such data (Shortliffe, 1989).

Recently reported AI applications extend beyond diagnostic tasks to AI-driven treatment planning and prognosis prediction, such as predicting diagnosis of orthodontic extractions, assessing need for orthodontic treatments, determining the growth and development of cervical vertebrae stages, assessing the impact of orthodontic treatment on the facial attractiveness, gender determination using mandibular morphometric parameters, estimating the age based on third molar development and predicting postoperative facial swelling following extractions.

In treatment planning, AI has been of immense value in automation for CBCT segmentation and 3D cephalometric analysis based on advanced 3D CNN algorithms. These AI systems could greatly impact the accuracy of diagnosis, enhancing clinical decision-making, and predicting the treatment prognosis which can help clinicians bring the best quality care to their patients.

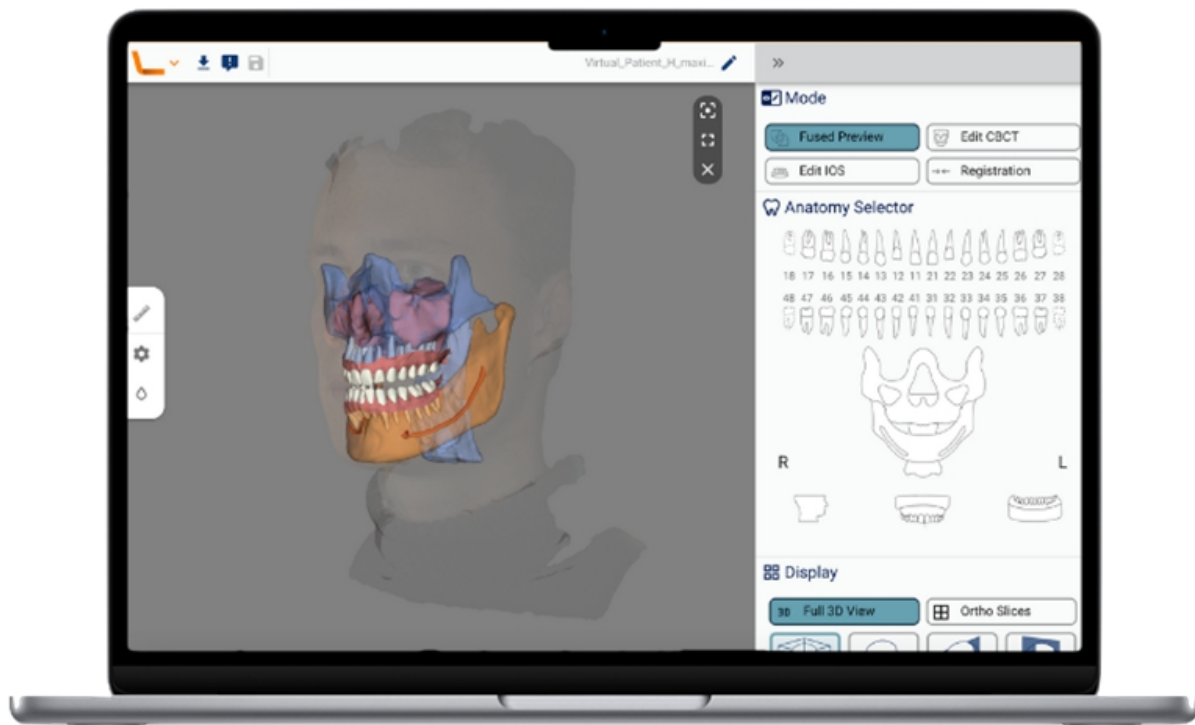
This article aims to shed light on some of the latest commercially available AI tools that can be incorporated into the dental practice, beyond automatic charting and AI-aided diagnostic tasks, to improve treatment outcomes as well as be used for dental research and education purposes.

## RELU® CREATOR

RELU® CREATOR is a cloud-based AI-assisted segmentation software for dental and maxillofacial images for automatic segmentation of CBCT dicoms, providing the user with a 3D model of the mandible, maxilla, teeth, sinuses, airway and mandibular canals in a matter of minutes. Segmentation allows a doctor to visualize anatomic features and improve the clinical presentation, and, most importantly, show this to the patient.

