Application of Chairside CAD/CAM and Its Influencing Factors among Chinese Dental Practitioners: a Cross-sectional Study

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Objective: *To examine the increased use of chairside CAD/CAM among Chinese dental practitioners, and to explore the existing barriers influencing its further application and satisfaction levels.*

Methods: *A semi-structured questionnaire was developed to gather respondents' demographic information, as well as their experiences and behaviours regarding the implementation of chairside CAD/CAM. A specialised web-based survey system and WeChat were used to display and distribute the final questionnaire. Then, the data were analysed with Chi-square tests and regression analyses to determine the effects of various demographic variables on chairside CAD/CAM applications.*

Results: *A total of 1,969 questionnaire responses were included in the analyses. Chairside CAD/CAM systems were used by 36.9% of participants, with a higher usage rate observed among prosthodontists (60.0%) and dental practitioners holding a PhD degree (57.7%). Chairside CAD/CAM-fabricated prostheses were most commonly used in the posterior maxilla (83.3%) and mandible (86.0%), followed by the anterior maxilla and mandible (63.8% and 48.6%, respectively). Major barriers to further application included high initial investment, frequent updates of equipment and software programs, and a lack of expertise in chairside CAD/CAM usage.*

Conclusion: *Most dental practitioners did not use chairside CAD/CAM systems. The application rate was significantly influenced by sex, location, educational background, department and type of healthcare facility. Chairside CAD/CAM users showed limited satisfaction with the aesthetic performance of the fabricated prostheses. To improve the popularity of chairside CAD/CAM systems, especially among dental practitioners lacking advanced academic degrees, it is highly advisable to optimise CAD software programs and offer comprehensive training opportunities.*

Keywords: *chairside CAD/CAM restoration, cross-sectional study, dental practitioners, survey*
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The development of dental materials and technologies has progressed significantly over the past century.[1] Traditional dental laboratory procedures, including lost wax precision casting of gold alloys, dough modelling and curing of acrylic resins, and powder sintering of dental porcelains, have been widely used for fabricating crowns, bridges and dentures[2,3]; however, since the 1970s, computer-assisted technology has revolutionised dentistry through the development of dental CAD/CAM systems.[4] A computer-controlled milling machine was introduced in 1971, which facilitated crown fabrication following an optical impression. This innovation, known as the Duret system, was developed by Dr Duret

and rapidly gained global recognition for transforming dental CAD/CAM systems.[5] In the 1990s, after achieving success in creating crowns and three-unit bridges, a CAD/CAM system was employed for the production of implant-supported abutments and frameworks.[6]

With the growth of social economy and the increased preference for metal-free materials, CAD/CAM techniques have entered a period of rapid development.[7] Based on the fabrication processes used, the CAD/CAM system can be classified into two major categories: laboratory and chairside manufacturing systems.[8] Both systems consist of optical impressions, digital design software programs and milling machines.[9,10] In the laboratory production approach, the dental technician is given full responsibility for fabricating the prostheses, which requires at least two visits. In contrast, chairside CAD/CAM enables dental practitioners to manage the whole procedure, from the digital impression and design to digital fabrication.[11] This approach allows for the completion of the definitive prostheses in a single appointment, which is attractive to both patients and dental practitioners.[7] Chairside CAD/CAM systems also boast the benefit of virtual simulation and digital design, allowing for multiple treatment steps using CAD software programs without direct contact with patients.[12] Furthermore, the utilisation of intraoral optical impressions substantially reduces the risk of infection, improves the gag reflex and alleviates patient discomfort, especially in elderly individuals with respiratory or oral mucosa diseases.[13]

To the best of the present authors' knowledge, research on the application of chairside CAD/CAM systems among dental practitioners worldwide remains scarce. The status of CAD/CAM technology in dental practices in the UK and Ireland was reported in 2016.[14,15] As yet, there are no published studies regarding dental practitioners' attitudes towards the quality of chairside CAD/CAM-fabricated prostheses and potential limitations in their further application.

Thus, the present authors explored the potential factors impacting the adoption of chairside CAD/CAM by using a semi-structured questionnaire. The research objectives were to determine the current status of chairside CAD/CAM in Chinese dental practices, to explore potential correlations between the application of chairside CAD/CAM and respondents' sociodemographic characteristics, and to identify the existing barriers influencing its further infiltration and levels of user satisfaction. The null hypothesis was that dental practitioners' demographic characteristics would not significantly affect the adoption of chairside CAD/CAM technology.

Materials and methods

Ethical approval

This study was conducted following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Table S1, provided on request).[16] Approval of the study protocol was obtained from the Medical Ethics Committee of the School and Hospital of Stomatology, Wuhan University (no. 2021-B21). Every participant was provided with a short introduction detailing the objectives of the study, the estimated time for questionnaire completion, and the researcher's contact information. To ensure completeness and accuracy of responses, the data collector provided clarity on any queries raised by participants. All respondents were informed that submitting the survey was seen as providing implicit consent to participate. The acquired data was kept strictly confidential and anonymous.

