

# Artificial intelligence shifts consumer behaviour and impacts orthodontics

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## Dentistry in the face of digital disruption

Digital technology is disrupting virtually every industry, overhauling traditional models of consumption in every part of our lives, healthcare and dentistry included. Providers have innovative technologies at their disposal and patients—consumers of healthcare services—have twenty-first-century demands and standards for care. However, there seems to be a gap between dental practitioners and their patients. The supply and demand for change is there, so why is the dental industry lagging behind?

While dentists and orthodontists have access to innovative tools and technologies, certain misguided practices (like the infamous “aligners through the mail” campaigns) reveal a willingness to sacrifice quality for convenience. Today’s patients want convenience too, but as educated consumers, they are not willing to sacrifice the quality of their care.

With the available remote solutions that are powered by artificial intelligence (AI), patients know that they do not have to sacrifice either. Recent surveys by DentaVox suggest that 78% of patients are likely to start using teledentistry within the next five years<sup>1</sup> and that 89% strongly agree that interactive dental care through an app can improve their oral health.<sup>2</sup> Especially in this (hopefully) post-pandemic world, these kinds of technology are becoming further embedded in our day-to-day lives and more integral to how we receive care.

Patients are ready for dental disruption. If dental care providers could better identify and scale the right innovative solutions for their practices, they might be ready too. Not only would dentists be able to provide a higher quality of care to their patients, but they would ultimately save time and money. It is a matter of implementing the right solutions in the right way.

## Lessons to learn from the healthcare industry

During the past few decades of technological transformation, the healthcare industry has witnessed unprece-

ented levels of innovation, from electronic health records to surgery-performing robots, but the industry still suffers greatly. Healthcare professionals are seen as apathetic or greedy by their patients, and physicians are overloaded with demands for their time (an average visit to the doctor is 7 minutes, or 12 minutes for new patients), and as a result, they sustain severe burn-out and depression.<sup>3</sup> Care is increasingly becoming depersonalised, leading to misdiagnoses and medical errors. There are 12 million significant misdiagnoses each year in the US alone, as much as 60% of the medical procedures performed are deemed unnecessary, and more and more lawsuits are being filed against physicians.<sup>3</sup> It is a vicious cycle, but the industry can break out of it.

According to world-renowned physician Dr Eric Topol, technology can be implemented in five ways to save the healthcare industry:

1. Leverage digital communication to augment relationships with new and existing patients.
2. Eliminate the time clinicians spend on administrative work (clinicians can spend up to twice as many hours on medical paperwork as with their patients).
3. Use technology to reduce errors. AI can enhance accuracy, leading to more accurate diagnoses, better treatment, improved outcomes and lower costs.
4. Harvest data to improve outcomes. Technology can collect and analyse patient data to better educate patients, predict problems and increase compliance.
5. Monitor remotely. Using virtual technologies, doctors and patients can connect from afar.

The goal, which could easily be applied to dentistry, is to leverage various technologies to establish a more patient-centric approach. By augmenting the relationship with current patients through digital communication and establishing relationships with new patients before they even set foot in the office, healthcare professionals can gain time and trust. They can also strengthen communication and offer more personalised treatment experiences to patients. Through developing the right mindset

**Advantages of teledentistry**

**Patient:**

1. improved access to primary and specialty dental services
2. timely (non-delayed) diagnosis of oral diseases
3. improved communication between the oral healthcare team and the patient
4. promotion of patient education and patient progress assessment (i.e. oral hygiene efficacy)
5. no cost of travel to location for face-to-face examination
6. scheduling of appointments and update of health history
7. availability of dental records if a problem is encountered when away from home

**Dental care provider:**

1. Increased capacity of individual providers
2. Efficient triage
3. reduced waiting time
4. reduction of unnecessary referrals
5. better interprofessional communication
6. facilitation of local referrals
7. enhanced interprofessional communication for geographically isolated providers

**Quality of care:**

1. enhanced efficiency
2. better oral health outcomes
3. reduced complications due to delayed diagnosis
4. improved patient monitoring

**Society:**

1. reduction of caregivers' time away from their primary offices
2. for children, reduction of the number of absences from school
3. addressing of inequality of oral healthcare services
4. addressing of the needs of underserved populations

**Box 1** (adapted from Estai et al.<sup>6</sup>)

and implementing the appropriate technologies, dental professionals can become more efficient and more successful.