Automatic segmentation of the crowns on a digital impression is also possible, as well as automatic alignment of CBCT, digital impressions and facial scan, creating a "virtual patient" holding all the necessary information for subsequent treatment planning, modeling in specialized software or printing of the model using a 3D printer.

The model also allows manual tools for segmentation, alignment and measurements, both 2D and volumetric, making it a valuable tool for research.



Automatic alignment of CBCT, digital impressions and facial scan. Image courtesy of [www.relu.eu/creator](http://www.relu.eu/creator)

## ATOMICA AI

Atomica's cloud-based prosthetic-driven implant planning platform offers a comprehensive guided digital workflow for implant treatment - from scanning and planning to drilling and implant placement to virtual restoration planning and placement. By incorporating AI, the platform allows automatic 3D rendering, automatic cut adjustments, automatic curve generation, automatic model matching, automatic sleeve positioning, and a streamline virtual restoration placement. Finally, a full surgical protocol with drill sequence is generated. AI-assisted surgical guide generation is another highlight of this system, allowing the dental practitioner to provide an accurate and predictable treatment outcome.

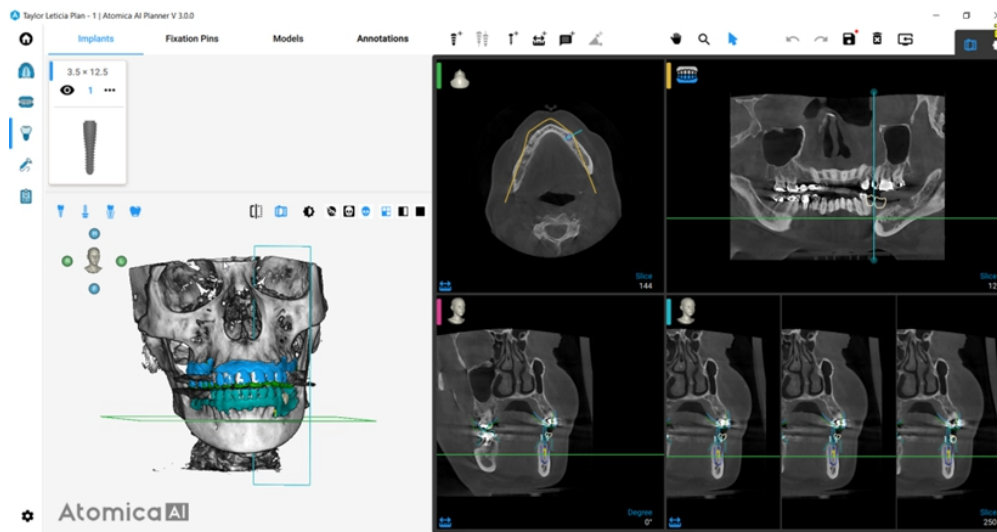


Image courtesy of <https://atomica.ai/>

## SPOTIMPLANT BY ALLISONE

SpotImplant tool uses the power of AI for instant implant recognition, an intelligent solution to the problem of dental implant traceability. It provides practitioners with an AI-based service to automatically identify unknown implants. It also generates a complete report, enabling the dental practitioner to order all compatible parts to restore the implant submitted for recognition.