Survey design and participant recruitment

Using the sample size calculation formulae for cross-sectional studies, the sample size was calculated. A recent study reported that CAD/CAM application rate in Hubei province was 24.8%.[17] The sample size was 1,164 with a 5% margin of error and 95% confidence interval when the sample proportion was 0.248. Given that 10% of the samples dropped out, the original sample size should be at least 1,280.

The questionnaire was developed with modifications based on previous studies[14,15,18] and optimised with the collaboration of the Department of Prosthodontics. It was pilot tested with 15 general dental practitioners and 15 prosthodontists, and the feedback was used to improve the quality of the final questionnaire. Employing a specialised web-based survey system (www.wjx.cn), the final questionnaire was prepared and then disseminated through the Chinese Stomatological Association (CSA) membership group on WeChat, the most widely used social media platform in China. Respondents could only submit the questionnaire after responding to all the questions. The survey was only accessible via WeChat, and each account could only complete it once. Once the questionnaires had been submitted, the respondents were unable to change their answers. As planned, surveys containing contradictory responses and anomalous completion times (less than 1 minute or more than 30 minutes) were excluded.

The questionnaire (supplementary material, provided on request) consisted of four parts containing 25

questions, and the primary language was Chinese. The first section (questions #1 to #11) focused on dental practitioners' demographic and clinical data. The next eleven questions (#12 to #22) surveyed attitudes and experiences related to chairside CAD/CAM application. Using Likert scale questions, chairside CAD/CAM users were asked to rate their actual feelings and behaviours, then evaluate the overall quality of chairside CAD/CAM-fabricated prostheses. Factors for evaluation included marginal fitness, contact points, aesthetics, occlusion and long-term outcomes. Two questions (#23 and #24) were designed to evaluate the perspectives of respondents who had never used a chairside CAD/CAM system before. The final question (#25) asked all respondents to evaluate their perspectives on the potential use of CAD/CAM technology. The Likert scale questions were rated on a scale from 1 to 5, with 1 indicating "completely disagree" and 5 indicating "completely agree". To ensure a representative sample, the questionnaire was distributed across seven geographic regions in China.

Statistical analysis

The original data were obtained from the specialised web-based survey system and entered into a database using SPSS (SPSS 18.0, IBM, Chicago, IL, USA). For the semi-open questions, on sources of CAD/CAM knowledge (#14) and types of chairside CAD/CAM-fabricated prosthesis (#18), three authors independently collected and coded the themes, with any inconsistencies resolved through discussion. Respondents' attitudes towards chairside CAD/CAM-fabricated prostheses were evaluated by calculating the mean of the Likert scale item scores (#21). Descriptive statistics and frequency tables were used to summarise respondents' background information. A Pearson chi-square test was conducted to investigate the differences in the application status of chairside CAD/CAM among respondents with various demographic characteristics. A one-way analysis of variance (ANOVA) with a Tukey adjustment was conducted to evaluate the perspectives of chairside CAD/CAM users on both the technology and the overall quality of prostheses.

The decision to use the chairside CAD/CAM system was explored using generalised estimating equations (GEE) regression analyses. Based on a predetermined criterion, all variables (#1 to #10) presented in the first section of the survey were regarded as independent variables, including age, sex, department, academic degree, monthly income, occupational title, years of practice, location, hospital level and type of healthcare facility. In this analysis, the present authors initially performed univariate analysis, and then added all significant variables to a multivariate analysis.

Results

General information

A total of 1,975 questionnaires were downloaded from the online survey system, and 1,969 valid responses were included in the further analyses. All participants completed the survey within 10 minutes. Respondents' sociodemographic data are presented in Table 1. Of 1,969 dental practitioners, there were 928 men (47.1%) and 1,041 women (52.9%), and dental practitioners from eastern areas constituted the highest proportion (33.7%). The age group of 26 to 35 years was significantly represented, with 671 participants (34.1%) falling within this range. More than half of the surveyed dental practitioners (986, 50.1%) worked in general dentistry, followed by prosthodontics (558, 28.3%) and implantology (158, 8.1%). Almost one quarter of them (485, 24.6%) had fewer than 5 years of work experience. Regarding participants' educational backgrounds, the majority held a bachelor's degree (823, 41.8%), followed by those with a master's degree (711, 36.1%), and 267 (13.6%) dental practitioners held a PhD. Respondents who worked in public hospitals were predominant (1409, 71.6%, including general and dental hospitals), followed by private services (514, 26.1%).

Basic characteristics of chairside CAD/CAM users

The study indicated that 36.9% of participants used chairside CAD/CAM systems. Based on the geographical distribution, individuals from the northwest and northern areas exhibited higher application rates than the national average, at 54.1% and 52.0%, respectively, whereas the central region reported the lowest rate at 29.1%. The regional difference in application rate was statistically significant ($P < 0.001$). In addition, over half of dental practitioners (51.9%) in public dental hospitals used chairside CAD/CAM, followed by those in private healthcare facilities (31.5%) and public general hospitals (26.9%). According to the level of healthcare facilities, respondents from tertiary hospitals had the highest application rate (40.1%), whereas private dental clinics/unspecified settings had the lowest application rate (26.9%); this difference was statistically significant ($P < 0.001$). Furthermore, 72.3% of users started using CAD/CAM within the last 5 years, and 64.0% of dental practitioners only used it once to twice a week.

