Journal of Prosthodontic Research

Official Journal of Japan Prosthodontic Society

Original article

Effect of computer literacy on the working time of the dental CAD software program

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Abstract

Purpose: The purpose of this study was to compare the correlation between the learning effect of dental computer-aided design (CAD) software and computer literacy in the clinical and preclinical experience groups of computer-aided design and computer-aided manufacturing (CAD/CAM).

Methods: A total of 28 participants were recruited, including 14 dental students and 14 dental technicians. Their working time was evaluated using a custom abutment design with two dental CAD software program (exocad GmbH and Deltanine). The working time of custom abutment design was measured 3 times. A survey was conducted to evaluate the computer literacy. For statistical analysis, Mann–Whitney U test was used to analyze the difference between the clinical and preclinical experience groups and the correlation between computer literacy and reduction in working time was confirmed by Spearman's Rank correlation analysis ($\alpha=.05$).

Results: The median working time showed the clinical experience group had faster than the preclinical experience group ($P<.001$). On the other hand, the reduction in working time was higher in the preclinical experience group ($P=.002$). Only preclinical experience group had a significant positive correlation between the computer literacy and reduction in working time ($P<.001$).

Conclusions: Basic computer skills are required for first-time users to achieve an excellent learning effect of dental CAD software program.

Keywords: Dental CAD/CAM, Dental CAD software, Learning effect, Computer literacy

Received date: 5 April 2020, Accepted date: 29 July 2020, J-STAGE Advance published date: 25 March 2021

1. Introduction

The fabrication of dental prostheses using dental computer-aided design and computer-aided manufacturing (CAD/CAM) systems has shown excellent results in terms of their working time, prosthesis precision, and marginal fit compared to conventional workflows [1–4]. In the digital workflow, computers are used for all the steps from intraoral or laboratory scanning to the prosthetic design and prosthetic manufacturing process [5–9]. The use of computers for prosthetic design is the most challenging part of the process [8].

The effective use of computers, as well as information and communication technology (ICT), are required for the education of dental students [10,11]. Nelson et al [12] found that students should

improve their computer application literacy in order to fully adapt to the digital society. Therefore, computer literacy is considered an essential element in the modern Internet-mediated world [13]. According to Gassert et al [14], a survey can assess the computer literacy of students. Seago et al [15] assessed that computer literacy of medical students over a 10-year survey and recommended that continuous improvement of computer literacy by medical students would improve learning and should be reflected in their curriculum. Thus, assessment of computer literacy among students is important for the effective use of clinical skills [16–18].

Many studies have examined the learning of digital equipment through changes to the digital workflow [8,9,19–21]. Learning effect can be achieved through the repetition of a specific task [22] (Fig. 1). Previous studies reported that repetitive learning of intraoral scanners resulted in decreased working time and increased usability [19–21]. Nagy Z et al [23] confirmed the effectiveness of digital assessment methods in the iterative learning of tooth preparation by students. However, no other studies have assessed the learning of dental CAD software program, except for previous studies [8,9], which evaluated the CAD software programs by applying the learning curve and confirmed that the learning effects differ according to the type of software program [8]. It was further

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Fig. 1. Graphical illustration of learning curve with three portions.

shown that after initial learning, the learning effect was equal regardless of the dental workers [9]. However, the effect of reduced working time of the dental CAD software program on computer literacy has not been studied. Conventional workflows for dental prostheses are increasingly being replaced by digital workflows [1–9]. Since this change necessitates the use of computer equipment, it is important to evaluate the correlation between the learning effect and computer literacy.

The purpose of this study was to evaluate the computer literacy, working time, and reduction in working time in the clinical and preclinical groups of CAD/CAM. The second purpose of this study was to compare the correlation between computer literacy and the reduced working time. The first null hypothesis is that there is no difference between the clinical and preclinical groups in terms of their computer literacy, working time, and reduction in working time. The second null hypothesis is that there is no correlation between computer literacy and reduction in working time.

2. Materials and methods

The scan files of case with an implant in the maxillary left first molar position were prepared for custom abutment design and stored in CAD software programs prepared on two computers with identical specification. The dental CAD software programs used were exocad CAD software program (exocad GmbH, Darmstadt, Germany) and Deltanine CAD software program (Daesung, Seoul, Republic of Korea).

