



# Kent Academic Repository

**Eaton, Kenneth A. (2022) *The development of digital dentistry in the UK: An overview*. Primary dental journal, 11 (4). pp. 94-98. ISSN 2050-1684.**

## Downloaded from

<https://kar.kent.ac.uk/99376/> The University of Kent's Academic Repository KAR

## The version of record is available from

<https://doi.org/10.1177/20501684221134198>

## This document version

Publisher pdf

## DOI for this version

## Licence for this version

CC BY (Attribution)

## Additional information

## Versions of research works

### Versions of Record

If this version is the version of record, it is the same as the published version available on the publisher's web site. Cite as the published version.

### Author Accepted Manuscripts

If this document is identified as the Author Accepted Manuscript it is the version after peer review but before type setting, copy editing or publisher branding. Cite as Surname, Initial. (Year) 'Title of article'. To be published in *Title of Journal*, Volume and issue numbers [peer-reviewed accepted version]. Available at: DOI or URL (Accessed: date).

## Enquiries

If you have questions about this document contact [ResearchSupport@kent.ac.uk](mailto:ResearchSupport@kent.ac.uk). Please include the URL of the record in KAR. If you believe that your, or a third party's rights have been compromised through this document please see our [Take Down policy](https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies) (available from <https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies>).

## KEY WORDS

Digital dentistry, teledentistry, online learning, history, challenges

## LEARNING OBJECTIVES

- To gain an understanding of the development of digital dentistry in the UK over the last 30 years
- To understand that it has influenced all aspects of clinical practice and education
- To appreciate how the COVID-19 pandemic has raised awareness of the need for distant consultations and education

## AUTHOR

**Kenneth A. Eaton BDS, MSc, PhD, MGDS RCS (Eng.), FFGDP(UK) hon, FFPH, FHEA, FICM, FNCUP, DHC**

Visiting Professor, University College London; Honorary Professor, University of Kent, UK

**KENNETH A. EATON**

Prim Dent J. 2022;11(4):94-98

# THE DEVELOPMENT OF DIGITAL DENTISTRY IN THE UK: AN OVERVIEW

## ABSTRACT

The COVID-19 pandemic has highlighted the benefits which digital technology offers to all aspects of dental practice and education. This paper provides an overview of how digital technology has enhanced clinical and administrative procedures within dental practice, including computer-aided design/computer-aided manufacture (CAD/CAM), digital radiography, 3D printing, patient records, electronic patient referrals and electronic communications from dental practices. It then considers the development of teledentistry (mHealth) and its benefits in enabling distant consultations with patients, who for one reason or another are unable to visit dental practices easily. It then goes on to consider how and why digital dental distance learning materials were provided to general dental practitioners in England by the Department of Health (DoH) (England) and how they evolved. Finally, this paper considers the use of digital technology in dental education by dental schools.

## Introduction

The topic of digital dentistry is very broad. An editorial written in 2017 suggested that: "So far as digital dentistry is concerned, it can be interpreted to mean whatever each of us dental professionals wish it to be".<sup>1</sup> For the purposes of this paper, digital dentistry is taken to include the use of digital and visual technologies in all aspects of the provision of oral healthcare. These include:

- clinical and administrative applications within dental practices, hospitals, dental schools, and dental laboratories
- teledentistry
- dental education

The development in each of these areas since 1990, will be considered in turn.

Prior to this date, the commercial internet did not exist, few people owned computers and the impact of digital technology on all aspects of the provision of oral healthcare and dental education was minimal. As will be described, uptake of digital dentistry has been slow in some areas.<sup>2</sup> However, the COVID-19 pandemic has provided a very strong incentive for the use of distant consultations, teledentistry and online teaching.

## Digital clinical and administrative applications

These include computer-aided design/computer-aided manufacture (CAD/CAM); digital radiography, 3D printing, electronic patient records and communication within the NHS, electronic patient referrals, and other communications from dental practices.



### Computer-aided design/computer-aided manufacture (CAD/CAM)

CAD/CAM was first introduced into dental practice in the 1980s. It had previously been used in the precision engineering of aircraft parts. Due to limiting factors, including requiring an inordinate amount of time to produce a viable product and high purchase cost, its take-up in dental practices in the UK has been slow. Other papers<sup>3-5</sup> in this edition of the *Primary Dental Journal* detail aspects of the use of CAD/CAM in dental practice.