Table 1 Demographic information of respondents.

Characteristic		n	Percentage (%)
Sex	Male	928	47.1
	Female	1,041	52.9
Location	East	663	33.7
	Central	351	17.8
	South	204	10.4
	North	98	5.0
	Northeast	291	14.8
	Northwest	205	10.4
	Southwest	157	8.0
Age (years)	≤ 25	150	7.6
	26~35	671	34.1
	36~45	600	30.5
	46~55	449	22.8
	> 55	99	5.0
Academic degree	Junior college or below	168	8.5
	Bachelor's	823	41.8
	Master's	711	36.1
	PhD	267	13.6
Occupational title (from lowest to highest)	Associate doctor	121	6.1
	Resident doctor	478	24.3
	Attending doctor	693	35.2
	Associate professor	451	22.9
	Professor	226	11.5
Years of dental practice	≤ 5	485	24.6
	5–10	354	18.0
	11–15	321	16.3
	16–20	235	11.9
	> 20	574	29.2
Monthly income (Chinese Yuan)	≤ 5,000	314	15.9
	5,001–10,000	427	21.7
	10,001–15,000	418	21.2
	15,001–20,000	331	16.8
	> 20,000	479	24.3
Type of healthcare facility	Public dental hospital	695	35.3
	Public general hospital	714	36.3
	Private services	514	26.1
	Other	46	2.3
Hospital rank in scale (from highest to lowest)	Tertiary hospital	1,151	58.5
	Secondary hospital	351	17.8
	Primary hospital	58	2.9
	Private clinic and unclassified	409	20.8
Department	General dentistry	986	50.1
	Prosthodontics	558	28.3
	Endodontics	98	5.0
	Implantology	159	8.1
	Other	168	8.5
Total		1,969	100.0

As illustrated in Fig 1a, manufacturers' technical support (74.7%) and medical journals (66.9%) were the leading sources of CAD/CAM-related knowledge, followed by continuing education (47.9%), private courses (45.5%) and social media (34.4%). Chairside CAD/CAM-fabricated prostheses were most commonly used in the posterior mandible (86.0%) and maxilla (83.3%), followed by the anterior maxilla (63.8%) and mandible (48.6%), and this difference in preferred location was statistically significant ($P < 0.001$) (Fig 1b). In terms of educational background, participants with a PhD degree (57.7%) display a tendency to employ the chairside CAD/CAM system at a frequency more than double that of respondents with a junior college degree or below (23.2%). Nearly two-thirds of the dental practitioners in the department of prosthodontics (60.0%) integrate chairside CAD/CAM into their practice, whereas doctors specialising in other disciplines have an application rate of lower than half (Table S2, provided on request); however, the application of chairside CAD/CAM by respondents with different numbers of years of dental experience was not statistically significant ($P > 0.05$).

In terms of the application of chairside CAD/CAM materials, glass-ceramics were found to exhibit the highest application rate (85.7%), followed by resin-matrix ceramics (39.8%) and polycrystalline ceramics (35.1%), and this preference in material selection was statistically significant ($P < 0.001$) (Fig S1, provided on request). Furthermore, inlays/onlays were the most commonly fabricated prostheses (86.2%), followed by all-ceramic crowns (79.3%), whereas other prostheses were adopted by fewer than 40% of respondents (Fig S2, provided on request). The GEE regression analysis results are presented in Table 2. According to the multivariate analysis, the application of chairside CAD/CAM was significantly associated with sex, location, academic degree, department and type of healthcare facility; however, no statistically significant differences were observed in relation to age, occupational title, years of dental practice or rank in scale of hospitals where they worked. The application rates demonstrated a marked increase among respondents from the north ($P = 0.011$) and northwest ($P < 0.001$). This trend was also mirrored in respondents who held an advanced degree, such as a Master's ($P = 0.015$) or PhD ($P < 0.003$). Additionally, professionals serving within the departments of prosthodontics ($P < 0.001$), implantology ($P < 0.012$) or endodontics ($P < 0.006$) also reported a significantly higher application rate.

Respondents' attitudes towards chairside CAD/CAM

CAD/CAM-fabricated prostheses were evaluated based on five primary criteria: marginal fitness, contact

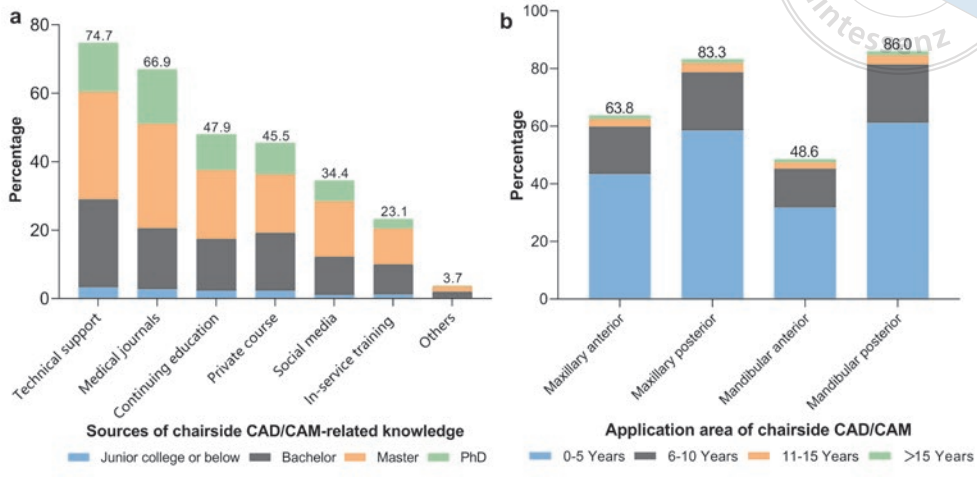

Fig 1a and b Sources of chairside CAD/CAM-related knowledge among respondents **(a)**. Application area of chairside CAD/CAM-fabricated prostheses **(b)**.

