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### Digital Dentistry- The Future of Oral Health

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Digital Dentistry- The Future of Oral Health

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Submitted in partial fulfillment of the requirements for the  
Masters Degree in Healthcare Informatics

HCIN 699 Professor Glenn Mitchell

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### **Abstract**

**Background and objective:** In the digital world, dentistry appears to be at least a decade behind in adopting the latest technologies in comparison to consumer electronics, biomedical engineering and aeronautics. However, recently, dental professionals have experienced the evolution of the dental profession as technological growth. Digital dentistry is the future of dentistry, and it will be essential to adopt and integrate technology into practice to improve the quality of care. The new generation of digital dentistry opens the exploration of innovations and advancement in technologies which will dramatically impact and improve all of dentistry. The objective of this paper is to describe advances, innovations, and the breadth of their impacts towards time and quality of care for both patients and dentists.

**Materials & methods:** A cross-sectional, anonymous online survey was conducted using a self-administered, pre-tested, structured questionnaire. The questionnaire consisted of 11 multiple choice questions. The statistical relationships among the variables was analyzed using exploratory visualization (histograms, pie charts and bar charts), descriptive data analysis, and multivariate data analysis.

**Results:** Almost all respondents used digital technologies in their daily practice. Most of them have noticed increased patient satisfaction with treatment outcomes. All responders were willing to use digital dentistry in the future.

**Conclusion:** Although both conventional and digital dentistry have advantages and disadvantages, digital dentistry is notably superior in terms of accuracy and patient acceptance, and it will surely become the future of dentistry.

**Keywords:** [digital dentistry; technologies; future of oral health; digital software; CAD/CAM; literature analysis]

**Introduction**

Digital systems and advancement in technologies are omnipresent in our lives. Interconnectivity has been increased in all fields through technological advancement. Nearly every device in our home or office can be controlled digitally with a push button or voice control, and it is not a surprise that digital systems are now becoming more and more available in the field of dentistry.

Dental procedures are evolving in different aspects by ever increasing ensemble of dental technologies. Digital dentistry in an umbrella term which include intra-oral scanners for obtaining impression to 3D printing dentures. Dentistry in past two decades became more digitized which ultimately improve time consumption for dentists as well to patients (Gorter et al). Digital software has reduced the time required to sort and store the patient records like radiographs, photographs, dental impressions and casts. One of the disadvantages associated with film-based imaging include the time required to process the film which interrupt the dental treatment time, and also the image quality associated with chemical film processing. In addition, film processing and storage require much space, and manipulation of film-based images is impossible after processing. In the recent trends, digital radiography has made more advancement in dental field which can save treatment time and also it can be easily stored and conveniently transferred (Versteeg, C.) It has improved efficiency and decreased the time frame to retrieve and analyze the data (Kudva P.B.). Patient acceptance and understanding to the dental treatments has increased with the help of live videos, three dimensional animations, voice activated software and intraoral cameras. (Kudva P.B) In the last decade CAD/CAM technology has enabled dental surgeons to move some of the manufacturing of restorations to the chairside only (Gorter et al). It has improved the accuracy and

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effectiveness of the treatment. (Kudva P.B). Digitization in dentistry has not only enhanced the work efficiency, it has also decreased time and cost for the patient.

A study conducted by Joda et al. indicated that digital workflow was more efficient and effective compared to well-established conventional pathway. Additionally, in terms of cost analysis, for the patient's value, overall treatment cost was less. In a controlled clinical trial study by Kurth et al concluded that digital techniques resulted in a more time-efficient and preferable from patients than conventional techniques used to make impressions. In addition, the overall procedure time for the conventional method was longer than that for digital techniques and treatment comfort was measured higher also for digital methods even though experienced operator performed conventional method.

To evaluate the efficacy and efficiency of digital dentistry in the Netherlands, they conducted a study to assess which are those factors associated with usage of technology and influence dental practitioners to adopt digitalization in their practice (Van Der Zande, et.al). However, more studies need to be conducted to increase the validity of data. The objective of this study includes the survey questionnaire for dental practitioners focusing on quality, cost-effectiveness and time efficiency with using digital technologies in dentistry.