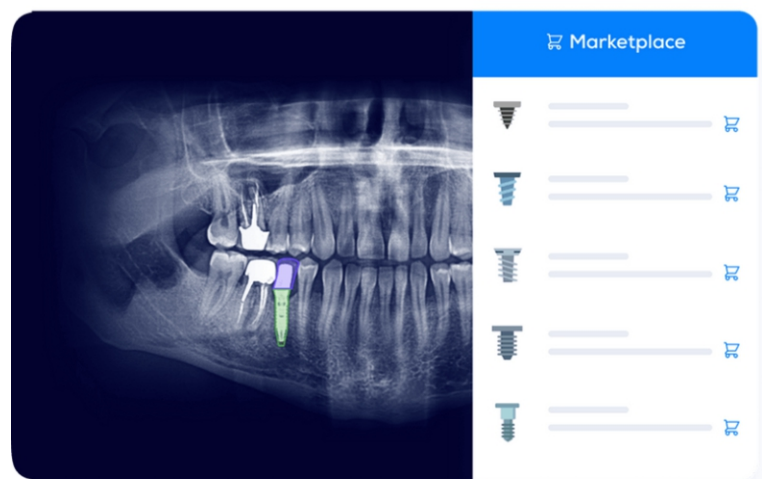


Image courtesy of <https://en.allisone.ai/spotimplant>



## CRANIOCATCH EDUCATION

CranioCatch Education is designed to help dental education professionals in teaching the anatomy and pathology of dento-maxillofacial radiology using artificial intelligence in 2D and 3D radiographs. Educational institutions can utilize this platform to provide a comprehensive overview of radiology, offering real-time dental radiographs that can deeply educate dental students.

Dental students can enhance their diagnostic skills through the hands-on experience in labeling dental radiographs. Tests and exercises that simulate real-life scenarios are provided, allowing them to practice identifying dental issues through tagging.



Image courtesy of <https://www.cranio catch.com/en/EDU>

## CRANIOCATCH ANNOTATION

Another AI tool developed by CranioCatch is used for ground tooth labeling and segmentation of various anatomical structures. Such tools are of great aid in annotating the training data used in developing deep learning algorithms.

## PRACTICE INTELLIGENCE® BY PEARL

Created by Pearl to integrate with Second Opinion®, Pearl's AI-powered radiographic pathology-detection tool, Practice Intelligence® collects evidence in patient radiographs detected by Second Opinion and treatment data from a practice management system and gives office staff an in-depth view of practice performance in the form of an AI-guided production toolset or ROI & performance toolset. Dentists, office managers, and clinical staff can apply these findings to inform training, staffing, and procurement decisions, enabling practices to ensure consistent and optimal performance.



Image courtesy of <https://www.hellopearl.com/products/practice-intelligence>

## TOMONAV BY RADIOMEMORY

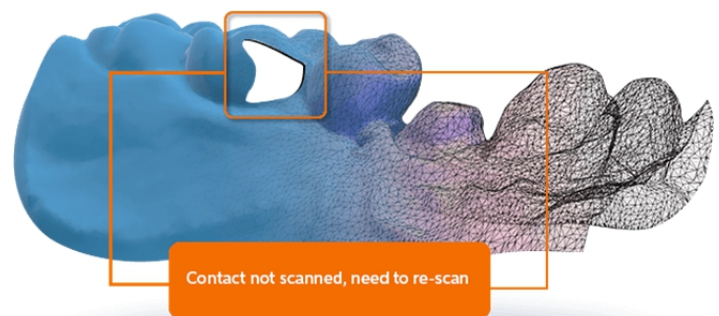
TomoNov is an Interactive web-based CT scans visualization / manipulation tool. This CBCT web navigation tool uses AI to analyze the volume data and pre-organize all relevant cuts to enable visualizing the necessary portions of the scan already annotated and aligned with the patient's anatomy and occlusal plane. It basically makes navigation through a cbct dataset easier by automating the time-consuming 3D aspects of preparing the scan for diagnostic analysis.

## SMART MARGIN® AND PREP ASSESS BY PEARL

Extending beyond the dental clinic and into the dental laboratories, AI solutions for automation and quality control can bring a new level of efficiency and accuracy to the restorative workflow.

Smart Margin is an example of an AI-powered tool trained by dental professionals to instantly and accurately mark the tooth-restoration margins on digital models, saving time and expense.

Another example is Prep Assess™, which enables dental practice and labs to assess the quality of margins and intraoral scans in real-time, allowing dental offices to easily improve preps and recapture impressions while patients are still in the chair and labs to produce restorations with precision fit



Prep Assess™ image courtesy of <https://www.hellopearl.com/products>

## SECOND DENTIST BY VELMENI

Velmeni is among the first dental AI developers to develop AI-driven 3D X-Ray analysis, merging automated detection with predictive AI. Velmini's AI tool, Second Dentist, is currently available for free to licensed dental practitioners in the USA.

## DENTAL CHATGPT BY DIGITAL DENTAL SCHOOLOGY

Last but not least, a dental ChatGPT, fed with a huge number of articles and textbooks covering a diversity of topics in dentistry is now available.