Ethical clearance was obtained from the Kyungpook National University Dental Hospital Institutional Review Board (IRB No. KNUDH-2019-02-02-02). Pilot experiments were conducted to determine the appropriate sample size, which was calculated to be 14 per group using the power analysis software (G * Power v3.1.9.2, Heinrich-Heine-Universität, Düsseldorf, Germany) (Actual power=99.79%; power=99.7%; $\alpha=.05$). The recruited participants included 14 dental technicians with more than 1 year of CAD/CAM clinical experience (the clinical experience group; 8 men, 6 women, median (interquartile range) age 28 (26–32.2) years, median (interquartile range) clinical experience 3 (1–6) years) and currently working in dental laboratories, and 14 dental students without CAD/CAM clinical experience (the preclinical experience group; 7 men, 7 women, median (interquartile range) age 28.5 (28–30) years). The participants who were unable to use the computer or had difficulty understanding the implant prostheses were excluded. In addition, the clinical experience group was recruited participants who have used CAD software for more than one year at the dental laboratory in the region and have a dental technician license. The preclinical experience group was

recruited as participants passed the implant classes among 3rd and 4th grade students at Kyungpook National University College of Dentistry and no CAD software experience.

The implant abutment design was determined based on the elements custom abutment angle and margin line) common to each software program (custom abutment angle: exocad CAD software, 4 degrees; Deltanine CAD software, 2 degrees. margin line: equigingival margin position). The participants received an hour of theoretical training on how to use the CAD software program and to design a custom abutment. The participants also watched a demonstration of custom abutment design and practiced once with each CAD software program on the computer just before the evaluation. The design of the custom abutment proceeded as follows: step 1 (software program execution and patient basic information input), step 2 (loading of the scan file), step 3 (setting the conditions before custom abutment design), and step 4 (custom abutment design). The participants' final design time, 3 times in seconds was measured by single investigator (K.S.). In this case, if the design pass criterion was not met, the additional design time was measured. Since evaluation of the first software program may affect the next software program, it was evaluated after 1 hour, and 7 of the 14 participants in each group were evaluated first in each software program.

The working time was calculated as a mean of 3 measurements and the learning effect was evaluated through reduction in the working time of the CAD software programs. The reduction rate was calculated for the improved working time of the next iteration according to the 3 iterations.

In order to evaluate the computer literacy, a questionnaire was created based on previous studies (Table 1) [14,16]. The basic computer use section consists of 7 items, which includes questions about computer usage time and basic computer usage. The software use section consists of 6 items that includes questions about the use of basic software programs and application software programs on the computer. Therefore, there were 13 items in total with a total score of 65 points. First, it was confirmed through a pilot test that the validity of the questionnaire is suitable for factor analysis [24,25]. All the variables were verified using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity [24,25]. As a result, a KMO value of 0.779 and a chi-square value of 270.053 were obtained ($P<.001$). This indicates that the validity of the questionnaire can be used with factor analysis [24,25]. Additionally, the results in Table 2 indicate that the questionnaire items were configured correctly [24,25].

All data were analyzed using statistical software (SPSS release 25.0, IBM, Armonk, NY, USA) ($\alpha=.05$). First, the normal distribution of data

Table 1. Items and likert scale criteria of survey for computer literacy.

Basic computer use			
Number	Items		Likert scale criteria
1	Time of computer use during the day	Usage time	Always (5): 5 hours or more; Often (4): 4–5 hours; Sometimes (3): 2–3 hours; Rarely (2): less than 1 hour; Never (1): not
2	Internet use on the computer	Web search, download, etc.	
3	Resolution of computer software problems	Errors and freezes in the computer and software programs	
4	Allows installation, management, and configuration of the computer operating systems	Computer OS Installation, Desktop and Other Operating System Settings	Excellent (5): expert level; Good (4): senior level; Fair (3): normal level of work; Poor (2): simple level of work; Very Poor (1): first time user
5	Peripheral devices can be installed	Keyboard, mouse, monitor, USB hub, etc.	
6	Can use and configure basic software programs	Vaccine, email, music and video playback, weather, etc.	
7	Have a certificate related to computer literacy	Number of certifications	Excellent (5): 5 or more; Good (4): 3–4; Fair (3): 1–2; Poor (2): 1; Very Poor (1): none
Software use			
Number	Items		Likert scale criteria
8	Word processor can be used	Microsoft Word, iWork pages, Google, etc.	
9	Can make presentations	Microsoft Powerpoint, Prezi, Google, etc.	Excellent (5): expert level; Good (4): senior level; Fair (3): normal level of work; Poor (2): simple level of work; Very Poor (1): first time user
10	Work with graphs and documents in spreadsheets	Microsoft Excel, Google, etc.	
11	Can make multimedia	Video, sound, picture production	
12	Can handle graphic software programs	Photoshop, Paint Shop, etc.	
13	Can handle 3D CAD software programs	CATIA, Solidworks, Rhino, etc.	

Table 2. Results of factor analysis of questionnaire.