**Teledentistry, its pros and its cons**

The concept of teledentistry is not something new. According to Jampani et al., the concept was introduced in 1994, when the US military sought ways to improve communication among dentists and dental laboratory technicians, thereby enhancing patient care.<sup>4</sup> Today, the emergence of new communication technologies has made it easier to implement it and reach out to virtually anyone and anywhere in the world.

**Barriers to the adoption of teledentistry**

**Individual:**

1. Patient acceptance not well defined
2. challenges if the patient has limited technological literacy
3. resistance to technological innovation (i.e. elderly)
4. absence of direct contact between the provider and the patient
5. concern for security of data/health records
6. accuracy and quality of the information
7. increased workload for providers
8. increased cost of practice
9. risk of fragmented care

**Infrastructure:**

1. limited Internet access in certain regions
2. lack of hardware/software compatibility
3. complexity of the technology required
4. poorly defined reimbursement/funding
5. lack of information technology support
6. lack of provider/patient training

**Organisational:**

1. lack of compatibility of technology with other digital records
2. lack of reimbursement/funding
3. absence of copyright, licensure and financial guidelines
4. medical/legal issues
5. bureaucratic difficulties
6. coordination difficulties between the hub and remote sites

**Box 2** (adapted from Estai et al.<sup>6</sup>)

By definition, teledentistry is the implementation of electronic information, imaging and communication technologies, including interactive audio, video and data communications, in order to provide and support dental care delivery, diagnosis, consultation, treatment and patient education. It can include virtual consultations and remote monitoring of patients, offering less expensive and more convenient care options for both patients and dentists. Teledentistry reflects a broader, changing healthcare landscape that is moving toward innovation, integration and convenience. Teledentistry is proof that the dental industry embraces innovation.<sup>5</sup>

A number of systematic reviews examining the outcomes and costs associated with teledentistry have been published. An early review suggests that this technology leads to improved clinical outcomes and high provider and patient satisfaction, as well as cost-savings.<sup>4</sup> Using this technology to communicate with patients has numerous advantages; however, dental professionals should be aware of its risks and use only the most appropriate and secure platforms in order to ensure data privacy (Boxes 1 & 2).