The number, diversity and tasks performed by AI-powered dental solutions continue to grow at a great speed. The precision of these commercial AI-based tools needs to be validated by clinicians before extending their use for a clinical setting or for research purposes. Clinical trials and evidence supporting the effectiveness and impact of dental AI-tools remains a necessity and is currently among the highest trending areas of dental and maxillofacial research.

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# PERIAPICAL LESIONS DETECTED THROUGH ARTIFICIAL INTELLIGENCE IS IT REALIBLE? A LITERATURE REVIEW



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## ABSTRACT

Apical lesions are considered a pathognomonic sign of dental diseases, mostly endodontic; causing an infection process which have an impact on systemic health and the tooth survival. Imaging techniques, including intraoral periapical radiographs, panoramic radiography and Cone-Beam Computed Tomography, are the most frequently used for the study of periapical diseases. Interpretation of the resulting images are still a task for the radiologist; despite preparation, perception and diagnostic errors can occur. Today, technological advances in our specialty are no longer limited to imaging modalities and hardware. Artificial Intelligence is being applied to detect periapical lesions using 2D and 3D imaging modalities by training deep models with the purpose of reduce the occurrence of prejudice and increase the diagnostic accuracy. This review aims to objectized the performance of Artificial Intelligence in detecting periapical lesions in published scientific literature and to provide a comprehensive of its functioning.



## KEYWORDS

Artificial Intelligence, diagnosis, periapical diseases, radiology, diagnostic imaging (MESH).

## INTRODUCTION

Apical lesions are considered a pathognomonic sign of dental diseases, mostly endodontic; causing an infection process which have an impact on systemic health,<sup>1</sup> and the tooth survival. So, it becomes imperative to diagnose and treat these lesions.<sup>2</sup> Imaging techniques, including intraoral periapical radiographs (IPR), panoramic radiography and Cone-Beam Computed Tomography (CBCT), are the most frequently use for the study of periapical diseases.<sup>3</sup> With the advance of technology, smaller voxel and consequently more precise details haven been able to be achieved; promoting the CBCT as the technique which attains the highest accuracy, but due to its high cost and radiation dose should be restricted to special cases;<sup>4</sup> thus, IPR is the imaging modality selection for evaluation before, during and after treatment.<sup>5</sup> Applying technology, images obtained through this technique can be improved, in a process called postprocessing imaging, by the use of filters.<sup>6</sup> The interpretation of these images are still a task for the radiologist; despite preparation, perception and diagnostic errors can occur, and inter and intra-observer agreement given mainly for expertise.<sup>7</sup> Today, technological advances in our specialty are no longer limited to imaging modalities and hardware.<sup>8</sup> Artificial

Intelligence (AI), also called the "fourth industrial revolution" has entered into our field in a much easier way than other specialties because diagnostic images are digitally coded, and hence, more easily interpreted into computer language,<sup>9</sup> assisting in different tasks such diagnosis, treatment planning and estimating a disease prognosis.<sup>10</sup> AI was first coined in 1950 with the purpose to mimic human intelligence behavior to solve problems, decision-making, object and word recognition.<sup>11</sup> Machine learning (ML) is a subset of IA, it can predict the result on the dataset giving to it using algorithms. Deep learning (DL) represents a subset of ML, it imitates human brain and have interconnected artificial neurons, allowing to learn large amount of data, analyze and interpret it, without explicit instructions, being the elected method to be applied in our field. Images are formed by a volume of pixel values; a possible learned feature in the first layer could be the presence/absence at particular locations and orientations in the image, at the second layer patterns could be detected, a third layer may gather these characteristics into a larger mixture forming parts of an object. So, upcoming layers would detect objects as combinations of these parts.<sup>12</sup> (fig. 1).