Basic computer use			
Number	Items	Factor analysis	
		Factor load	Contribution rate (%)
1	Time of computer use during the day	0.82	36.27
2	Internet use on the computer	0.808	0.68
3	Resolution of computer software problems	0.608	0.625
4	Allows installation, management, and configuration of the computer operating systems	0.634	0.706
5	Peripheral devices can be installed	0.799	0.681
6	Can use and configure basic software programs	0.819	0.686
7	Have a certificate related to computer literacy	0.655	0.572
Software use			
Number	Items	Factor analysis	
		Factor load	Contribution rate (%)
8	Word processor can be used	0.605	27.915
9	Can make presentations	0.815	0.793
10	Work with graphs and documents in spreadsheets	0.692	0.723
11	Can make multimedia	0.672	0.593
12	Can handle graphic software programs	0.822	0.692
13	Can handle 3D CAD software programs	0.55	0.631

was examined by Shapiro-Wilk test, and the data did not have a normal distribution. The results of the survey were confirmed by Cronbach's alpha coefficient to analyze reliability. Friedman test was conducted to confirm the significant reduction in working time due to repetitive learning. The Mann–Whitney U test was conducted to confirm the differences in working time, reduction rate, and computer literacy between the clinical and preclinical experience groups. Spearman's

Rank correlation analysis was used to evaluate the correlation between the reduction rate and computer literacy. Multivariate of variance tests with partial eta-squared (η^2) by the Kruskal–Wallis and Mann–Whitney U-tests were performed to determine the effects of independent variables and interactions.

3. Results

Cronbach's alpha coefficient was 0.902 in the reliability result of the survey of 13 items. These results show that the computer literacy questionnaire used in the present study has very high reliability.

There were significant differences between the clinical experience group (dental technician) and the preclinical experience group (dental student) in the 3 iterations ($P < .001$), and there was a significant decrease in working time (Fig. 2; $P < .001$). In the clinical experience group, the median (interquartile range) first, second, and third working time are 117.1 (108–162.7), 108.7 (94.1–121.9), and 97.4 (92.9–97.4), respectively (Fig. 2). In the preclinical experience group, the median (interquartile range) first, second, and third working time are 207.6 (191–230.9), 148.7 (133.6–160), and 131.8 (123.8–140.5), respectively (Fig. 2). In both groups, there was no significant difference between the second and third working time (Fig. 2; $P > .05$).

The working time ($P < .001$), reduction rate ($P = .002$), and computer literacy ($P = .004$) were significantly different between the clinical experience group and the preclinical experience group (Table 3). The median working time was lower in the clinical experience group compared to the preclinical experience group, but the reduction in working time was better in the preclinical experience group. The clinical experience group had a higher computer literacy score than the preclinical experience group.

The correlation between the reduction rate and computer literacy differed according to groups (Table 4). The clinical experience group showed no significant correlation between the computer literacy and reduction in working time ($P = .964$). On the other hand, the preclinical experience group showed a significant correlation ($P < .001$), and the computer literacy and reduction in working time showed a strong positive correlation (correlation coefficient = .989).

The gender ($P = .132$) and age ($P = .41$) did not affect the working time, but the computer literacy score did affect the working time ($P = .002$; Table 5). And the computer literacy score and working time had a weak negative correlation (correlation coefficient = -.521; Table 5). The clinical experience did not affect gender ($P = .132$) and age ($P = .41$) and had a significantly weak positive correlation with computer literacy score (correlation coefficient = .632; Table 5). The computer literacy score had a negative correlation with gender (correlation coefficient = -.461), which means that the median (interquartile range) score evaluated was higher in males (48 (37–52) scores) than in females (35 (31–41.5) scores).

4. Discussion

The results of the present study showed that there was a difference in the computer literacy, working time, and reduction in working time according to the clinical experience of CAD/CAM. The correlation between the learning effect of dental CAD software program and computer literacy could be different according to the clinical experience of CAD/CAM. Therefore, both null hypotheses of the present study were rejected ($P < .001$). In the preclinical experience group, the computer literacy and reduction in working time showed a very strong correlation (correlation coefficient = .989), which suggests that high computer literacy can show an excellent learning effect. On the other hand, since the present study recruited dental technicians with more than 1 year of clinical experience, there was no correlation between the computer literacy and reduction in working time of the clinical experience group ($P = .964$). Since the clinical experience group had used the dental CAD software program for more than 1 year, computer literacy was not considered to have a significant effect on learning the dental CAD software program. Divaris et al [11] suggested that computer literacy should be improved for the effective use of ICT in dental students. The improvement of computer literacy is important for the effective use of clinical techniques [11]. The results of the present study confirmed the importance of computer literacy for dental students, which

need to be improved through continuous evaluation.