### **Materials and Methods**

This paper contributes an in-depth analysis on importance of advanced technology on oral health considering various circumstances and its strengths and future opportunities by survey methods and research analysis. Moreover, most complex dental treatments require several appointments which can be difficult to accomplish for many patients. So, a significant goal of digital dentistry is to implement a transformation of conventional practice to the new technology

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where patients will have complete care in single visit.

A cross-sectional study design was used with the anonymous surveys administered to clinicians, industry experts and dental researchers. Both postal and online surveys comprised of 11 multiple choice questions were sent, after HU IRB approval, to a convenience sample of general dental practitioners as well as oral specialists. The data were analyzed using descriptive statistics and graphic visualizations. The survey measured the use of different administrative, communicative, clinical and diagnostic technologies, as well as personal factors and dental practice characteristics.

The survey was organized in three sections to evaluate professional activity and opinions about accepting digital technologies in dentistry. All the questions are contained in Table 1. The first section, questions one and two, is focused on collecting background data and is completed by the general dentists, specialists, and dental faculties at dental schools. The second section, questions three to nine, explores the use of digital technologies in their practices and their opinions. Finally, the third section, questions ten and eleven, explores attitudes about the future of oral health.

Table 1

*Survey Questions:*

1. Which age group do you belong to?
  - a. <30
  - b. 30-39
  - c. 40-49
  - d. 50-59
  - e. Over 60
2. Do you have a specialization?
  - a. Yes
  - b. No
3. The dental industry is moving closer to a complete digital workflow, Will the new technology add new excitement, drive, and happiness in your practice?
  - a. Positive
  - b. Neutral
  - c. Insignificant
4. Do you use digital technology anytime in your practice?
  - a. Yes
  - b. No
5. If yes, how often do you use them?
  - a. Daily
  - b. Weekly
  - c. Monthly
  - d. Less than monthly
6. For which procedures do you feel digital technologies useful?
  - a. Diagnostic procedures (Intra oral cameras/ Digital radiography, etc.)
  - b. Clinical procedures (CAD/CAM, Lasers, etc.)
  - c. Other (explain): \_\_\_\_\_
7. Can you share your experience? (Check all that apply)
  - a. Patient satisfaction
  - b. Quality of treatment achieved
  - c. Time Saving
  - d. Improved efficiency
  - e. Improved accuracy in comparison to previous methods
  - f. High level of predictability of outcome
8. In your opinion, do digital technologies improve the quality of treatment methods?
  - a. Yes

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<p>b. No c. May be</p> <p>9. How have majority of dentists have responded to the trend of digital dentistry generally since past 5 years?</p> <p>a. 10-30% b. 31- 49% c. 50-70% d. 70-90%</p> <p>10. What are the challenges do you see after adopting and integrating technology in dental world? Select all that apply.</p> <p>a. Expensive (Initial cost) b. Require high digital skills and precision c. Staff need to be trained c. Large gap between dentists and dental technicians d. Time consuming d. Insurance decline to pay</p> <p>11. Will dentistry be better if it integrates into primary medical care?</p> <p>a. Yes b. No</p> <p>12. If yes, is it possible to accomplish integration in next 2 years?</p> <p>a. Yes b. No c. Maybe</p>
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### Results

The response rate was 50% of the total number of practitioners who were sent survey forms. It is possible that more responses could have been collected since the COVID 19 pandemic began during the data collection period. The respondents ages varied from 30-60 years so the group included millennial to baby-boomer generations. This diversity of responders helped yield a richer understanding of the use and effect of digital dentistry from both the advanced and traditional dental practice perspectives.

