

# Survey on the use of CAD-CAM technology by UK and Irish dental technicians

E. Blackwell,<sup>1</sup> M. Nesbit<sup>2</sup> and H. Petridis<sup>\*3</sup>

## In brief

Most technicians reported using some form of CAD/CAM in their workflow.

Most reported that the technology did not affect their working relationship.

Suggests CAD/CAM has influenced material selection, leading to an increase in the use of zirconia.

Highlights that high initial investment cost remains a barrier in adopting this technology.

**Statement of the problem** Digital workflows (CAD/CAM) have been introduced in dentistry during recent years. No published information exists on dental technicians' use and reporting of this technology. **Purpose** The aim of this cross sectional survey was to identify the extent digital technology has infiltrated the workplace and to investigate the factors affecting the use of CAD-CAM technology by dental laboratory technicians within Ireland and the UK. **Materials and methods** A web-based questionnaire was composed (Opinio, Object Planet Inc. Oslo, Norway) and distributed to UK and Irish dental technicians. Answers to all questions were anonymous and grouped such that general information was gathered initially, followed by branching of the survey into two sections depending on whether or not the respondent worked with CAD-CAM technology. Results were compiled and statistical analysis (Fisher's Exact test, SPSS, IBM, Armonk, New York, USA) was performed in order to investigate any correlation between various demographic variables and the answers provided. **Results** The survey was distributed to 760 UK technicians and 77 Irish technicians. The total number of completed surveys was 105, which yielded a total response rate of 14%. Most technicians reported using some form of CAD/CAM aspect in the workflow, and this was more significant for technicians working in large laboratories. Most training received was company-led. Large laboratories were also significantly correlated with less outsourcing of CAD/CAM work and a change in dental material use leading to the increase of zirconia and the decrease of noble alloys. Dental technicians did not report any significant change in working relationships and staffing as a result of CAD/CAM incorporation. High initial investment cost was the most common reason quoted from non-users, along with the lack of such technology in their working environment.

## Introduction

The application of computer-aided design/computer-aided manufacture (CAD/CAM) technology has evolved rapidly and has led to changes in the traditional workflow which affect both clinicians and dental laboratory technicians.<sup>1,2</sup> The demand for aesthetic and metal-free restorations has led to the development of high strength ceramics in dentistry,<sup>3</sup> which may only be used in conjunction

with CAD/CAM technology.<sup>4-6</sup> Following on from the success of CAD/CAM in the fabrication of crown and bridgework, CAD/CAM was incorporated into the production of implant abutments and frameworks in the 1990s<sup>7</sup> and it has also shown to be reliable in constructing implant abutments, crowns and superstructures.<sup>5</sup>

Despite the aforementioned advances in technology and materials, there are currently no published studies regarding the actual utilisation of CAD/CAM aspects by either dentists or dental care professionals. This holds true for both the UK and global markets. The only available data comes from sourcing of private market research companies. Millennium Research Group, a Canadian medical devices research provider, in a 2012 report stated that the global dental CAD/CAM market would

grow strongly to reach more than \$540 million by 2016 despite the economic slowdown.<sup>8</sup> Another marketing group updated this figure in 2017 to estimate total market worth of over \$3.3 billion in 2027 as the awareness of CAD/CAM increases.<sup>9</sup> This report<sup>9</sup> also estimated that the entry of new competitors would generate new market interest whilst intra-oral scanners would see particularly rapid adoption as dentists would increasingly use these devices to incorporate CAD/CAM technology into their surgeries rather than purchasing complete chairside systems. A report series by iData Research broadly came to similar conclusions and also predicted that all-ceramic restorations would approach the porcelain fused to metal share by 2019.<sup>10</sup> A recently published study<sup>11</sup> provided some independent information regarding CAD/CAM use by UK dentists.

<sup>1</sup>MSc Conservative Dentistry Graduate; <sup>3</sup>Senior Lecturer, Department of Restorative Dentistry; <sup>2</sup>Senior Technical Instructor, Prosthodontics Unit, UCL Eastman Dental Institute, London, United Kingdom.

\*Correspondence to: Dr. Haralampos Petridis  
Email: c.petridis@ucl.ac.uk

Refereed Paper. Accepted 26 January 2017  
DOI: 10.1038/sj.bdj.2017.407

The aim of this study, by means of a survey of UK and Irish dental technicians, was to investigate the level of infiltration of CAD-CAM technology into the workflow of dental laboratories, and to investigate the relationship of various demographic factors to the answers regarding use or non-use of this technology.