In the present study, the clinical experience group showed an excellent working time of the dental CAD software program. On the other hand, the preclinical experience group showed an excellent reduction in the working time. Although the dental technicians also showed a significant reduction in working time during the 3 iterations of learning, these effects were lower probably because they had previous experience of the dental CAD software program. Kim J et al [20] and Al Hamad et al [19] showed a decrease in the working time due to repeated learning of intraoral scanners in the participants without prior experience. The present study recruited participants who had clinical experience and preclinical experience with CAD/CAM and analyzed the correlation between reduction in working time and computer literacy by repeated learning of the dental CAD software program.

In the present study, despite the clinical experience of CAD software, the work time was improved in three repetitive learning. This is because the case of the implant used in the present study has not been experienced. This means that learning in the experience group has been done by repeatedly designing the clinical case. The experience group have significantly lower working times than the preclinical experience group, but the experience group has a lower rate of working time reduction. This can be assumed that the experience group has a low working time and time reduction rate because the basic work process is skilled at the level of the expert of CAD software.

In the previous studies about learning effect of CAD software [8,9], differences in the learning curves were found between the dental CAD software programs and dental practitioners. The previous studies showed that there was a significant difference in the learning effect according to dental CAD software programs, but there was no significant difference in the learning effect among the dental practitioners [8,9]. The results of the present study suggest that improving basic computer literacy can result in a better learning effect of the dental CAD software programs.

The development and application of digital workflows has highlighted the importance of computer literacy [5–9]. Many dental digital equipment and software programs (intraoral scanners, dental CAD software programs, dental CAM software programs, computer-guided implant planning software programs) used in actual clinical practice require computer literacy. The present study is the first to evaluate the correlation between computer literacy and the dental CAD software program. Advances in the digital workflow will lead to the emergence of more dental digital equipment and software programs in the future, and further studies are needed to evaluate their correlation with computer literacy. In addition, further studies are needed to determine how much CAD/CAM clinical experience is required for computer literacy to affect learning of the software programs.

5. Conclusion

Within the limitations of this study, the following conclusions were drawn:

1. In the preclinical experience group (dental student), the better the computer literacy, the faster the working time.
2. On the other hand, in the clinical experience group (dental technician), the computer literacy does not affect the reduction in working time of the dental CAD software program.
3. Therefore, basic computer skills are required for first-time users to achieve an excellent learning effect of dental CAD software program.

Fig. 2. Working time of first, second, and third repetitions of abutment design. A: Clinical experience group. B: Preclinical experience group. Significance determined by pairwise comparison post hoc test, * $P < .05$; ** $P < .001$. n.s.: non-significant difference.

Table 3. Comparison of computer literacy (score), working time (seconds), and reduction in working time (%) in clinical experience and no experience groups.

Group	Computer literacy (score)	Working time (seconds) Median (IQR)	Reduction in working time (%)
Clinical experience group	48 (39.5–52.5)	110.9 (99.9–127.8)	11.5 (4.9–15.4)
Preclinical experience group	36 (30–42.2)	162.1 (152.4–179.1)	19.8 (13.6–24)
<i>P</i>	0.004*	<.001*	0.002*

IQR: Interquartile range; *Significance determined by Mann–Whitney U test, $P < .05$.

Table 4. Comparison of correlation coefficient of computer literacy (score) and reduction in working time (%) in clinical experience and no experience groups.

Group	<i>P</i>	Correlation coefficient
Clinical experience group	0.964*	0.013
Preclinical experience group	<.001*	0.989

*Significance determined by Spearman's Rank correlation analysis, $P < .05$.

Table 5. Results of multivariate analysis.

Factors	<i>P</i>	Correlation coefficient
Working time		
Gender	0.132*	0.219**
Age	0.410*	0.045**
Computer literacy	0.002*	-0.521**
Clinical experience		
Gender	0.101*	-0.249**
Age	0.147*	0.205**
Computer literacy	<.001*	0.632**
Computer literacy		
Gender	0.007*	-0.461**
Age	0.097*	0.229**

*Significance determined by Multivariate of variance analysis, $P < .05$; **Correlation coefficient determined by Spearman's Rank correlation analysis.

Acknowledgments

The authors thank the researchers in Advanced Dental Device Development Institute, Kyungpook National University for their time and contributions to the study. This work was supported by the Technology Innovation Program (or Industrial Strategic Technology Development Program (10077743, The development of the handpiece design for the air turbine and root canal treatment) funded by the Ministry of Trade,

Industry & Energy(MOTIE, Korea); and Industrial Strategic Technology Development Program (10062635, New hybrid milling machine with a resolution of less than 10 μm development, using open CAD/CAM S/W integrated platforms for one-day prosthetic treatment of 3D smart medical care system) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea); and Korea Institute for Advancement of Technology (KIAT) through the National Innovation Cluster R&D program (P0006691).

Declaration of Competing Interest

There are no conflicts of interest to declare.

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