points, aesthetics, occlusion and long-term outcome. The results indicated that respondents expressed the highest level of satisfaction regarding marginal fitness (4.02 ± 1.06), with 75.2% of them rating it as excellent or very good, followed by contact points (74.1%) and occlusion (73.7%); however, satisfaction with aesthetics was the lowest (3.72 ± 1.08), with only 28.0% of doctors believing that CAD/CAM-fabricated prostheses delivered excellent aesthetic performance (Fig 2). Interestingly, the satisfaction levels of respondents with varying weekly usage frequencies were statistically significant in terms of marginal fitness, contact points, aesthetics, occlusion and long-term outcome ($P < 0.05$) (Table 3).

Figure 3 illustrates the perspectives of chairside CAD/CAM users in relation to their clinical experience, whereas Fig 4 presents the perspectives of non-users based on their subjective comprehension. The Cronbach alpha values for Q16 and Q23 were 0.832 and 0.989, respectively, suggesting a high level of internal consistency.[19] The majority of chairside CAD/CAM users believed that it decreased fabrication costs and improved quality and productivity. More than half of respondents believed that chairside CAD/CAM techniques increased work efficiency, shortened operative time and decreased the number of visits required. Nearly two-thirds of chairside CAD/CAM users (66.1%) felt that their clinical decisions were influenced by the system, and the vast majority (94.4%) said they would recommend it to their colleagues. With regard to non-users, approximately 46.0% stated that the initial cost of equipment was high. Moreover, they felt that technology upgrades occurred too frequently. Around 47.8% of non-users lacked knowledge on how to use CAD/CAM equipment correctly. Surprisingly, the majority of non-users (91.6%) were interested in integrating chairside CAD/CAM techniques into their dental practice. In the last section of the survey, 1,817 individuals (92.3%) expressed confidence in the future importance of chairside CAD/CAM.

Discussion

This study provided information about the implementation of chairside CAD/CAM in Chinese dental practices and potential factors that could influence its continued adoption. Based on the results, the application rate was significantly influenced by sex, location, educational background, department and type of healthcare facility. Accordingly, the null hypothesis was rejected.

The present study found that 36.9% of respondents used chairside CAD/CAM systems in clinical workflows. Among these dental practitioners, 72.3% had begun adopting this technology within the last 5 years, with 64.0% of them using it once to twice per week. A study conducted in Switzerland documented an application rate of 23% among surveyed dental practitioners.[20] Dental practitioners in the United Kingdom were surveyed to examine the infiltration of CAD/CAM technology in dental clinics, and the findings revealed that the majority of dental practitioners surveyed did not employ any component of the CAD/CAM system.[14] Based on a study carried out in dental clinics and laboratories of the United States Navy, it was discovered that by June 2017, a substantial proportion of indirect prostheses were manufactured using CAD/CAM systems (38.1%), and that there has been consistent growth in the adoption of CAD/CAM-fabricated prosthesis over the past 5 years.[21] In an in vivo study, Vogler et al[22] evaluated the

Table 2 Results of univariate and multivariate generalised estimating equations (GEE) regression analyses for chairside CAD/CAM application.