### Digital radiography

Digital dental radiography provides instant images at the chairside and eliminates the need for the use of chemicals to process films and a suitable light-free environment. In 2010, a study indicated that nearly 50% of general dental practitioners (GDPs) working in West Kent used digital radiography.<sup>6</sup> The author of this paper has been unable to find a report of the percentage of GDPs working in the UK who used digital radiography in 2022, however, anecdotally it may well be over 90%.

### 3D printing

3D printing, or additive manufacturing, is the construction of a three-dimensional object from a CAD or digital 3D model. It is used in a growing number of industries, including aerospace, fashion and by the military. In dentistry it has been used to produce working models (casts) and several different types of prostheses and guides, including complete dentures, removable partial denture frameworks, occlusal splints and surgical implant guides.<sup>7,8</sup> Studies have suggested that crowns produced by 3D printing have a good fit and complete dentures produced using this technique are accurate.<sup>8,9</sup>

### Electronic patient records and communication within the NHS

Most GDPs in the UK use electronic patient record software systems. For those dental practices with an NHS contract there is a requirement to transmit patient related information to the NHS Business Services Authority electronically. Unfortunately, there is no one electronic patient record system and, as a result, transmission of electronic patient records can be a problem. In the

past, GDPs with NHS contracts were unable to obtain N3 connections (a secure system to allow the transmission of patient records within the NHS) to access the secure NHS email system. Recently, the NHS Health and Social Care Network (HSCN) has been established. Its aims include:

- enabling organisations to rationalise their connectivity by obtaining public (internet) and private network services over a single connection
- allowing simple access to NHS Digital's national applications, making it easier to work collaboratively across both health and social care
- making it easier to share information, confirm NHS numbers, share patient Care Plans and access Summary Care Records<sup>10</sup>

It is uncertain whether GDPs with NHS contracts will be able to use the HSCN.

### Electronic patient referrals

Referrals of dental patients to NHS hospitals and the community dental services in England are made electronically. However, different referral systems exist in different parts of the country. In London and the South and South East of England, the Rego (NEC Software Solutions, Hemel Hempstead, UK) electronic patient referral software system has been used since 2018.<sup>11</sup>

### Other electronic communications from dental practices

These include dental practice websites, online appointment booking and reminders to patients of their appointments transmitted via text messages to mobile phones or emails.

### Teledentistry (mHealth)

The definition of teledentistry has changed over time. In 1997, when the author of this paper was appointed as Teledentistry Lead at the Eastman Dental Institute, UK, the term included the use of digital technology to provide education and training as well as providing advice and provisional diagnoses to patients remotely from clinics and practices. The broad definition suggested by Chen et al. (2003),<sup>12</sup> which was "Teledentistry is a technology pertaining to e-health or telehealth which combines the use of telecommunications and dentistry,"

encapsulated this concept. However, more recently, for some, the term teledentistry has become synonymous with mobile health (mHealth), as defined by the World Health Organization,<sup>13</sup> implying that teledentistry may not include distance learning for dentists and other dental professionals. For this reason, the use of digital technology to provide dental education will be considered in a separate section to mHealth, in this paper.

In the late 1990s, the orthodontic department at the Bristol Dental School provided advice to dentists and patients in West Cornwall via video conference using Integrated Services Digital Network (ISDN) links to transmit live images of the patients, their radiographs and study casts.<sup>14</sup> This may have been the first use of digital technology in the UK to provide distant dental consultations and treatment plans. Between 1998 and 2002, informal one-off consultations in real time using videophones and ISDN 6 links, also took place, to distant dental practices from the Eastman Dental Institute. Figure 1 shows such a link, during which advice on the probable reason for an unretentive porcelain jacket crown (PJC) was given to a GDP in a practice 40 miles distant.

In other countries, since 2014 and prior to the COVID-19 pandemic, examples of the use of teledentistry to provide distant diagnosis and advice include: to the residents of care homes for the elderly in Australia<sup>15,16</sup> and in Brazil to diagnose dental caries in juvenile offenders in prison.<sup>17</sup>

During lockdowns caused by the COVID-19 pandemic, GDPs in the UK used mobile phones and/or computers to provide online advice to their patients, usually in real time. It is also possible for patients to store and forward images to their clinicians.

As a result of the COVID-19 pandemic, there has been a marked increase in papers written on teledentistry. Readers of this paper are referred to two such papers, one a systematic review<sup>18</sup> and the other a narrative review.<sup>19</sup> The narrative review<sup>19</sup> is particularly useful as it succinctly deals with the scope of teledentistry, the equipment required,

## THE DEVELOPMENT OF DIGITAL DENTISTRY IN THE UK: AN OVERVIEW



Figure 1: Advice via a live link on reasons for an unretentive porcelain jacket crown (PJC)

the use of teledentistry in general dental practice and specialist practice, its role in oral medicine, oral and maxillofacial surgery, endodontics, orthodontics, prosthodontics, periodontics, children's dentistry and preventive dentistry, the pitfalls of teledentistry, informed consent and patient confidentiality.