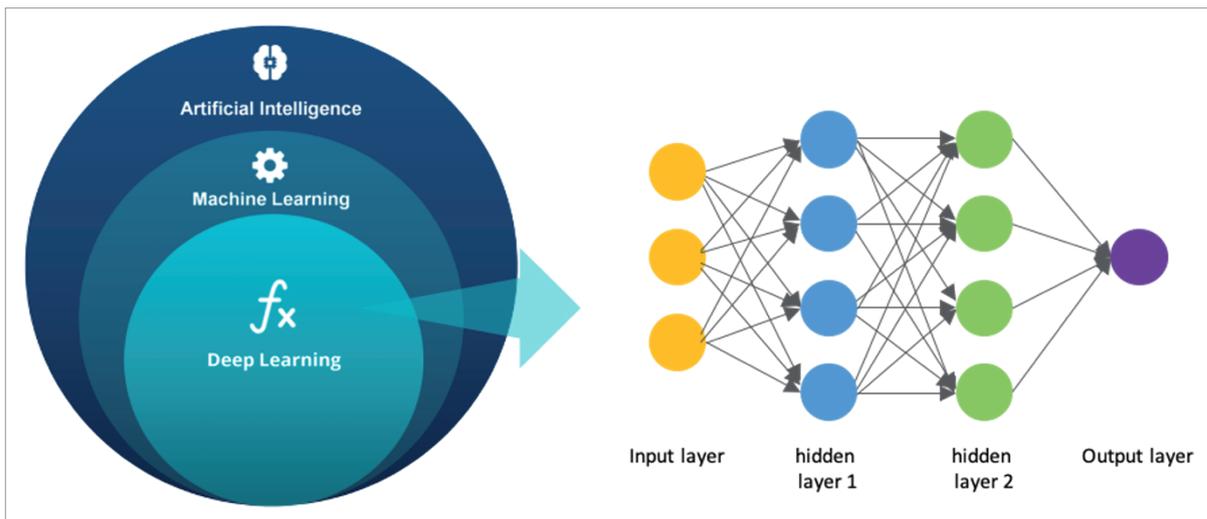


Fig. 1: AI attempts to mimic human thought to solve complex tasks.

Technology	Description	Application
<b>Machine learning</b>	A data-driven learning technique that focuses on the development of computer programs that can access past information contained in collected data and use it to learn for itself, identifying patterns and honing classificatory and predictive performance	Wide range of use in dentistry
<b>Supervised learning</b>	An optimised trial-and-error process based on labelled data; an algorithm compares outputs with the correct outputs during training	Used to detect anomalies in images
<b>Unsupervised learning</b>	When the training samples are not labelled; the algorithm just looks for patterns and teaches itself	Used to find new correlations
<b>Convolutional neural network</b>	Employs the principle of convolution, a mathematical operation that basically takes two functions to produce a third one; instead of feeding in the entire data set, it is broken into overlapping tiles with small networks and max pooling, used especially for images	Used to detect anomalies in X-rays
<b>Natural language processing</b>	A machine’s attempt to “understand” speech or written language like a human does	Used to eliminate the manual entry of patient data
<b>Deep learning</b>	A type of neural network that is a subset of machine learning composed of algorithms; permits software to train itself to perform tasks by processing multilayered networks of data	More complex analysis <sup>3</sup>

Table 1: Technologies of artificial intelligence.

### AI versus human intelligence.

AI has come a long way since it was first conceptualised in 1936 by Alan Turing in a concise research paper.<sup>3</sup> Today, it is key to the modernisation of the healthcare industry, helping to reinvent the field. AI guides healthcare professionals and organisations to perform better, faster and more efficiently at a fraction of the cost. It is a very powerful tool that will transform the way we treat our patients.

AI, in brief, is an umbrella term for a range of technologies and approaches that attempt to mimic human thought to solve complex tasks (Fig. 1). It relies heavily on neural networks with deep structures, which are basically computing systems inspired by animal brains. Each of these computing units mimics how a neuron works. AI is not one technology, but rather a collection of them (Table 1). Most of these technologies have immediate relevance to the healthcare field, but the specific processes and tasks they support vary widely.

While AI's dynamic algorithmic capabilities can help us solve medical challenges in unprecedented ways, from the automation of data processing to the tracing of rare diseases based on genomic sequencing, it does have an Achilles heel. AI still relies on common sense and human behaviour. As Prof. Fei-Fei Li, co-director of the Stanford Institute for Human-Centered Artificial Intelligence in California in the US, often explains to her students: we should not "be misled by the name artificial intelligence—there is nothing artificial about it. AI is made by humans, intended to behave by humans and, ultimately, to impact human lives and human society". And this is why it will never replace human intuition, which is essential in diagnosis and decision-making. AI will not displace or replace healthcare professionals. However, when doc-

tors work synergistically with AI, their combined power and efficiency are unrivalled.

The most complex forms of machine learning involve deep learning, a type of neural network with many levels of features, or variables, that trains itself to perform tasks. There may be thousands of hidden features in such models, which are uncovered by the faster processing of today's graphics processing units and cloud architectures. A common application of deep learning in healthcare is the recognition of potentially cancerous lesions in radiographs.<sup>3</sup>

### Robotic process automation

This technology performs structured digital tasks for administrative purposes, that is those involving information systems, as if it were a human user following a script or rules. It relies on a combination of workflow, business rules and presentation layer integration with information systems acting like a semi-intelligent user of the systems. In healthcare, they are used for repetitive tasks like prior authorisation, updating patient records and billing.