## Materials and methods

A short online survey of 22 questions (Appendix 1, page 692) was designed and piloted, in order to encourage participation and provide information on demographics and CAD/CAM use, which could be statistically analysed. An online rather than postal approach was decided on in order to increase sample size, maximise response and decrease costs. The data being collected in a digital format would also be more readily collated and analysed.

The survey was anonymous and addressed to both users and non-users of CAD/CAM and most questions were multiple-choice closed questions, but an option was offered for further comments at the end of relevant questions. The survey was distributed using a web-based survey tool administered by University College London, Opinio (ObjectPlanet Inc. Oslo, Norway) in June 2015. This software was able to send to all email addresses a covering letter explaining the use of the survey with a link to the survey embedded in this. The letter stated the purpose of the study and emphasised that anonymity would be preserved. Two databases were used with the assistance of the respective professional bodies: for access to UK dental technicians, the Dental Laboratory Association (DLA, Nottingham, UK) which is the professional body for dental laboratory owners in the UK, for Irish dental technicians, the Dental Technicians Association (DTA, Dublin, Ireland); this latter association represents individuals rather than laboratory owners.

The survey was accessible for a five week period and the Opinio survey system was programmed to send out five reminders over this period to individuals who had not yet responded to the survey. Reminders were sent at different times of the day and on both weekdays and weekends to target as many dental technicians as possible.

The answers were collated through Opinio software as Excel spreadsheets. Statistical analysis via Fisher's Exact Test (SPSS, IBM, Armonk, New York, USA) was performed in order to examine potential associations

between the survey responses and the various demographic variables, consisting of: country of work; operator age; operator level of training; size of workplace; and type of work predominantly carried out (NHS or private). A significance level of 2.5% was used rather than a conventional 5% level to reduce the potential effects of multiple testing.

## Results

The survey was distributed to 760 UK technicians and 77 Irish technicians. The total number of completed surveys was 105, which yielded a total response rate of 14% (11% and 29% for UK and Ireland respectively). The complete survey along with the percentage results for each question can be found in Appendix 1, page 692. The majority of respondents worked in England, followed by the Republic of Ireland. No responses were received from Wales. Most respondents had obtained their training either through some form of apprenticeship or Diploma. Most dental technicians (43.3%) had obtained CAD-CAM training from companies and manufacturers. Very few (6.3%) had training from educational institutes. More than twice as many technicians who answered were in the 41-60 age bracket than in the 20-40 year age bracket. The majority (44.7%) of the respondents worked in small laboratories, undertaking predominantly private work (69.1%). The vast majority of respondents (82%) stated that CAD/CAM technology was utilised. The statistical analysis showed that technicians in larger laboratories in this survey were more likely to report using CAD/CAM ( $P = 0.015$ ).

The majority of dental technicians who responded constructed all kinds of restorations through CAD-CAM, with the exception of removable partial denture frameworks. Most respondents considered implant-supported crowns as the most challenging prostheses to make. Almost half of the respondents reported doing the majority of CAD/CAM work 'in-house' as opposed to outsourcing. This was significantly correlated with the size of the laboratory ( $P = 0.007$ ) with larger ones outsourcing less. The results of this survey also highlighted that the adoption of CAD/CAM led to a decrease in the use of noble alloys and an increase in the use of Zirconia. These changes in material use were statistically significant for larger laboratories ( $P = 0.007$ ). The main reasons for this change, mentioned in the comments, were that dentists were now asking

for metal-free restorations, and that zirconia production was cheaper and more efficient compared to the use of metal alloys.

Various reasons were reported for embracing CAD/CAM, especially the desire for new technology, and the expectation for increased productivity and reliability. Most respondents felt that it was still early days to assess whether their investment had delivered on expectations; however, many of them reported that productivity and quality had improved. The adoption of CAD/CAM did not lead to changes in staffing according to the majority of respondents, who also felt that it had improved their role. However, additional comments from a large number of dental technicians highlighted what was perceived as significant inaccuracies in the scanning process and the need for further improvement in reliability, as well as cost effectiveness of this technology. A number of respondents also highlighted the problem of the technology being outdated soon after the investment.