### Digital dental education

This section describes in detail how and why the Department of Health (DoH) (England) funded the development of a range of digital distance learning for GDPs and how digital learning has developed in dental schools over the last 30 years.

### Department of Health (England) distance learning for GDPs in England

Section 63 of the NHS Act 1968 permits the secretary of state for health to make NHS funds available for the provision of the continuing education of dentists who have NHS General Dental Services (GDS) contracts.<sup>20</sup> Prior to 1997 in England, the Dental Division of the DoH (England) administered Section 63 funds and supervised their distribution. In 1997, the Department outsourced this responsibility to the National Centre for the Continuing Professional Education of Dentists (NCCPED).

The reason why the DoH (England) commissioned the provision of distance learning material for GDPs with NHS contracts, related to the Schanschieff Report of an enquiry into alleged overprescription of treatment by GDPs with NHS contracts. It found that there was little evidence of deliberate over-treatment but there was evidence that several GDPs had not updated their knowledge since they graduated.<sup>21</sup> A subsequent national survey<sup>22</sup> found that the main reasons for this were lack of time and difficulty in accessing continuing professional development (CPD) courses. The DoH (England) therefore decided to commission a series of videos on 18 different topics to update GDPs. The videos were made available free of charge to all dental practices in England with a contract to provide NHS general dental services. However, these videos did not include any active learning so the next stage was to commission interactive computer-aided learning (CAL) programmes, initially on floppy discs, then on CD-ROMs, and finally on DVDs. Most topics in clinical dentistry were covered, as listed in Table 1.

Prior to their general release, each CAL programme was assessed by 50 GDPs and any problems relating to the accuracy of their contents or ease of use were addressed. Subsequently, quality standards for distance learning materials

for dentists were published,<sup>23</sup> addressing three broad questions:

- does the material encourage and enable effective learning?
- are its contents scientifically correct?
- is the technology user-friendly, reliable, and durable?

In 2000, NCCPED funded a successful series of 40 video conferences which linked presenters from the then four London dental schools (Eastman, Guy's, King's, and the Royal London) to groups of GDPs meeting in postgraduate centres in the home counties. The project was named PROVIDENT (Postgraduate Regional Online Video conferencing in Dentistry).<sup>24,25</sup> In the following year, five webinars were produced and broadcast to 200 dentists in their homes.

The digital distance learning programmes were funded by retaining a small percentage of the annual Section 63 budget centrally. The rest of the Section 63 funds were distributed to the postgraduate deaneries for local CPD courses and hands-on skills centres.

Unfortunately, in 2003 the DoH (England) decided to close the 20 agencies (colloquially known as "off-shore islands") which it had established to administer various activities, including CPD for GDPs and Dental Vocational Training. As a result, the two dental agencies (NCCPED and the Committee for Vocational Training), were closed. The DoH (England) then transferred all funds for CPD direct to postgraduate deaneries and none were retained for central initiatives, such as the production and evaluation of digital distance learning. The then Faculty of General Dental Practice (UK) was also a loser as, between its foundation and 2003, it had received Section 63 funds for activities such as national one day CPD conferences held in London.

### Digital dental education in dental schools

From the mid-1990s two pioneers lead the development of CAL and digital dentistry in UK dental schools. They were Professor Chris Stephens of Bristol and Professor Pat Reynolds of King's College London (KCL). A CAL facility was established in the University of Bristol in

**TABLE 1****COMPUTER-AIDED LEARNING TOPICS COMMISSIONED BY THE DEPARTMENT OF HEALTH (ENGLAND) 1990–2003**

Orthodontic assessment
Aspects of partial denture design
Minimal preparation resin-retained bridges
Endodontic diagnosis and management
Dentistry for special needs patients
Oral manifestations of HIV
An introduction to occlusion
Aspects of minor oral surgery
SafeQuest (infection control now updated by programme 12)
New dentures for old
Compilation CD-ROM of programmes 2 – 10
SafeQuest (Infection control)
The X-ray files
Core skills in informatics (no longer available)
Oro-facial signs of child abuse
Management of traumatised incisors
Oral ulcers
Pulp therapy for deciduous teeth
Fissure sealants
Tooth wear
Pulp fiction (diagnosis and management of pupal and periapical pathology)
The dental management of medically compromised patients
Dental photography and imaging
Oral mucosal white patches
The use of gold alloys in restorative dentistry
The last post (restoration of endodontically treated teeth)
Behavioural management
Screening for oral cancer and pre-cancer
Assessing the periodontium
The X-ray files – modules 2 – 5