### How AI works with Dental Monitoring

The transmission of the information from the patient's mouth to the servers happens remotely. The Patient is given a DM ScanBox (a piece of hardware designed to facilitate, standardize and improve the quality of the process of taking intra-oral pictures by the patient with their smartphone hence obtaining high quality images). When the patient is prompted to scan (according to your protocols, he will receive a notification), this scanning process will send between 20 and 30 pictures to the servers for processing.



Raw images



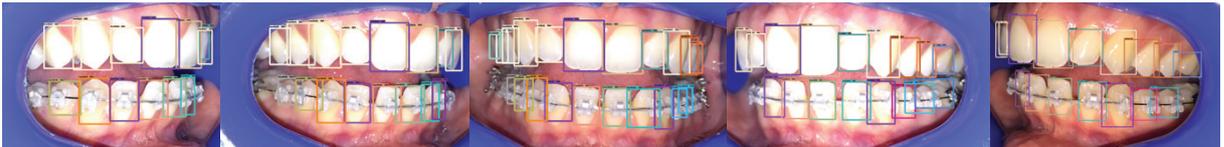
The raw images are processed by the system. For example, they are screened for quality in order to determine if the patient needs to take another scan or not; teeth are detected to proceed to teeth numbering.

Images cropping



The system is able to detect the teeth and identify them with a prediction score (percentage of certainty) – It is so advanced that in some cases it is able to differentiate if the tooth is a first or second premolar in cases of ortho extraction.

Tooth detection



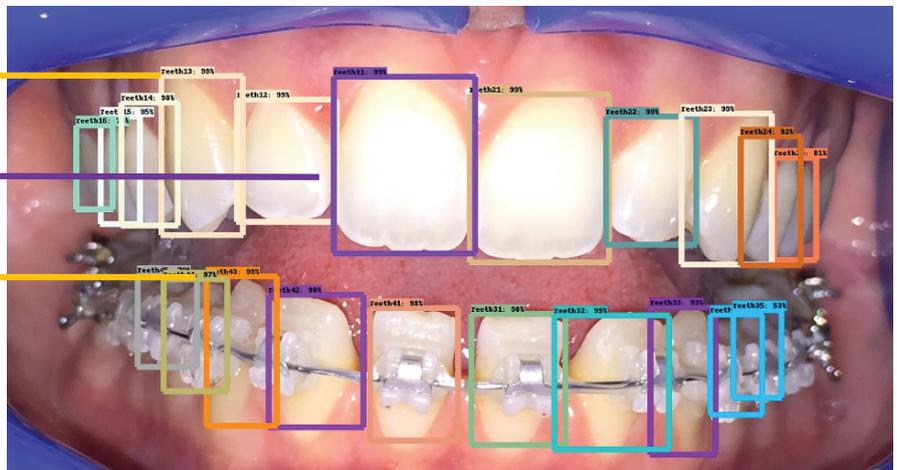
Gingiva detection



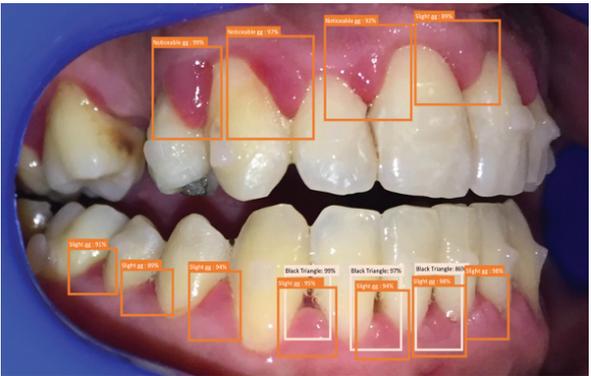
Tooth number

Detected zone

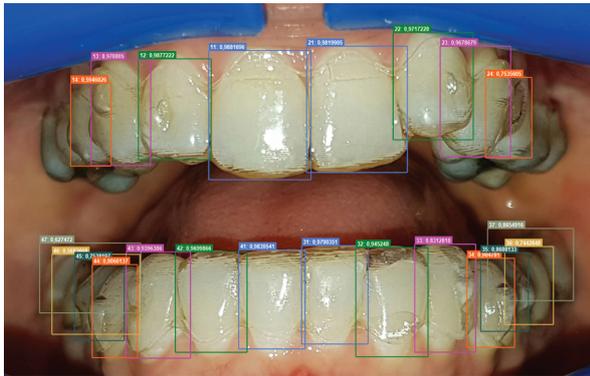
Prediction score/  
Percentage of certainty  
of the detection