Variable		Univariate analysis			Multivariate analysis		
		Odds ratio	95% confidence interval	*P* value	Odds ratio	95% onfidence interval	*P* value
Sex				0.268			0.019*
	Male	Reference			Reference		
	Female	0.902	(0.751, 1.083)	0.268	0.763	(0.609, 0.957)	0.019*
Location				< 0.001*			< 0.001*
	East	Reference			Reference		
	Central	0.746	(0.564, 0.987)	0.040*	0.805	(0.589, 1.101)	0.175
	South	0.795	(0.567, 1.115)	0.184	0.815	(0.555, 1.197)	0.296
	North	1.976	(1.289, 3.029)	0.002*	1.904	(1.160, 3.126)	0.011*
	Northeast	0.954	(0.714, 1.274)	0.747	0.733	(0.518, 1.037)	0.079
	Northwest	2.151	(1.566, 2.954)	< 0.001*	2.310	(1.572, 3.396)	< 0.001*
	Southwest	1.287	(0.902, 1.836)	0.164	0.665	(0.436, 1.012)	0.057
Age				0.152			0.631
Highest degree				< 0.001*			0.002*
	Junior college or below	Reference			Reference		
	Bachelor's	1.298	(0.880, 1.916)	0.188	1.225	(0.778, 1.931)	0.381
	Master's	2.428	(1.648, 3.579)	< 0.001*	1.891	(1.130, 3.165)	0.015*
	PhD	4.508	(2.925, 6.948)	< 0.001*	2.442	(1.359, 4.386)	0.003*
Occupational title				0.117			
Years of dental practice				0.342			
Monthly income (Chinese Yuan)				< 0.001*			0.033*
	≥ 5,000	Reference			Reference		
	5,001–10,000	0.699	(0.489, 0.914)	0.011*	0.887	(0.572, 1.374)	0.591
	10,001–15,000	1.052	(0.777, 1.424)	0.745	1.430	(0.909, 2.250)	0.122
	15,001–20,000	1.064	(0.773, 1.464)	0.705	1.237	(0.768, 1.993)	0.382
	> 20,000	1.328	(0.992, 1.779)	0.057	1.504	(0.912, 2.483)	0.110
Type of healthcare facility				< 0.001*			< 0.001*
	Public dental hospital	Reference			Reference		
	Public general hospital	0.340	(0.272, 0.425)	< 0.001*	0.528	(0.399, 0.700)	< 0.001*
	Private services	0.426	(0.336, 0.540)	< 0.001*	1.193	(0.722, 1.972)	0.491
	Other	0.291	(0.145, 0.582)	< 0.001*	0.520	(0.240, 1.126)	0.097
Hospital level				< 0.001*			0.269
	Tertiary hospital	Reference			Reference		
	Secondary hospital	0.932	(0.729, 1.191)	0.574	1.013	(0.733, 1.401)	0.938
	Primary hospital	0.727	(0.415, 1.273)	0.264	0.894	(0.471, 1.696)	0.731
	Private clinic and unclassified	0.549	(0.428, 0.703)	< 0.001*	0.620	(0.352, 1.092)	0.098
Department				< 0.001*			< 0.001*
	General dentistry	Reference			Reference		
	Prosthodontics	4.618	(3.695, 5.772)	< 0.001*	3.737	(2.798, 4.991)	< 0.001*
	Implantology	2.404	(1.572, 3.675)	< 0.001*	1.797	(1.137, 2.839)	0.012*
	Endodontics	2.480	(1.757, 3.501)	< 0.001*	1.721	(1.164, 2.545)	0.006*
	Other	0.809	(0.543, 1.206)	0.299	0.740	(0.464, 1.180)	0.206

*Statistically significant ($P < 0.05$).

impression quality and accuracy of CAD/CAM-fabricated posts and cores in comparison to conventionally cast posts and cores. They found that the application of a fully digital chairside workflow achieved better accuracy of fit of posts and cores and higher feasibility of impression taking than the conventional workflow.[22] Ming et al[23] compared CAD/CAM-fabricated glass fibre posts and cores with traditional casting titanium posts and cores, posts and cores fabricated using the selective laser melting (SLM) technique, and prefabricated

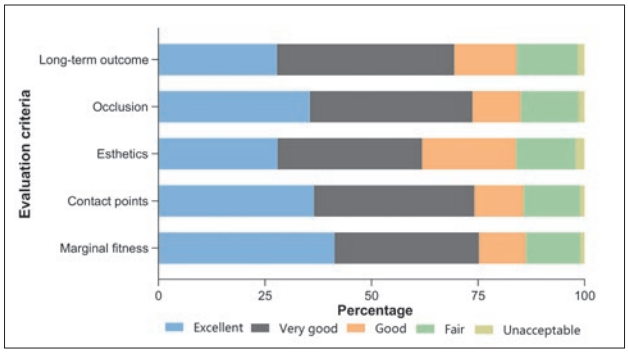

Fig 2 Evaluation of chairside CAD/CAM-fabricated prostheses.

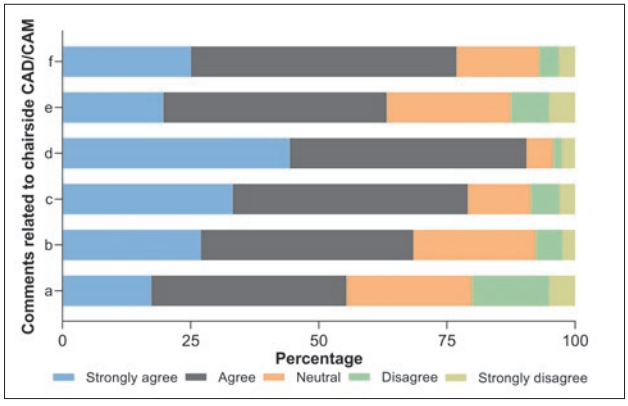

Fig 3 Attitudes of chairside CAD/CAM users based on clinical experience. a, It decreased the cost of fabricating prostheses; b, It improved the overall quality of prostheses; c, It increased productivity; d, It reduced operative time and frequency of visits; e, It was a marketing tool for patient recruitment; f, It makes it possible to keep up with the development of digital dentistry.