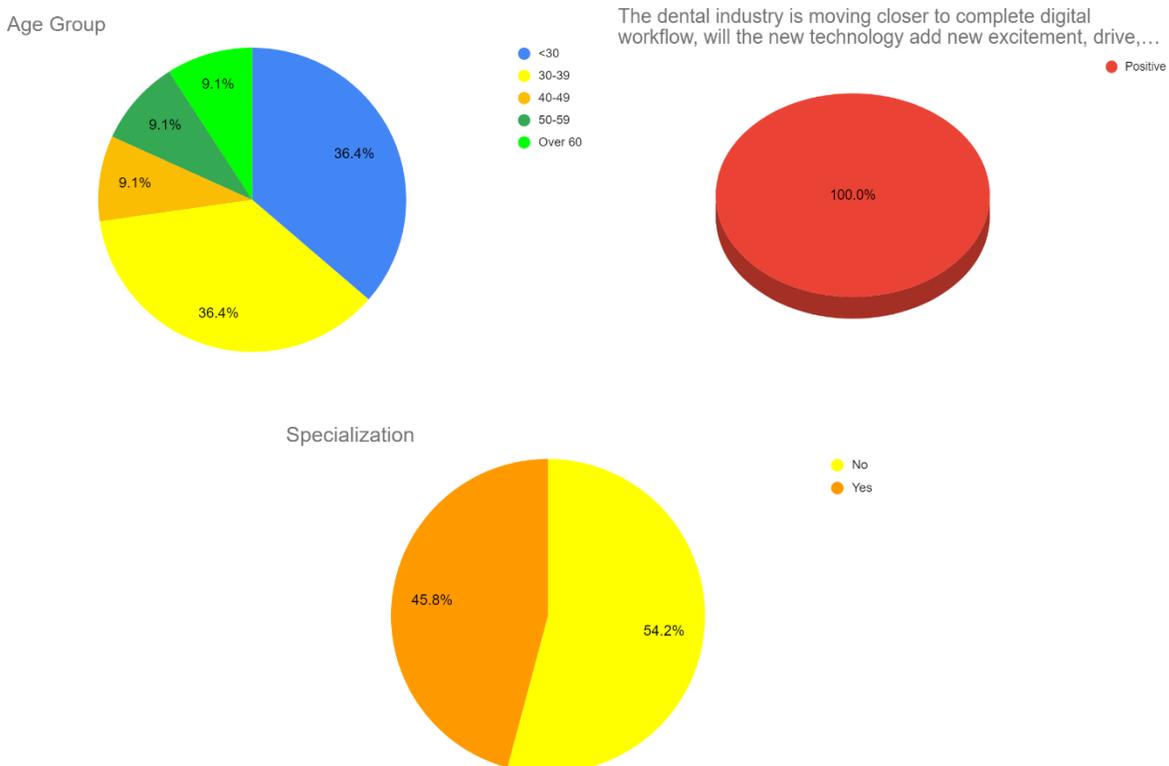
The data was collected using Google forms and statistical analysis was performed using Microsoft Excel and R-Studio. Medians, percentiles and visual graphs were used to describe the

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data. Exploratory data analysis (histograms, pie charts and bar charts), multivariate data analysis, and descriptive data analysis (measure of central tendency) were done to visualize and analyze the data.

Fig. 1 shows the respondents' ages with 72.8% participating dentists are less than 40 years of age. Fig.2 demonstrates that 100% of participating dentists agree that digital dental industry is moving closer to complete digitalization and that trend will bring new excitement, drive and happiness to the dental practices in coming future. The data also shows that the population over 60 years of age also made the same assumptions about the outcome of digital dentistry. Fig 3. shows the diversity of respondents. Not only specialists but general dental practitioners are implementing the newer technologies into their daily practices.