1994 and the Centre for Computer Assisted Teaching in Medicine was based in Bristol.<sup>26</sup> In addition to the provision of distant orthodontic

consultations from Bristol to West Cornwall described earlier in this paper,<sup>14</sup> Professor Stephens produced a range of digital educational material,

including an expert rule-based system for fixed appliance treatment planning.<sup>27</sup>

At KCL, Professor Reynolds promoted the use of technology enhanced learning (TEL) and virtual learning environments (VLEs). At KCL, TEL and VLE initiatives have included the development of an International Virtual Dental School (IVIDENT),<sup>28</sup> a computer game for public health planning (Games Research Applied to Public Health with Innovative Collaboration [GRAPHIC]),<sup>29</sup> and haptic dental training (Haptel) simulators to help dental students acquire tactile skills when drilling teeth.<sup>30</sup> Several other haptic stimulators have been developed for dental teaching, including Dentsim (Image Navigation, New York, USA), Simodont (Nissin Dental Products Inc., Kyoto, Japan), and Periosim (College of Dentistry, University of Illinois, Chicago, USA). None are perfect, however, they are improving all the time.

Moodle™ (Moodle, Perth, Australia) and Blackboard® (Blackboard Inc., Reston, Virginia, USA) have been developed as online repositories for teaching material and the transmission of student assignments, and Turnitin (Advance Publications, Oakland, California, USA) has been developed to assess whether student assignments, dissertations and other written work have been plagiarised.<sup>31</sup>

### Online forums for dentists and dental care professionals

GDPUK,<sup>32</sup> one of the earliest online forums for GDPs, was established in 1997. There are now several others and most dental organisations, such as the College of General Dentistry and the General Dental Council, produce monthly updates which are distributed via email and social media.

### Conclusions

This paper has reviewed some of the initiatives involving digital media which have transformed all aspects of dental practice and dental education in the last 30 years. Progress has not been made at a consistent speed. However, the recent COVID-19 pandemic has highlighted the benefits of using digital technology in all aspects of dental practice and education.