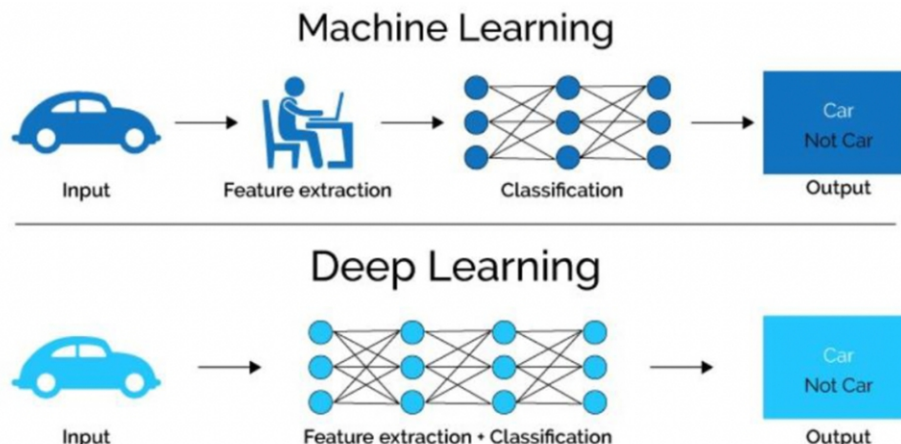


Figure 1. comparison between machine learning (ML) and deep learning (DL).<sup>13</sup>

AI can detect diseases, make predictions, image segmentation and classification at levels that equals and even exceeds human ability, being able even to rectify human errors.<sup>14</sup> AI can be applied to detect periapical lesions using 2D and 3D imaging modalities by training deep models with the purpose of reduce the occurrence of prejudice and increase the diagnostic accuracy.<sup>15</sup> This review aims to objectized the performance of Artificial Intelligence in detecting periapical lesions in published scientific literature and to provide a comprehensive of its functioning.

## APPLICATIONS OF IA IN ENDODONTICS

Diagnosis and treatment planning relies on an adequate and accurate understanding of pulpar and periapical tissues and complementary examination, where imaging modalities takes an important role.<sup>4,16</sup> Low contrast, early stage disease, noise, overlapping structures, can cause an apical process go unnoticed by human eye.<sup>17</sup> Minimal changes at a single pixel could be missed even by an expert radiologist, AI-based network could be the solution.<sup>18</sup>

Dental caries, periapical lesions, root fractures, stem cell viability, working length, root canal system anatomy, location of apical foramen, success of treatment and retreatment are the main applications of IA in endodontics.<sup>18</sup>

## IA IN DETECTING PERIAPICAL LESIONS AUTOMATED DIAGNOSIS

The basis of learning algorithms for diagnostic purposes it to make and explore associations between the input images or features and the output diagnosis automatically without human intervention.<sup>19</sup> The workflow for ML algorithms is as follow: 1) input image data, 2) image preprocessing, 3) selection of the region of interest, 4) segmentation of lesion, 5) extraction of selected characteristics in the segmented lesion, 6) analysis of the extracted characteristics and 7) output of the diagnosis or classification.<sup>20</sup>

Untreated caries progresses into periapical diseases. Over 75% of the radiolucent jaw lesions are caused by a prevalent condition such as apical periodontitis, 90% of the inflammatory lesions are classified as apical granuloma, apical cysts or abscesses.<sup>21</sup> DL methods can quantify these lesions based on size and severity.<sup>22</sup> Applying and resuming the detection of periapical lesions could be graphited as: 1) classification, requiring a labelled dataset, and it categorize the image into healthy or non-healthy tooth; 2) detection, also requires labelled dataset with marking of the region of interest, allowing to localize and identify periapical lesions by demarking the area; and 3) segmentation, using also labelled dataset with precise demarcation of the object of interest, defining the pixel-wise boundaries of the lesion.<sup>23</sup>