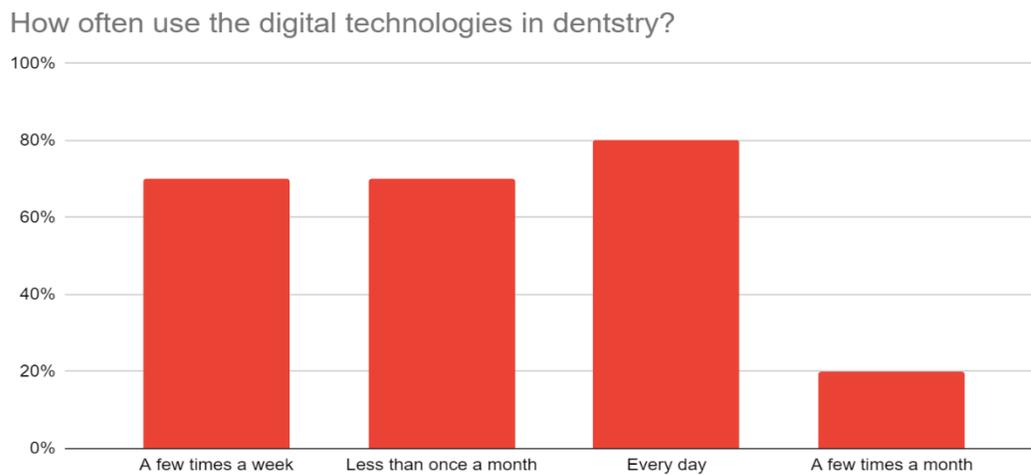
Fig.1,2,3



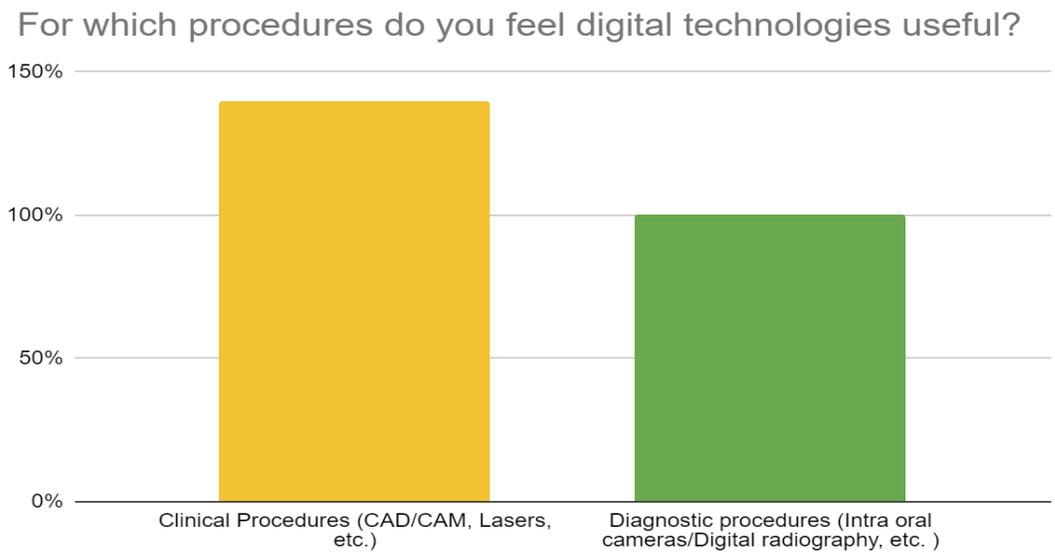
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Cross-sectional surveys provide valuable data on frequency of using the newest technologies in their practices. Fig 4. shows that 80% of participants use digital technologies every day in their practices and about 70% use it at least several times a week. Fig.5 shows that most participants use digital technologies during clinical procedures which include CAD/CAM, 3D Printers, endomicroscopy, robotic implant surgeries, guided implant surgeries, lasers, and others. Many participants in this study use newer technologies for diagnostic purposes, too, including intraoral cameras, digital radiographs, and CBCT.

Fig.4,5



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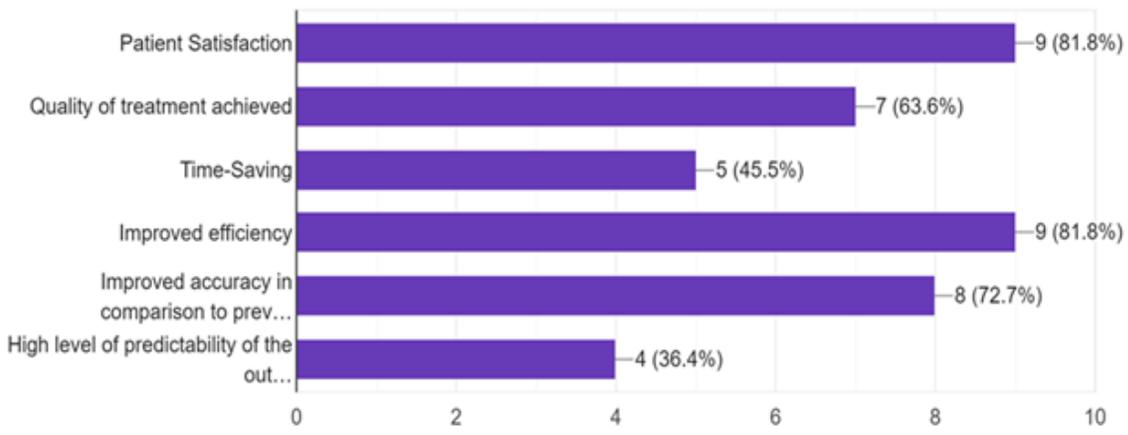
In terms of oral health behaviors and subjective measures of oral health further encouraging results were found which shows the opinions of our participant dentists on effect of technologies on patients and benefits of using them in their practices. Based on the outcomes,

fig.6 portrays the patient satisfaction, which is drastically improves using these newer digital methods, 81.8% participants agreed upon that digital technologies help to achieve patient satisfaction and enhance efficiency of the dental treatments. Fig. 7 shows that majority of dentists from the survey believe that it also improves the quality of dental treatments.