Non-users of CAD/CAM quoted the high financial commitment as the primary reason for this, along with the lack of such technology in their laboratory. This group was also split in half regarding their intention to use CAD/CAM in the future.

## Discussion

An online rather than postal method of delivery was used for the survey even though lower responses have been recorded with online surveys.<sup>12,13</sup> This allowed for a potentially larger sample size and decreased the costs of this project. However, the response rate was very low, especially for UK-based dental technicians, even compared to another recent survey<sup>14</sup> of the same group utilising the same method. Therefore, the results of this survey should be interpreted with caution as the respondents may not be representative of the dental technician population in the UK and the Republic of Ireland. Despite the low response rate, to the knowledge of the authors, this is the first attempt worldwide to explore the issue of CAD/CAM use by dental technicians in an independent way, and the results do permit some meaningful conclusions, within the limitations mentioned.

The majority of dental technicians who completed the survey came from England, were in the mid-age group, and delivered predominantly private laboratory work. The geographic distribution correlated well with the

actual percentages found in the GDC's 'Facts and Figures'.<sup>15</sup> The latter two demographic variables (age group and type of work) might suggest that more experienced individuals, delivering mostly private laboratory work were more likely to have filled out the survey.

The majority of respondents reported using some kind of CAD/CAM aspect in the dental laboratory workflow, especially if they worked in large laboratories. This is the first time that a statistic on CAD/CAM use by dental technicians has been reported in a peer-reviewed study and the first of its kind for the UK. The lack of similar studies does not allow for meaningful comparisons of the results of the current study with the existing literature. The percentage seems relatively high and may partially reflect a more selective cohort of respondents. It also highlighted the increased ability of larger laboratories to fund this technology and possibly take advantage of the increased productivity workflow that was reported. This effect was also compounded by the finding that these larger laboratories were also reporting significantly less outsourcing.

An important result was the fact that most dental technicians had obtained relative CAD/CAM training from companies and manufacturers with educational institutions playing a minor role. This finding highlights a potential deficiency and knowledge gap as the whole process appears to be company-led with the obvious ramifications regarding the lack of objectivity during the appraisal and selection of CAD/CAM machinery and resulting products. A similar outcome was recorded in a recently published survey of UK dentists.<sup>11</sup>

An alarming finding of this survey was the apparent effect that CAD/CAM technology has had on material selection for fixed prostheses, with a reported reduction in the use of noble alloys and an increase of the use of zirconia, titanium, and base metal alloys. Once again, these changes were more significant for larger laboratories. Although material choice is the responsibility of the prescribing dentist, it seems that the profession might be facing a push for

the use of materials potentially based not on clinical evidence,<sup>16,17</sup> but rather on production costs, efficiency, and the need for 'metal-free' restorations. The effect of this technology on the use of various dental materials was also highlighted in a recent survey of UK dentists.<sup>11</sup> The decreased use of noble alloys has been also reported before,<sup>18</sup> but may have some future consequences regarding corrosion resistance.<sup>19</sup>

An interesting finding of the survey was the fact that CAD/CAM technology appeared not to have disrupted the working relationships and staffing of the respondents. This is contrary to the popular assumption that machines might replace human labour, but this result might also reflect the potential bias of the group who responded to this survey.

High investment cost and ongoing commitments were highlighted as some of the primary reasons for not adopting CAD/CAM use in the workflow, along with the concern of the technology being outdated soon after investment. This appears to be a genuine issue among the non-users of digital technology in dentistry.<sup>11,20</sup>

## Conclusion

Within the limits of this study, the following conclusions could be drawn:

- Most of the respondents used some form of CAD/CAM technology in their workflow
- Initial costs and short shelf life of this technology were highlighted as factors influencing non-users
- CAD/CAM use has led to a change in dental material use
- Most dental technicians received training from companies or manufacturers
- Larger laboratories were more likely to take advantage of CAD/CAM technology.

### Acknowledgements

The authors acknowledge UCL for funding this project and David Boniface for his help in the statistical analyses.

1. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. *Dent Mater J* 2009; **28**: 44–56.