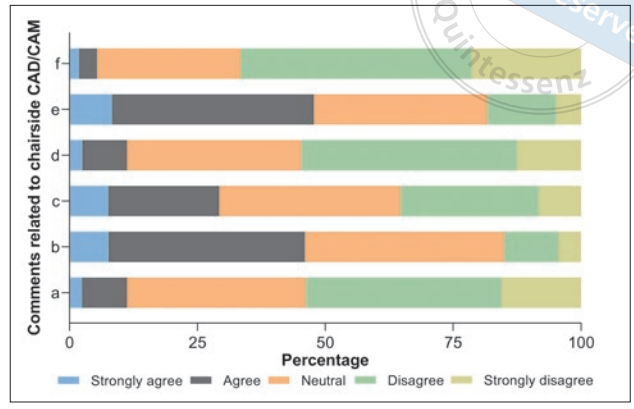

Fig 4 Attitudes of non-users of chairside CAD/CAM based on self-perceived knowledge. a, The quality of CAD/CAM-fabricated prostheses was inferior to that of traditional methods; b, The initial investment in chairside CAD/CAM equipment was high, and upgrades were needed too frequently; c, The conventional impression was more accurate and convenient; d, I did not perceive any advantages over conventional procedures, and I am unable to change my working habits; e, I am not familiar with chairside CAD/CAM systems, or none were available; f, I prefer traditional techniques over digital dentistry.

Table 3 Relationship between satisfaction levels and weekly use frequency based on five criteria.

Variable	Weekly use frequency (mean ± standard deviation)					*F*	*P* value
	1~2 (n = 465)	3~4 (n = 126)	5~6 (n = 34)	7~8 (n = 27)	> 8 (n = 74)		
Marginal fitness	3.89 ± 1.06	4.11±1.05	4.18 ± 0.94	4.48 ± 0.98	4.42 ± 0.98	6.230	< 0.001*
Contact points	3.86 ± 1.05	3.98 ± 1.10	4.18 ± 0.90	4.37 ± 1.01	4.24 ± 1.00	3.930	0.004*
Aesthetics	3.62 ± 1.07	3.75 ± 1.12	3.91 ± 0.87	4.15 ± 1.03	4.01 ± 1.09	3.783	0.005*
Occlusion	3.83 ± 1.05	3.94 ± 1.10	4.26 ± 0.96	4.37 ± 1.01	4.23 ± 1.05	4.670	< 0.001*
Long-term outcome	3.68 ± 1.03	3.79 ± 1.09	4.15 ± 0.93	4.30 ± 0.99	4.23 ± 0.96	7.395	< 0.001*

*Statistically significant ($P < 0.05$).

glass fibre posts and composite resin cores. The internal adaptation and mechanical properties were evaluated. The results demonstrated that CAD/CAM-fabricated glass fibre posts and cores exhibited excellent internal adaptation and high fracture resistance, similar to traditional casting titanium posts and cores and 3D-printed posts and cores, and the fracture pattern was mostly restorable.[23] These findings provide valuable insights into the current landscape of chairside CAD/CAM in dental practice and offer a positive outlook on its incorporation into clinical workflows.

Interestingly, the present survey reflected broad satisfaction and a positive attitude towards chairside CAD/CAM systems. Chairside CAD/CAM users reported that it increased work efficiency, shortened operative time, and improved quality and productivity. Thus, it was unsurprising that a significant proportion of dental practitioners who participated in the study said they

would recommend chairside CAD/CAM techniques to their colleagues. At the same time, most non-users believed that the initial investment required was one of the major obstacles. Economically, dental practitioners could face challenges in recouping their investment due to the high cost involved in procuring equipment. Consequently, it seems that dental professionals might encounter pressure to use materials that are not supported by clinical evidence but are instead chosen based on economic factors such as production costs, efficiency and the desire for all-ceramic restorations.[15]

According to geographical distribution, respondents from the northwest and north used chairside CAD/CAM at a higher rate than the average. Chairside CAD/CAM equipment enables dental practitioners in underdeveloped regions to maintain a relatively high level of prosthetic quality despite the absence or uneven geographic distribution of dental laboratories. Additionally, dental professionals working in public dental hospitals and tertiary hospitals exhibited a greater tendency to use chairside CAD/CAM systems. In contrast, dental practitioners working in other facilities showed a stronger preference for traditional fabrication methods. The preference for chairside CAD/CAM systems in public dental hospitals and tertiary hospitals might stem from the frequent encounters with complex clinical cases that require careful handling of occlusal reconstruction and material selection. Valuable tools like virtual articulators and occlusion detectors offered by some CAD/CAM systems enhance these processes.[24,25]

Another interesting finding was that dental professionals were more likely to use chairside CAD/CAM-fabricated prostheses in the posterior maxilla and mandible. In the anterior area, achieving a successful dental restoration requires more than a high survival rate; it also demands long-term aesthetic stability that is dependent on several variables, such as material selection, prosthesis design and cementation methods.[26,27] Differences in saturation, hue and transparency between restorations and natural teeth can lead to aesthetic complications.[28] The survey used in the present study revealed that only 28.0% of dental practitioners agreed that CAD/CAM-fabricated prostheses could deliver an excellent aesthetic result. Thus, aesthetics may be a crucial factor influencing the popularity of chairside CAD/CAM. However, treatment outcomes depend greatly on the level of consideration given to selecting the distinct characteristics and attributes of the different CAD/CAM materials. In terms of material selection, glass-ceramics were found to be the most commonly used, with an application rate of more than twice that of other materials. One specific type of glass-ceramic, the lithium disilicate block, is provided in a pre-crystallised state and has a flexural strength of 130 ± 30 MPa. This initial state makes it easier to mill the material. After undergoing heat treatment in a ceramic oven at 850°C for 20 to 25 minutes, its strength can be significantly increased, meeting the requirements for crown and inlay/onlay restorations.[29,30] On the other hand, polycrystalline ceramic is relatively opaque and high in strength and takes longer to fabricate, which may limit its use in chairside and aesthetic zone restorations.[31,32] It is worth noting that the industry has implemented polychromatic blocks and ultra-translucent zirconia materials for CAD/CAM applications with the aim of enhancing the aesthetics of full contour monolithic restorations over the past few years.[33]

