Reshaping dental practice in the face of the COVID-19 pandemic: leapfrogging to Dentronics

Author

Jayaweera, Mahesh, Amarasinghe, Hemantha, Johnson, Newell W

Published

2021

Journal Title

Oral Diseases

DOI

10.1111/odi.14043

Reshaping dental practice in the face of the COVID-19 pandemic: leapfrogging to Dentronics

Mahesh Jayaweera[a], Hemantha Amarasinghe[b,*], Newell W Johnson[c,d]

[a] *Department of Civil Engineering, University of Moratuwa, Sri Lanka*

[b] *Oral Health Unit, Family Health Bureau, Ministry of Health, Colombo, Sri Lanka* [c]*Menzies Heath Institute Queensland, Griffith University, Queensland, Australia*

[d]*Faculty of Dentistry and Craniofacial Sciences, King's College London, UK*

[*] Corresponding author: Hemantha Amarasinghe, Email: hemanthaamarasinghe@yahoo.com Tele +94712208316; Fax: +94112837988

Keywords: Aerosols, Artificial Intelligence, Big Data, Dentistry, Digitalization, SARS-CoV-2,

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/odi.14043

Abstract

With the ongoing COVID-19 pandemic, the general dental practice has dwindled worldwide. Many usual activities performed before have been restricted, and dentists face great difficulties coping with their regular work. Such post-COVID-19 situations have leveraged the digitalization era to creep into the dental landscape as a blessing in disguise. Hence, bringing Dentronics into the dental landscape is vital, and it helps reduce the transmission potential of the COVID-19 virus largely. This paper helps grasp knowledge on such devices, and the application of such devices is purposefully promoted. We collated information on digital devices that could be used for general dental settings in the post-COVID-19 era with their advantages and limitations. Furthermore, we highlighted the modes of transmission of the COVID-19 virus to be controlled by such devices in dental settings. A dentist can cut down the time spent on a patient's dental care with these devices, enhancing productivity. Such improvements then help dentists engage in their routine work even if new virulent viruses emerge in the future.

Since the advent of the COVID-19 pandemic in late December 2019, regular dental practice has been crippled (Odeh et al., 2020). Dentists and their assistants worldwide feel that practices regarded as routine during the pre-COVID-19 era may no longer be plausible because of continuing risk of transmission of disease to staff and patients - even from asymptomatic individuals - who may visit dental clinics with emerging virulent and highly contagious SARS-CoV-2 variants (Limeres Posse et al., 2021). Currently, the general public is reluctant to visit dentists because of inherent fears of contracting disease. Concurrently, the progressive aging of the global population increases the need for the provision of oral health care services and the requirement for safe facilities (Mascitti & Campisi, 2020). At the same time, the ever-changing global COVID-19 situation with waves of new variants causing new epidemics is preventing dentists from engaging in oral health programs, as they are confronted with escalating risks when they are at work. Major risks include the potential transmission of SARS-CoV-2 by fomites, droplets, and aerosols from COVID-19 asymptomatic people (Innes et al., 2021). Aerosol generating procedures (AGPs) in general dental settings increase these risks, and it is impossible to remove them entirely (Innes et al., 2021, Dudding).

Totally safe and reliable facilities and logistics to prevent cross infection in the current climate, and with inevitable future epidemics, need to be developed (Mascitti & Campisi, 2020). Dentists require enhanced settings for the provision of patient care. The application of Dentronics could facilitate these: Dentronics is the hypernym of a wide field of modern dental technologies, such as medical robot systems and specialized artificial intelligence, hardware, software, human-machine interaction, robot safety, and assistive functions. Until recently, there has been little use of Dentronics in dental practice, but it is beginning to gain popularity in some countries (Grischke et al., 2020). This paper delineates numerous applications of Dentronics, which every dentist can embrace for the safe and uninterrupted provision of dental care.

Dentronics can enable many activities to be performed remotely with minimal exposure to patients. These require the application of artificial intelligence and big data analytics. Artificial intelligence (AI), the term first coined by John McCarthy (1989) (McCarthy J), is a technique used for tasks usually performed by humans to be superseded by a computer or a robot controlled by a computer. Big data analytics is a complex process of examining a vast amount of data to uncover hidden patterns, correlations, trends, and preferences: for example, in screening patients for oral

disease (Listl S., 2021). Records of patients' medical and dental histories, symptoms and signs of disease, photographic images, radiographic, PET and MRI data and results of laboratory tests can be stored and appropriately linked in computer cloud. Under digitalized systems, maneuvering such data could be done with the aid of the Internet of Things (IoT). IoT refers to a system of interrelated and internet-connected objects that collect and transfer data over a wireless network without human intervention (Balaji Ganesh S, 2020).