2. Davidowitz G, Kotick P G. The use of CAD/CAM in dentistry. *Dent Clin North Am.* 2011; **55**: 559–570.
3. Raigrodski AJ. Contemporary materials and technologies for all-ceramic fixed partial dentures: A review of the literature. *J Prosthet Dent* 2004; **92**: 557–62.
4. Beuer F, Schweiger J, Edelhoff D. Digital Dentistry: An overview of recent developments for CAD/CAM generated restorations. *Br Dent J* 2008; **204**: 505–511.
5. Kapos T, Evans C. CAD/CAM technology for implant abutments, crowns, and superstructures. *Int J Oral Maxillofac Implants* 2014; **29**: 117–136.
6. Miyazaki T, Nakamura T, Matsumura H, Ban S, Kobayashi T. Current status of zirconia restoration. *J Prosthodont Res* 2013; **57**: 236–261.
7. Priest G. Virtual-designed and computer-milled implant abutments. *J Oral Maxillofac Surg* 2005; **63**: 22–32.
8. Millenium Research Group. Global Markets for Dental CAD/CAM systems. 2012. Available at <http://www.businesswire.com/news/home/20120726005162/en/Global-Dental-CADCAM-System-Market-Grow-Strongly> (accessed April 2017).
9. Market Research Future. Global Dental CAD?CAM Market Research Report-Forecast to 2027. 2017. Available at <https://www.marketresearchfuture.com/reports/dental-cad-cam-market> (accessed April 2017).
10. iData Research. Latest Developments in European Dental Prosthetics and CAD/CAM device markets. 2014. Available at <https://www.idataresearch.com/european-dental-prosthetics-and-cadcam-devices-markets/> (accessed April 2015).
11. Tran D, Nesbit M, Petridis H. Survey of UK dentists regarding the use of CAD/CAM technology. *Br Dent J* 2016; **221**: 639–644.
12. Cook C, Heath F, Thompson RL. A Meta-Analysis of Response Rates in Webor Internet-Based Surveys. *Educ Psychol Meas* 2000; **60**: 821–836.
13. Nulty DD. The adequacy of response rates to online and paper surveys: what can be done? *Assess Eval High Educ* 2008; **33**: 301–314.
14. Berry J, Nesbit M, Saberi S, Petridis H. Communication methods and production techniques in fixed prosthesis fabrication: a UK based survey. Part 1: Communication methods. *Br Dent J* 2014; **217**: E12.
15. General Dental Council. GDC Annual Survey of Registrants 2013 Data Tables. Available at: <https://www.gdc-uk.org/about/what-we-do/research> (accessed April 2017)
16. Pjetursson B E, Sailer I, Malzarov N A, Zwahlen M, Thoma D S. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part II: Multiple-unit FDPs. *Dent Mater* 2015; **31**: 624–639.
17. Sailer I, Makarov N A, Thoma D S, Zwahlen M, Pjetursson B E. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part I: Single crowns (SCs). *Dent Mater* 2015; **31**: 603–623.
18. Berry J, Nesbit M, Saberi S, Petridis H. Communication methods and production techniques used by dentists and commercial dental laboratories regarding fixed prosthesis fabrication: a UK based survey. Part 2: Production techniques. *Br Dent J* 2014; **217**: E13.
19. Upadhyay D, Panchal M A, Dubey R S, Srivastava V K. Corrosion of alloys used in dentistry: A review. *Mat Sci Eng* 2006; **432**: 1–11.
20. Trost L, Stines S, Burt L. Making informed decisions about incorporating a CAD-CAM system into dental practice. *J Am Dent Assoc* 2006; **137** Suppl: 325365.

## Appendix 1 Survey with results for each question (cont. on pg 693)

### Section 1 – Demographics

Where do you currently work?

- England (67%)
- Wales (0%)
- Scotland (7.5.0%)
- Northern Ireland (2.1%)
- Republic of Ireland (23.4%)

What is the highest level of dental laboratory technology training you have achieved? (Please tick all that apply)

- On the job training or Apprenticeship (35.2%)
- Degree (17.6%)
- Diploma (33.3%)
- Other – please specify (13.9%)

What is your age bracket?

- 20 40 yrs (26.6%)
- 41 60 yrs (70.2%)
- Over 60 years (3.2%)

How many other dental technicians do you work with?

- Sole trader or I work with 3 or less technicians (44.7%)
- Work with 4 9 technicians (33%)
- Work with more than 10 technicians (22.3%)

Is your work: (Please tick answer that applies)

- Predominantly NHS (30.9%)
- Predominantly Private (69.1%)

Do you use any form of CAD-CAM technology, (either 'in-house' or outsourced to another facility) in your place of work?