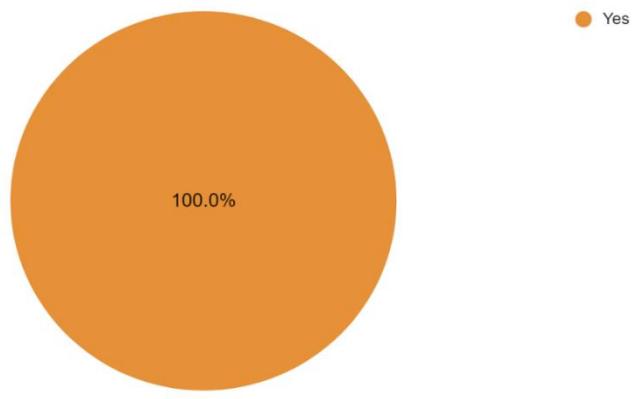
Fig. 8 shows that technologies have made many significant impacts on the outcome of dental treatments. Around 50-60% have already performed implants using technologies in their dental treatments during the last 5 years.

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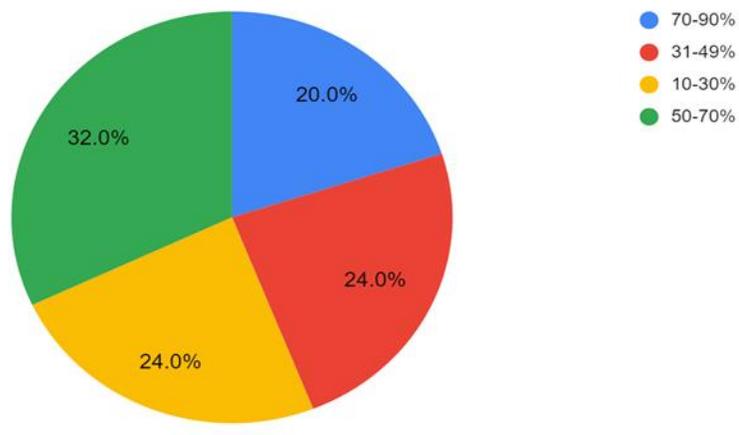
Fig.6,7,8



Do Digital technologies really improve the quality of treatment methods?



How have the majority of dentists have responded to the trend of digital dentistry generally since the past 5 years?



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These technologies also come with the challenges. According to Fig.9, all participants believe that training staff will be the most challenging task while they believe that patient dental insurance is the least challenging road block they must face. Moreover, 54.5% of practitioners also report that equipment cost is one of the major downsides in digitizing dentistry.