With these technologies, scientists have invented state-of-the-art technology-embedded products for dentistry. These include smart goggles with LED illumination and eyesight corrections, smart facemasks, AI-built spittoon with air suction, intelligent robotics, 3-D printing, intraoral cameras fitted with LIDAR sensors, and smart doors, among others. These devices assist dentists in educating, screening and diagnosing, and follow-up activities with patients while maintaining good hygiene, even when dealing with large numbers for a given day. During pandemics, these devices help reduce the risk of disease transmission by shortening the exposure duration of patients compared to that of a conventional setting. Besides, such Dentronic applications can reduce the downtime or fallow time between dental patients so that the number of patients visiting a clinic could be improved. Muehlematter et al. (2021) elaborate that 222 and 240 such devices have been approved in the USA and Europe (Muehlemaater), respectively, as medical devices to be used to ease the situation caused by the COVID-19 pandemic. Table 1 depicts the capabilities and the potential beneficiaries of a number of these approaches and devices.

With new SARS virus variants of concern emerging globally, awareness of their probable high infectivity, high transmission (reproduction number), increased severity of disease, increased airborne time, and less effectiveness against vaccines makes the growth of dentronics essential. While evidence for the efficacy of the above devices is limited, it is prudent to put Dentronic applications to the test as we strive to provide oral health services in these challenging times.

Table1: Capabilities and potential beneficiaries of AI-based smart devices in dental practice

Type of application	Salient features and their effect on control of risk factors	Risk factor/s reduced	Reference
Smart goggle with LED illumination and eyesight corrections	Digital data on LDR sensor attached with the spectacles detecting the amount and type of rays falling on eyes (For dentists - reduced eye strain; hence, improved productivity, less time taken for patient observation)	Fomite, droplets, and aerosol	(Chandrasekaran, 2021)

Intelligent face mask	A device embedded in a face mask composed of flexible immunosensor based on high-density conductive nanowire array, a miniaturized impedance circuit, and wireless communication units; detection of viral concentration as low as 7 pfu/mL from the aerosol particles in the face mask in 5 min, which is ideal for asymptomatic patients. (This will enable easier detection of COVID-19 infectious patients and others visiting clinics).	Fomite, droplets, and aerosol	(Xue, 2021)
	Improved protection against SARS-CoV-2 spreading through aerosol or droplets with integrated real-time data analysis for improving the immediate safety of the users and improved services for long-term health data storage and big data analytics; Improved comfort, sensing ventilation, voice correction, real-time instructions, temperate detection (For patients - Improved collection of patient data)	Droplets and aerosol	(Hyysalo, 2021)
AI-built spittoon with air suction	Improved collection of splatters with a suction device to minimize aerosols and droplets falling in the neighborhood of dental chair; automatic cleaning with disinfectants when spitting and closing the spittoon; smart opening with eye contact (For dentists and assistants - The minimized risk of aerosols and droplets in clinics)	Droplets and aerosol	Unpublished
Intelligent robotics	Improved services for telemedicine, cleaning, assistance rendered in dental equipment mobility, data recording, medicine dispatching (For dentists and assistants - Minimized exposure to likely COVID-19 patients)	Fomite, droplets, and aerosol	(Khan, 2020)
3-D printing	Improved production of physical models for implants, the manufacture of dental, craniomaxillofacial, and orthopedic implants, and the fabrication of copings and frameworks for an implant and dental restorations (For dentists and assistants - Minimized exposure to likely COVID-19 patients)	Fomite, droplets, and aerosol	(Jain, 2016)

Intraoral cameras fitted with LIDAR sensors	Improved 3-D data acquisition rate, accuracy, signal to noise ratio, and dynamic depth resolution in imaging systems, automatic Lux level adjustment (For dentists - Minimized exposure to likely COVID-19 patients)	Fomite, droplets, and aerosol	(Sandborn, 2017)
Smart doors	Improved identification of patients by inbuilt cameras, temperature imaging, automatic door opening, UV light scanning for virus and bacteria destruction, message and information delivery by AI-based architecture (For dentists and assistants - Minimized exposure to likely COVID-19 patients)	Fomite, droplets, and aerosol	Unpublished

Dentists are currently confronted with many challenges in setting up, operationalizing, training, maintaining, and repairing facilities to provide oral health care. Public- and private-sector involvements in providing such services have been limited, particularly in developing countries. The necessary networking between professions with the range of competencies needed is absent. Inherent fears prevent many dentists from embracing these technologies. Governmental support is lacking in many countries. Approval procedures required for these devices need to be streamlined while retaining rigor. Privacy in patient's data storage systems needs to be guaranteed. In many countries, legal aspects covering ethical and privacy matters are lacking.

Standard dashboards and agreed policies are needed to facilitate data sharing among stakeholders. For example, international funders such as Welcome Trust and the Bill & Melinda Gates Foundations have mandated that funding recipients share data from research related to COVID-19 as soon as a study is complete, regardless of publication status. Nevertheless, the digital era for a sound dental practice is demanded in the COVID-19 situation, particularly in public health clinics. It will become a new normal for dentists.