The present study showed that the main sources of knowledge about chairside CAD/CAM were manufacturers' technical support and medical journals, followed by continuing education. Dental practitioners with a higher level of academic qualification demonstrated a great inclination towards incorporating chairside CAD/CAM technology into their workflows. Meanwhile, respondents with a PhD degree expressed a preference for acquiring knowledge by reading medical journals. In contrast, dental practitioners with a junior college degree showed a greater willingness to accept technical support. This might be due to the fact that PhD students have a strong interest in new technologies and have developed problem-solving skills from reading medical journals.[34] Previous research has demonstrated the significant role that continuing education plays in enhancing clinicians' diagnostic and treatment skills.[35] Continuing education programmes provide healthcare professionals with opportunities to update their knowledge, learn new techniques and keep pace with the latest advancements in their respective fields. Furthermore, the present study demonstrated a positive correlation between dental practitioners who use CAD/CAM more frequently and higher levels of satisfaction with the marginal fitness, contact points, aesthetics, occlusion and long-term outcomes achieved using prostheses. Considering all of these factors, it is clear that chairside CAD/CAM-related training programmes are vital for dental practitioners, particularly those without high academic degrees or occupational titles.

Using a semi-structured questionnaire is an effective strategy for collecting data on the perspectives and experiences of a diverse group of respondents.[36] However, a limitation of the present study is the fact that although the CSA holds the highest authority in the field, there remains the potential for sample bias. To reduce the risk of bias and ensure clarity, the pres-

ent authors developed the survey questions with the help of specialists and conducted a pilot study. In future research, a qualitative study will still be necessary to conduct a more comprehensive analysis of the experience and attitudes of Chinese dental practitioners towards the CAD/CAM system. By including semi-open and open questions, researchers can collect a broader range of personalised opinions from both users and non-users of this technology. This method can provide a profound understanding of the current limitations of CAD/CAM systems and respondents' expectations for their future development. Considering that dental practitioners were the primary providers of information, further investigation is still required to better reflect the perspectives not only of dental practitioners but also of patients, dental technicians and manufacturers throughout the treatment procedure. By incorporating data from multiple sources, researchers can gather unique insights into the factors influencing the slow adoption of chairside CAD/CAM techniques and identify potential areas for improvement. This topic can be explored in future research.

Conclusion

Within the limitations of this study, several conclusions could be drawn. First, most participants did not employ any part of the chairside CAD/CAM system, but expressed strong belief in its future significance and an interest in incorporating it into their workflows. Second, CAD/CAM-fabricated prostheses were more frequently used to treat posterior teeth. Glass-ceramic was the material of choice, followed by resin-matrix ceramics and polycrystalline ceramics. The chairside CAD/CAM application rate showed a significant association with sex, department, location, educational background and healthcare facility. Third, dental practitioners with high academic degrees showed a significant interest in incorporating chairside CAD/CAM into their workflows, with a preference for obtaining relevant knowledge from medical journals. In contrast, those with a bachelor's degree or below showed a greater willingness to seek technical support. Finally, the major barriers to wider adoption of chairside CAD/CAM included the high initial investment, frequent updates of hardware and software programs, a lack of perceived aesthetic benefits, and a lack of expertise in operating these systems.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Aihemaiti MUHETAER contributed to the conception, method, data collection, investigation, analysis and manuscript draft; Dr Hong Ye YANG contributed to the visualisation, writing, review and editing of the manuscript; Dr Cui HUANG contributed to the conception, funding support, research supervision and manuscript revision.