### Examples of clinical situations detected



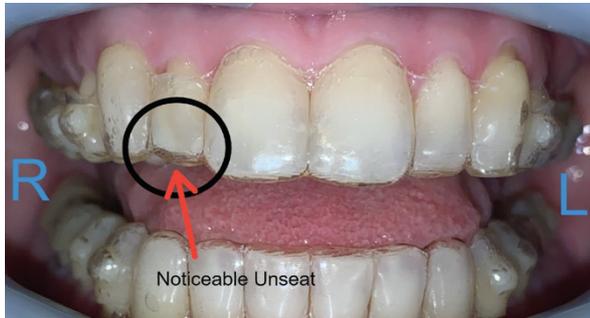
Gingival recession



Detection of aligners and unseats



Insufficient oral hygiene



Noticeable unseat



Missing attachment



Missing bracket

## Building your virtual practice with AI

### Systems considerations

The first step of building your virtual practice consists of piecing together various software products and combining them with workflows to create a system. These products might include email or messaging tools. However, providers should keep in mind that standard email and text messaging generally do not meet Health Insurance Portability and Accountability Act (HIPAA) security and privacy standards. It is essential to implement solutions that provide safe, secure ways to upload photographs and records, to communicate sensitive information, and to allow for secure payment and scheduling. If a provider is using multiple systems to collect information and interact with patients, it becomes even more important to ensure compliance and compatibility among those systems. Certain innovators of teledentistry, like Dentalmind, provide fully HIPAA-compliant solutions.

### Raising awareness

Reaching out to new patients using digital communication is a way to generate new leads and convert them effectively. Make patients aware of your services through digital communication and ads, driving traffic to your website, where you will have your virtual practice embedded. Keep track of these leads and monitor the conversion rates so you can try different approaches to enhance your communication strategies.

### Planning and deploying systems

Create a best practices-based workflow using both synchronous and asynchronous teledentistry systems. The goal is to provide virtual consultations in order to dispense advice and treatment plans, eventually converting leads into patients. Take advantage of these systems to ensure patient consent and engagement prior to their initial in-office appointment.

### Onboarding new patients

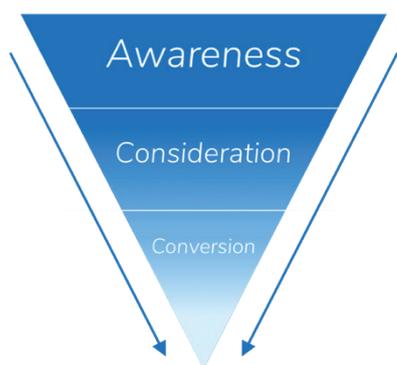


Fig. 2: Workflow for onboarding new patients.

When onboarding new patients, there are several critical communication touchpoints (Fig. 2):

- **Awareness:** This is the initial contact, wherein the potential patient receives an email, is shown an ad, performs a Google search, sees sponsored content on social media, visits a website or calls the office.
- **Consideration:** Through virtual consultations, using a tool like SmileMate, the patient receives a detailed report about his or her oral condition, as well as treatment recommendations. Dentists can also schedule video consultations as needed.
- **Conversion:** The patient consents to the proposed treatment, signs the consent form and schedules an in-office appointment.

### Going forward

Building your virtual practice through a smart combination of technology, planning and systems implementation has never been easier. By understanding AI technologies themselves and selecting the right tools, healthcare professionals can break the vicious cycle of underperformance and under-appreciation in the dental industry. Let AI empower you to amplify your practice and the level of care you provide to your patients.

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