The digitalization era in dental settings has just begun, and it will continue in many parts of the world in the foreseeable future. There have been many new Dentronic applications developed worldwide based on AI architecture. The time has come for dentists to deploy such applications in dental settings in averting the transmission potential of the COVID-19 virus. With these devices, a dentist can cut down the time spent on a patient’s dental care; thereby, productivity can be

enhanced. Such improvements then help dentists to engage in their routine work even if new virulent viruses emerge in the future.

Author Contributions

Jayaweera M. contributed to conception and drafted the manuscript. Amarasinghe H. and Johnson N.W. contributed to conception and critical revision of manuscript drafts. All authors give final approval of the manuscript before submission and agree to be accountable for all aspects of work, ensuring integrity and accuracy.

Conflict of Interest

The authors report no conflict of interest.

Acknowledgments

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Balaji Ganesh S SK (2020). Internet of Things—A Novel Innovation in Dentistry. . *Journal of Advanced Oral Research* **12**: 42-49.

Chandrasekaran RVS, Vijayaraj.S.., Surendhar, S.P.I.L., (2021). Smart goggle prototype. . *Annals of R.S.C.B.* **25**.

Dudding, T., Sheikh, S., Gregson, F., Haworth, J., Haworth, S., Main, B.G., Shrimpton, A.J., Hamilton, F.W., Ireland, A.J., Maskell, N.A., Reid, J.P., Bzdek, B.R., Gormley, M. A clinical observational analysis of aerosol emissions from dental procedures. MedRxiv, 2021. doi: https://doi.org/10.1101/2021.06.09.21258479.

Grischke, J., Johannsmeier, L., Eich, L., Griga, L., Haddadin, S. (2020). Dentronics: Towards robotics and artificial intelligence in dentistry. *Dent Mater* **36**: 765-778.

Hyysalo, J.D., Sandun H., Jari S., Christian R., Mikko, L.T. (2021). Smart Mask – Wearable IoT Solution for Improved Protection and Personal Health. . *TechRxiv. Preprint,* .

Innes, N., Johnson, I.G., Al-Yaseen, W., Harris, R., Jones, R.K.C. S., McGregor, S., Robertson, M., Wade, W.G.,Gallagher, J.E. (2021). A systematic review of droplet and aerosol generation in dentistry. *J Dent* **105**: 103556.

Jain, R., Supriya, B. S., Gupta, K. (2016). Recent Trends of 3-D Printing in Dentistry- A review. . *Annals of Prosthodontics & Restorative Dentistry.* **2**: 101-104.
Khan, Z.H., Siddique, A., Lee,C.W. (2020). Robotics Utilization for Healthcare Digitization in Global COVID-19 Management. , . *International Journal of Environmental Research and Public Health* **17**: 3819.

Limeres Posse, J., van Harten, M.T., Mac Giolla Phadraig, C., Diniz Freitas, M., Faulks, D., Dougall, A., Daly, B., Diz Dios, P. (2021). The Impact of the First Wave of the COVID-19 Pandemic on Providing Special Care Dentistry: A Survey for Dentists. *Int J Environ Res Public Health* **18**.

Listl, S. (2021). Big Data and Machine Learning. In: Peres M.A., Antunes J.L.F., Watt R.G. (eds) *Oral Epidemiology. Textbooks in Contemporary Dentistry, Springer, Cham.*: 357-365.

Mascitti, M., Campisi, G. (2020). Dental Public Health Landscape: Challenges, Technological Innovation and Opportunities in the 21st Century and COVID-19 Pandemic. *Int J Environ Res Public Health* **17**.

McCarthy, J. (1989) Artificial intelligence, logic and formalizing common sense. In: Thomason RH (ed). Philosophical logic and artificial intelligence. Dordrecht: Springer:161–190.

Muehlemaater, J., Daniore, P., Vokinger, K.N., (2021) Approval of artificial intelligence and machine learning- based medical devices in the USA and Europe (2015–20): a comparative analysis. Lancet Digit Health 3: e195–203. https://doi.org/10.1016/ S2589-7500(20)30292-2

Odeh, N.D., Babkair, H., Abu-Hammad ,S., Borzangy, S., Abu-Hammad, A., Abu-Hammad, O. (2020). COVID-19: Present and Future Challenges for Dental Practice. *Int J Environ Res Public Health* **17**.

Sandborn, P.A.M. (2017). MCW Lidar: Scaling to the Chip-Level and Improving Phase-Noise-Limited Performance. A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Engineering - Electrical Engineering and Computer Sciences in the Graduate Division of the University of California, Berkeley. ProQuest Dissertations Publishing, 10687479.

Xue, Q., Kan, X., Pan, Z., Li, Z., Pan, W., Zhou, F., Duan, X. (2021). An intelligent face mask integrated with high density conductive nanowire array for directly exhaled coronavirus aerosols screening. 186, 113286, 2021. . *Biosensors and Bioelectronics* **186**: 113-286.