A 92,75% success rate was obtained diagnosing through DL periapical lesions in periapical radiographies.<sup>24</sup> Endres et al. found that DL was more accurate as the 24 oral and maxillofacial surgeons, not oral and maxillofacial radiologist, who participate on their study, detecting periapical radiolucencies on panoramic radiographs.<sup>25</sup> Also, a 65% of sensitivity and 87% of specificity was found in a study designed to train DL to detect periapical.<sup>26</sup> Arijji et al, trained DL algorithms to detect and classify ameloblastomas, odontogenic keratocysts, dentigerous cysts, radicular cysts and simple bone cysts, reaching a sensitivity of 88% using two testing data sets, this learning model gave also false positives (1 in 25 images).<sup>27</sup> Orhan et al, in 2020, observed an accuracy rate of 92,8% for the identification of cystic lesions on CBCT.<sup>28</sup> Several methods haven been proposing to differentiate periapical lesions, some promising advances have been achieved, Okada et al, in early 2015, trained an specific DL model to make a differential diagnose between granulomas and periapical cysts in CBCT, observing a 94,1% effectiveness.<sup>29</sup> Lee et al, evaluated the performance of panoramic radiographies and CBCT on DL models detecting odontogenic keratocyst, dentigerous cysts and periapical cysts, concluding that sensitivity and specificity were higher on CBCT than panoramic radiographies (sensitivity: 96,1% versus 88,2%, and specificity: 77,1% versus 77,0%).<sup>30</sup>

Only one study was found to compared AI models and an oral and maxillofacial radiologist to classify periapical lesions, AI model had a better performance with an accuracy of 70% and a specificity of 92,39%.<sup>31</sup> An accuracy of 93% and a specificity of 88% was observed by Setzer et al, using a DL algorithm for automated segmentation of CBCT and detection of periapical lesions.<sup>32</sup> Most studies have positive and encouraging results, permitting to reduce radiologist burnout and diagnostic time.<sup>15</sup>

## LIMITATIONS

Even though there are several studies supporting and evidencing the higher accuracy of CBCT over 2D imaging studies,<sup>33</sup> most DL algorithms have been created for 2D, because is commonly prescribed and hence more representable than CBCT.<sup>34</sup>

Most studies lack from generalizability and reliability because use patients data from reduce medical facilities and over one defined time period;<sup>18</sup> DL models are mainly trained and tested using confirmed disease imaging, and images were likely obtained using the same device and imaging protocols, resulting in a lack of data heterogeneity.<sup>20</sup> Tasks involving human judgement, the derived reliability of AI is difficult to understand, accept and justify; datasets must be interpreted, this can be challenging even for the most experienced radiologist.<sup>35,36</sup>

Patient's data is being shared and use for the development of IA without any privacy guarantee. Until today, there are no laws governing IA development and application.<sup>37</sup>

In practice, apply IA for automated interpretation it is expensive; requires large data which needs to be suitable and processed by experts. Delving on this topic, AI needs data curation, meaning organize and integrate data from different sources. Applying this term to imaging, it is needed to anonymize, check the representativeness of the data, standard the data format, segmentate the area of interest, minimize the noise and make annotations.<sup>38</sup> Problems between manual and automated segmentation has been observed. While some authors claims that manual segmentation can be subject to human error,<sup>4</sup> others found both methods where comparable.<sup>28</sup>

DL models needs correct labels that are created by experts, the radiologist can make annotations during the image review or it can be use the information from the radiology report, these are the two ways to make labels. As it can be inferred, first option requires not only a lot of time but also effort and could be differences among radiologists and the second one needs to be re-tested to correct labels.<sup>39</sup>

As technology evolves, seems to be a solution for the need of large amounts of data: data augmentation; it alters the data set changing its representation but keeping the same label using tools like cropping, flipping, translation, zooming, rotation, elastic deformation, skewing, changing resolution or contrast.<sup>40</sup> But here a red flag is noticed, when applying data augmentation, must be ensured that the area of interest is not removed. Extrapolating this information, DL model could detect for example a caries with a concomitant periapical lesion but then when the image is processed through data augmentation the apical lesion is removed, so obviously DL model degrade its performance (Fig 2).<sup>14</sup>