- Yes (82%)
- No (18%)

### Section 2 – Questions for CAD/CAM Users

How did you obtain the knowledge to undertake CAD-CAM fabrication of prostheses? (Please tick all that apply)

- Self-taught (22%)
- Companies or manufacturers (43.3%)
- Educational Institutes (6.3%)
- Occasional courses (27.6%)
- Other-please specify (0.8%)

Which element of CAD-CAM technology do you work with primarily? (please tick all that apply)

- I receive digital intra-oral impressions from dentists (8.7%)
- I perform laboratory scanning of models and impressions (33.5%)
- I perform CAD (design on computer) (32.3%)
- I perform CAM (manufacture of prosthesis including outsourcing) (25.5%)

What do you construct using CAD-CAM technology? (Please tick all that apply)

- All ceramic restorations (35.3%)
- Crown and bridge tooth supported frameworks (30.5%)
- Crown and bridge implant supported frameworks (29.3%)
- Removable partial dentures (4.9%)

Is your CAD-CAM work carried out 'in house' or is it outsourced to another facility?

- Less than 25% is carried out in-house (34.3%)
- 26% 70% is carried out in-house (17.9%)
- More than 71% is carried out in-house (47.8%)

What factors enticed you to embrace digital technology in the workplace? (Please tick all that apply)

- Requests from dentists (12.3%)
- Desire to use new technology (26.8%)
- Fear of becoming outdated (17.8%)
- The hope of obtaining smoother work-flow and increased productivity (22.1%)
- To automate procedures in the hope of gaining increased reliability (21%)

Has the adoption of CAD-CAM fabrication led directly to a change in the number of staff in your place of work?

- Reduction in staff (6%)
- Increase in staff (7.5%)
- No change (86.5%)

Are dentists aware if their prosthesis is fabricated using CAD-CAM technology?

- Yes (70.1%)
- No (3%)
- Sometimes (26.9%)

Do you feel that CAD-CAM has proven to be beneficial in the following areas? (Please tick all that apply)

- Better quality assurance that is, more predictable means of prosthesis fabrication (45.5%)
- Delivers improved productivity (31.7%)
- Facilitates improved communication between dentist and technician (14.6%)
- Other (Please specify) (8.2%)

What do you find the most challenging prosthesis to make by means of CAD-CAM technology? (Please tick all that apply)

- Single all ceramic crowns (9.8%)
- Metal substructure crowns (9.8%)
- Fixed bridges (20.7%)
- Resin bonded bridges (23.2%)
- Implant supported crowns (36.5%)

Has the use of CAD-CAM technology led to an INCREASE in your use of the following materials? (Please tick all that apply)

- Zirconium (53.7%)
  - Titanium (24.1%)
  - Precious metal alloys (2.8%)
  - Base metal alloys (including titanium) (19.4%)
- Why? (Please specify)

Has the use of CAD-CAM technology led to a DECREASE in your use of the following materials? (Please tick all that apply)

- Zirconium (4%)
  - Titanium (2.6%)
  - Precious metal alloys (77.4%)
  - Base metal alloys (including titanium) (16%)
- Why? (Please specify)

Within the CAD-CAM work-flow, which elements do you feel need improvement in order to facilitate and streamline your work? (Please tick all that apply)

- Intra or Extra oral scanning (52.3%)
- CAD-Design on computer (29%)
- CAM-Manufacture of prosthesis (18.6%)

Please state why

## Appendix 1 Survey with results for each question (cont. from pg 692)

How do you feel the digital work- flow affects the role of the dental technician?

- It doesn't affect it at all (12%)
- It improves my role (76.1%)
- It is threatening my role (12%)

Do you feel that your investment in CAD-CAM has delivered on your expectations?

- Yes (48.1%)
- No (3.7%)
- In the most part (25.9%)
- It is too early to tell (22.3%)

Please state why

### Section 3 – Questions for non CAD/CAM Users

Why do you not use CAD-CAM technology? (Please tick all that apply)

- I work in a laboratory that does not use CAD-CAM (43.5%)
- I think CAD-CAM technology is too immature / untested for me to change my practice habits at this stage (4.3%)
- The financial commitment involved is too high (30.4%)
- I do not have sufficient technical training in the procedures involved in CAD-CAM (13%)
- Other (Please specify) (8.8%)

Do you plan to use CAD-CAM technology in the future?

- Yes (50%)
- No (50%)