## THE DEVELOPMENT OF DIGITAL DENTISTRY IN THE UK: AN OVERVIEW

### REFERENCES

- Hancocks S. What is digital about dentistry? *Br Dent J.* 2017;223(5): 305
- Hancocks S. Famous for 15 minutes. *Br Dent J.* 2020;229(3): 145.
- de Freitas RFCP, Pereira ALC, Carreiro AdFP. CAD/CAM technology for fabrication of reduction guide for RPD parallel guiding planes preparation: A dental technique. *Prim Dent J.* 2022;11(4): 66-70.
- Pucci J, Picolo MZD, Brasil L, et al. Influence of surface treatment and aging on the bond strength of resin cement to hybrid and ceramic CAD/CAM materials. *Prim Dent J.* 2022;11(4): 78-85.
- Benli M, Turkyilmaz I, Martinez JL. Clinical performance of lithium disilicate and zirconia crowns using digital impressions: A systematic review. *Prim Dent J.* 2022;11(4): 71-76.
- Mauthe PW, Eaton KA. An investigation into dental digital radiography in dental practices in West Kent following the introduction of the 2006 NHS General Dental Services contract. *Prim Dent Care.* 2011;18(2): 73-81.
- Dawood A, Marti Marti B, Sauret-Jackson V, Darwood A. 3D printing in dentistry. *Br Dent J.* 2015;219(11): 521-529.
- Tian Y, Chen C, Xu X, et al. A review of 3D printing in dentistry: technologies, affecting factors, and applications. *Scanning.* 2021;9950131. doi: 10.1155/2021/9950131
- Jang Y, Sim JY, Park JK, et al. Evaluation of the marginal and internal fit of a single crown fabricated based on a three-dimensional printed model. *J Adv Prosthodont.* 2018;10(5): 367-373.
- NHS Health and Social Care Network HSCN. [Internet]. Leeds: NHS Digital; 2022. Available at <https://digital.nhs.uk/services/health-and-social-care-network/benefits-of-hscn> [Accessed May 2022].
- Evans S. Dentally now integrates with Rego. *Dentistry.* 6 Dec 2018. Available at <https://dentistry.co.uk/2018/12/06/dentally-now-integrates-rego/> [Accessed May 2022].
- Chen JW, Hobdell MH, Dunn K, et al. Teledentistry and its use in dental education. *J Am Dent Assoc.* 2003;134(3):342-346.
- World Health Organization (WHO). mHealth: new horizons for health through mobile technologies: second global survey on eHealth. [Internet]. Geneva: WHO; 2011. Available at [https://www.who.int/goe/publications/goe\\_mhealth\\_web-pdf](https://www.who.int/goe/publications/goe_mhealth_web-pdf) [Accessed Jun 2021].
- Cook J, Edwards J, Mullings C, Stephens C. Dentists' opinions of an online orthodontic advice service. *J Telemed Telecare.* 2001;7(6):334-337.
- Mariño R, Tonmukayakul U, Manton D, et al. Cost-analysis of teledentistry in residential aged care facilities. *J Telemed Telecare.* 2016;22(6):326-332.
- Tynan A, Deeth L, McKenzie D, et al. Integrated approach to oral health in aged care facilities using oral health practitioners and teledentistry in rural Queensland. *Aust J Rural Health.* 2018;26(4):290-294.
- Morosini IAC, de Oliveira DC, Ferreira FM, et al. Performance of distant diagnosis of dental caries by teledentistry in juvenile offenders. *Telemed J E Health.* 2014;20(6):584-589.
- Fernández CE, Maturana CA, Coloma SI, et al. Teledentistry and mHealth for promotion and prevention of oral health: A systematic review and meta-analysis. *J Dent Res.* 2021;100(9):914-927.
- Deshpande S, Patil D, Dhakar A, et al. Teledentistry: A boon amidst COVID-19 lockdown - A narrative review. *Int J Telemed Appl.* 2021;8859746. doi: 10.1155/2021/8859746
- Eaton KA, Veale B, Rothwell PS. What are Section 63 and "approved" courses and how are they organised? *Br Dent J.* 1992;173(9):307-311.
- No authors listed. The Schanschieff report. *Br Dent J.* 1986;160(9): 315. doi: 10.1038/sj.bdj.4805851
- Mouatt RB, Veale B, Archer K. Continuing education in the GDS: An England survey. *Br Dent J.* 1991;170(2):76-79.
- Eaton KA, Hammick M. Distance learning materials for dentists – a users guide to quality. *Br Dent J.* 2003;194(5):253-256.
- Odell EW, Francis CA, Eaton KA, et al. A study of videoconferencing for postgraduate continuing education in dentistry in the UK – the teachers' view. *Eur J Dent Educ.* 2001;5(3):113-119.
- Eaton KA, Francis CA, Odell EW, et al. Participating dentists' assessment of the pilot regional online videoconferencing in dentistry (PROVIDENT) project. *Br Dent J.* 2001;191(6):330-335.
- Reynolds PA, Eaton KA, Dobozy E. The dawn of the digital era in dental education: Charting the changes and challenges up to 2020. Part II The dawn of digital dental education. *Dent Hist.* 2021;66(1):1-16.
- Stephens C, Mackin N. The validation of an orthodontic expert system rule-base for fixed appliance treatment planning. *Eur J Orthod.* 1998;20(5): 569-578.
- Suman S, Amini A, Elson B, Reynolds P. Design and development of virtual learning environment using open source virtual world technology. In: Reynolds N, Turcsányi-Szabó M. (eds.) *Key Competencies in the Knowledge Society.* IFIP TC3 International Conference, KCKS, WCC 2010 Brisbane, Australia, September 20-23, 2010. Springer, New York; 2010. p379-388.
- Sipiaryuk K, Gallagher JE, Hatzipanagos S, Reynolds PA. Acquiring critical thinking and decision-making skills: An evaluation of a serious game used by undergraduate dental students in dental public health. *Tech Knowl Learn.* 2017;22(2): 209-210.
- San Diego JP, Cox MJ, Quinn BFA, et al. Researching haptics in higher education: The complexity of developing haptics virtual learning systems and evaluating its impact on students' learning. *Comput Educ.* 2012;59(1): 156-166.
- Reynolds PA, Mason R, Eaton KA. Webcasting: casting the web more widely. *Br Dent J.* 2008;204(3): 145-149.
- GDPUK. An online forum for general dentists. [Internet]. Manchester: GDPUK; 2022. Available at <https://www.gdpuk.com/> [Accessed May 2022].