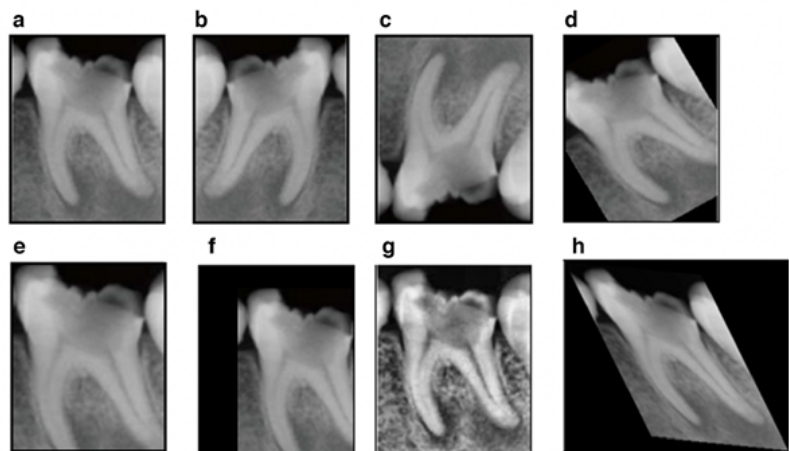


Figure. 2 Data augmentation example of periapical X-ray. a. Original image, b, c. Flip, d. Rotation, e. Zoom, f. Translation, g. Contrast adjustment, h. Elastic deformation. Note that apical lesion is removed in d, e, and f, which can degrade performance of periapical lesion detection model (obtained from Heo et al).<sup>39</sup>



Has been exposed also the difficulty for AI to distinguish between lesions and soft tissue, presence of concomitant lesions such as endo-perio, periodontal defects and even alveolar bone loss may altered AI measurement, also normal anatomical structure can disrupt AI performance (mental foramen, maxillary sinus, inferior alveolar canal and others), large lesions associated with multiple teeth, root-canal treatments, dental anomalies, incomplete apex development, open apex, and others.<sup>41</sup>

Most of the used software on the published articles are not commercially available.<sup>20</sup> No studies have been performed in a real clinical situation, so there has been no true applicability of these systems.<sup>42</sup> So it is expected when become an open-source, could be possible to verify findings.<sup>20</sup>

## CONCLUSIONS

As oral and maxillofacial radiologist we must interpretate imaging, if we make a mistake whereas of what we see or miss, could obviously lead to over or undertreat a patient. There is some concern whereas IA will replace us. As exposed on this article, IA can achieve accurate detection of periapical lesions; but needs to be learned with large amounts of data, further validation and testing needs to be done. Intuition, perception and even empathy cannot be mimicked. So, authors believe that the invitation is to use technologies into our favor by reducing time and prepare to handle informatic advances.

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# INTERVIEW

**Dr. Maxine Feinberg DDS**

## Dr. Maxine Feinberg DDS

Periodontist

Dr. Maxine Feinberg, a periodontist, was the third woman to hold the Office of ADA President in 2014-15. She is Chief Strategy Officer for Velmeni, a cutting edge leader in the field of Dental AI. She is also an advisor for the Renew Corporation. Dr. Feinberg graduated from New York University College of Arts and Sciences in 1977 and NYU's College of Dentistry in 1980. She returned to NYU after her residency in anesthesiology and working as a general dentist and treating patients confined in nursing homes to complete her certificate in Periodontics in 1984. Dr. Feinberg is a past president of the New Jersey Dental Association and the New Jersey State Board of Dentistry, where she served for 9 years. She has been a delegate in both the ADA and New Jersey Dental Associations House of Delegates. She initiated the New Jersey Give Kids A Smile campaign for 2002 and 2003. She remains active in both her component dental society and the NJDA. She was Elected Chair of the Commission on Dental Accreditation (CODA) in August 2023. CODA oversees the accrediting process for dental education programs in the United States. She served as an ADA's Delegate to the FDI World Dental Congress for over 10 years. Dr. Feinberg sits on the Boards of the NJDDS/Donated Dental Services and the Gillette Hayden Foundations. She is a fellow in the American College of Dentists, the International College of Dentists and the Pierre Fauchard Academy. Dr. Feinberg resides in Westfield New Jersey with her husband John Wynne. She is the proud mother of two daughters Haley and Rebecca Wynne.

## INTERVIEW

Q. **CBCT**

Hello, **Dr Maxine**,  
can you please share some  
insights about your  
professional life .



**Dr. Maxine Feinberg**

As a women in dental school and entering private practice in the late 70s early 80's there were many challenges. Women were not always made to feel welcome by their peers. Patients were not accustomed to having women treat their dental needs. But we persisted and prevailed. It was also challenging to manage both our professional lives and our families. The idea of work/life balance did not exist at that time; so we learned from each other and juggled both. Many of the women dentists my age chose private practice so we could be our own bosses and have toe ability to make decisions that allowed us to have greater flexibility in managing all aspects of our lives.