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References

1. Li RW, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: State of the art. J Prosthodont Res 2014;58:208–216.
2. Yang J, Li H, Xu L, Wang Y. Selective laser sintering versus conventional lost-wax casting for single metal copings: A systematic review and meta-analysis. J Prosthet Dent 2022;128:897–904.
3. Saeed F, Muhammad N, Khan AS, et al. Prosthodontics dental materials: From conventional to unconventional. Mater Sci Eng C Mater Biol Appl 2020;106:110167.
4. 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.
5. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am 2011;55:559–570, ix.
6. Alfarsi MA, Okutan HM, Bickel M. CAD/CAM to fabricate ceramic implant abutments and crowns: A preliminary in vitro study. Aust Dent J 2009;54:12–16.
7. Spitznagel FA, Boldt J, Gierthmuehlen PC. CAD/CAM ceramic restorative materials for natural teeth. J Dent Res 2018;97:1082–1091.
8. Alghazzawi TF. Advancements in CAD/CAM technology: Options for practical implementation. J Prosthodont Res 2016;60:72–84.
9. Zaruba M, Mehl A. Chairside systems: A current review. Int J Comput Dent 2017;20:123–149.
10. Aziz A, El-Mowafy O, Tenenbaum HC, Lawrence HP, Shokati B. Clinical performance of chairside monolithic lithium disilicate glass-ceramic CAD-CAM crowns. J Esthet Restor Dent 2019;31:613–619.
11. Lambert H, Durand JC, Jacquot B, Fages M. Dental biomaterials for chairside CAD/CAM: State of the art. J Adv Prosthodont 2017;9:486–495.
12. Barenghi L, Barenghi A, Garagiola U, Di Blasio A, Giannì AB, Spadari F. Pros and cons of CAD/CAM technology for infection prevention in dental settings during COVID-19 outbreak. Sensors (Basel) 2021;22:49.
13. Siqueira R, Galli M, Chen Z, et al. Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: A systematic review. Clin Oral Investig 2021;25:6517–6531.
14. Tran D, Nesbit M, Petridis H. Survey of UK dentists regarding the use of CAD/CAM technology. Br Dent J 2016;221:639–644.
15. Blackwell E, Nesbit M, Petridis H. Survey on the use of CAD-CAM technology by UK and Irish dental technicians. Br Dent J 2017;222:689–693.

16. von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg 2014;12:1495–1499.
17. Muhetaer A, Yang H, Zhao Y, Huang C. A survey of application of digital technology in Hubei dental practice [in Chinese]. Kou Qiang Yi Xue Yan Jiu 2021;37:1084–1088.
18. Nassani MZ, Ibraheem S, Shamsy E, Darwish M, Faden A, Kujan O. A survey of dentists' perception of chair-side CAD/CAM technology. Healthcare (Basel) 2021;9:68.
19. Eisinga R, Grotenhuis Mt, Pelzer B. The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? Int J Public Health 2013;58:637–642.
20. Mühlemann S, Sandrini G, Ioannidis A, Jung RE, Hämmerle CHF. The use of digital technologies in dental practices in Switzerland: A cross-sectional survey. Swiss Dent J 2019;129:700–707.
21. Walker S, Kosaraju A, Lien W, Vandewalle KS. A survey of US air force general dentists regarding computer-aided design/computer-aided manufacturing usage. J Contemp Dent Pract 2020;21:249–252.
22. Vogler JAH, Billen L, Walther KA, Wöstmann B. Conventional cast vs. CAD/CAM post and core in a fully digital chairside workflow - An in vivo comparative study of accuracy of fit and feasibility of impression taking. J Dent 2023;136:104638.
23. Ming X, Zhang Z, Xie W, Zhang Y, Li Y, Zhang W. Internal adaptation and mechanical properties of CAD/CAM glass fiber post-cores in molars: An in vitro study. J Dent 2023;138:104685.
24. Lepidi L, Galli M, Mastrangelo F, et al. Virtual articulators and virtual mounting procedures: Where do we stand? J Prosthodont 2021;30:24–35.
25. Joda T, Zarone F, Ferrari M. The complete digital workflow in fixed prosthodontics: A systematic review. BMC Oral Health 2017;17:124.
26. Kurbad A. A new milling machine for computer-aided, in-office restorations. Int J Comput Dent 2017;20:201–213.
27. Edelhoff D, Prandtner O, Saeidi Pour R, Liebermann A, Stimmelmayr M, Güth JF. Anterior restorations: The performance of ceramic veneers. Quintessence Int 2018;49:89–101.
28. Ishikawa-Nagai S, Yoshida A, Sakai M, Kristiansen J, Da Silva JD. Clinical evaluation of perceptibility of color differences between natural teeth and all-ceramic crowns. J Dent 2009;37 suppl 1:e57–e63.
29. Zarone F, Di Mauro MI, Ausiello P, Ruggiero G, Sorrentino R. Current status on lithium disilicate and zirconia: A narrative review. BMC Oral Health 2019;19:134.
30. Chen Y, Yeung AWK, Pow EHN, Tsoi JKH. Current status and research trends of lithium disilicate in dentistry: A bibliometric analysis. J Prosthet Dent 2021;126:512–522.
31. Tabatabaian F. Color in zirconia-based restorations and related factors: A literature review. J Prosthodont 2018;27:201–211.
32. Miyazaki T, Nakamura T, Matsumura H, Ban S, Kobayashi T. Current status of zirconia restoration. J Prosthodont Res 2013;57:236–261.
33. Mao L, Kaizer MR, Zhao M, Guo B, Song YF, Zhang Y. Graded ultra-translucent zirconia (5Y-PSZ) for strength and functionalities. J Dent Res 2018;97:1222–1228.
34. Wang W. Medical education in China: Progress in the past 70 years and a vision for the future. BMC Med Educ 2021;21:453.
35. McAdams CD, McNally MM. Continuing medical education and lifelong learning. Surg Clin North Am 2021;101:703–715.
36. Edwards P. Questionnaires in clinical trials: Guidelines for optimal design and administration. Trials 2010;11:2.