Fig.9

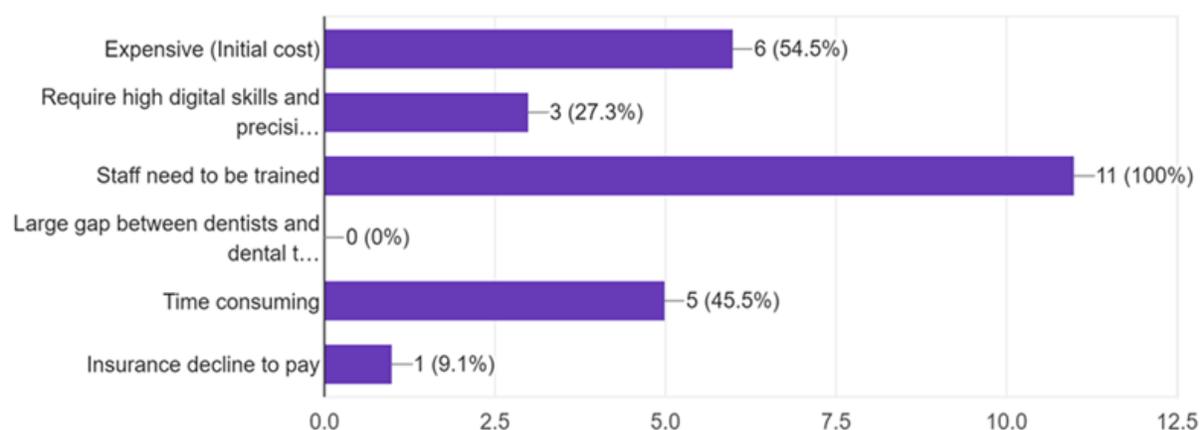
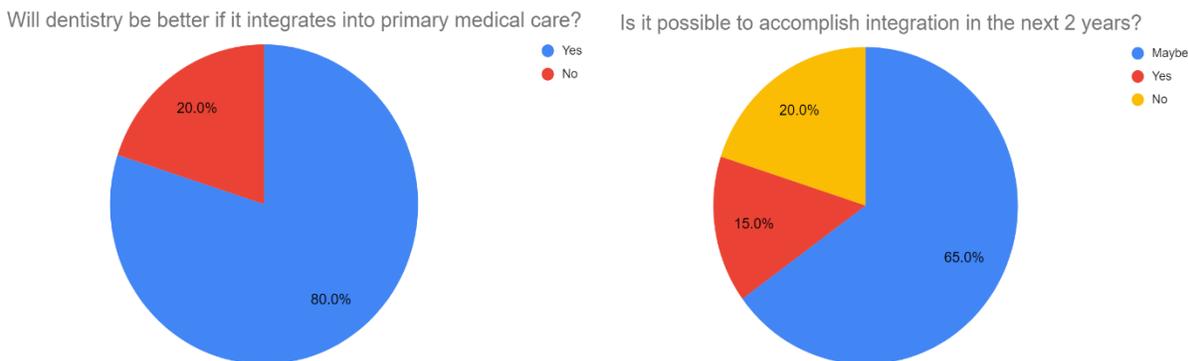


Fig. 10,11 represents that survey participants are general dentists, specialists and dental school faculties. Among them 80% of them believe that dentistry can be better if it integrates to primary care. However, it is difficult to predict when will be the merger possible in current scenario. Therefore, fig. 11 shows that 65% participants said that they are not sure if it can be possible within coming 2 years.

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Fig. 10,11



### Discussion

In current era, dentistry is evolving at a rapid rate and to maintain the pace with the current dental requirements, digitization is much important. Dentists are morally obligated to provide the best oral health care to their patients. Scientific evidence certainly indicate sthat using digital treatments meets these requirements.

Furthermore, dental treatments are often perceived as painful modalities. People tend to avoid them as they don't like unusual things in their mouths such impression materials and sharp instruments. Even after going through all these difficulties, the outcome is unpredictable using older techniques. Digital dentistry helps to reduce the equipment needed in the mouth while increasing the accuracy of the dental treatment. It also helps to abate patient fear with painless methods of treatment.

### Discussion

This study explored how far we have come in implementing digital dental treatment in the clinic setting. It also included assessment of attitudes towards various aspects of the future of digital dentistry and the thought processes of dentists accepting new digital techniques. The study also revealed how many older practitioners are using and willing to use the digital methods

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over conventional treatment approach. Results were encouraging, and decreasing the complexity and increasing the cost efficiency of digital instruments will help to attract more dentists, especially older dentists, to learn and use them.

There are limitations to this study. First, the survey was self-reported and anonymous and could have contained selection bias. Also, the number of participants in the study was relatively small. A more comprehensive study with larger numbers needs to be carried out using these results as baseline data. A comprehensive approach that includes aggressively implementing digital dentistry in educational institutions could increase newer generation to exposed with the digital dentistry in the early of their career. Research from Brownstein SA et al. tells that “incorporating various technology into dental schools follows that of private practice as the technologies that were adopted the most were those with the greatest acceptance and use in private practice”. Additionally, governing bodies should provide education, including low cost or free webinars as well as continuing education courses for practitioners to improve their understanding and acceptance of dentistry’s future.

## **Conclusion**

Despite the fact that conventional methods still compete with digital dentistry, it is evident that future of the dentistry is digital. However, there are challenges in adopting newer digital methods. In any case, from basic dental procedures to complex treatments, digitizing the treatments will likely improve overall treatment outcome with improving dentist and patient acceptance and satisfaction.

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