## Q. **CBCT**

What according to your experience is the most innovative research /technology which will define dentistry in the next decade.

I believe Artificial Intelligence will have the greatest impact on our profession. Not only in improving our diagnostic abilities but it could revolutionize dental education.



Dr. Maxine Feinberg

## Q. **CBCT**

Female dentists are outnumbering their male counterparts in the current scenario across the globe. What factors according to you is leading this scenario .

More women have entered the work force in the last 40 years. Dentistry is appealing to those women who would like to have a rewarding career. Many see dentistry as conduit for achieving those goals and allowing them to also balance a family life.



Dr. Maxine Feinberg

## Q. **CBCT**

You are playing a pivotal role in artificial intelligence as one of the board members of VELMENI , an AI based dental company. Kindly share your experience and what we can expect from Velmeni .

Velmeni is a very forward thinking company. With a woman as CEO; Mini Suri has put together a team that is very inclusive and has a strong female presence. The diversity of our team has lead to a very progressive approach to AI technology.



Dr. Maxine Feinberg

## Q. **CBCT**

Digital dentistry, 3D printing and AI are going to be pillars for successful dental practice . What are your thoughts about these classes defining today's dentistry.

Digital Dentistry, 3D printing and AI have already impacted the way dentists are practicing and the ways we are teaching dentistry. The future will see major expansion of these and newer emerging technologies. They do unfortunately come at a cost and dentists must be willing to invest in their future and the future of dental care for their patients.



Dr. Maxine Feinberg

## Q. **CBCT**

What will be your advice to young female dentists who wish to pursue career in dentistry. ?

My advice to young dentists female and male is to be open minded and flexible. Dentistry allows for a wide range of career opportunities, be willing to explore and consider options. be willing to make changes if one path does not seem to work for you. For example you may start in a corporate environment and decide to consider your own practice or even academia.



Dr. Maxine Feinberg

## Q. **CBCT**

You have seen the dentistry changing in all these years of practice . What according to you is the receipe for a successful dental practice . ?

The recipe for a successful Dental Practice is to embrace innovation and change. It will keep you interested and enthusiastic about your profession and will enable you to continually provide the best and most up to date care for your patients.



Dr. Maxine Feinberg



# XVI INTERNATIONAL CAI MEETING & 'PIONEERS COURSE' ATHENS 2023



The Computer Aided Implantology (CAI) Academy is the oldest 'non-profit' international scientific organization in its field. It has consistently been at the forefront of the development and application of 'Digital Dentistry' and the driving force behind it.

Its Active Members are the pioneers and inventors of Computer Guided Surgery. They have invested much of their career in developing relevant 'Digital Workflows', while proving their actual value in 'Dental & Maxillofacial Clinical Practice'.

The above statements were reconfirmed at the XVI International Meeting in Athens, on 23rd & 24th June 2023. The theme of the annual meeting was the 'Past, Present and Future of Computer Aided Implantology'. It brought together and bridged all significant developments that have taken place over the years, demonstrated the present methods, procedures and challenges, but also provided a concrete view of the future ahead.

It was the first time that a whole scientific meeting was presented in an educational course format. The new concept of the 'Pioneers Course' was introduced, guiding the participants from basic principles to static implant guidance, dynamic navigation, robotic surgery and advanced custom applications.

A highlight of the event was the award of an Honorary Membership to Dr Philippe Tardieu and Dr Luc Vrielinck, two prominent clinicians and true pioneers of Computer Aided Implantology. Their contribution has set a solid base to what nowadays is known 'Digital Dentistry'.

This 'historic' meeting can actually be revisited and all lectures can be watched again at the CAI Academy website: [www.yourcaiacademy.org](http://www.yourcaiacademy.org).

Sincere and warm thanks to all the CAI Active Members, Speakers, Participants and Partners, for making this another memorable scientific event!

With best 'digital' greetings!

**Panos Diamantopoulos**

President of the International CAI Academy

[www.yourcaiacademy.org](http://www.yourcaiacademy.org)

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