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CAD/CAM; digital dentistry; prosthodontics; adoption; clinical experience; cross-sectional survey; training; technology implementation

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Exploring the Relationship Between Clinical Experience and CAD/CAM Adoption in Prosthodontic Practices: A Cross-Sectional Study

ABSTRACT
Background: Computer-aided design and computer-aided manufacturing technologies have been increasingly integrated into prosthodontic workflows; however, adoption remains variable across clinicians and practice contexts. The current study examined whether clinical experience is associated with CAD/CAM adoption and sought to characterize utilization patterns and perceived implementation factors within prosthodontic practice.
Methods: A web-based cross-sectional survey using an online, structured instrument was performed. Clinical experience was grouped as <5 years, 5–10 years, and >10 years. The main outcome measured was the adoption of CAD/CAM (adopter versus non-adopter). Secondary measures included experience with CAD/CAM in years and frequency, system familiarity, range of procedures, material usage, whether any kind of training had been received, and perceived facilitators/obstacles. The associations were tested by chi-square/Fisher's exact tests and Kruskal-Wallis tests, while independent predictors for adoption were tested by multivariable logistic regression ($p < 0.05$).
Results: Of the 190 responses analyzed, 169 respondents were adopters (88.9%). Adoption varied by experience with χ^2=12.10, df=2; p=0.003; Cramer's V=0.25; adoption was lower among clinicians who have less than 5 years of experience at 80.5 percent compared with 5–10 years (96.6%) and >10 years (93.3%). In adopters, duration of CAD/CAM use significantly varied across experience strata (p<0.001), but not frequency of use (group comparisons: p=0.952; ordinal Kruskal–Wallis: p=0.985). In multivariable analysis, independent predictors of adoption included formal training (adjusted OR 24.01, 95% CI 4.93–116.92; p<0.001) and excellent self-rated knowledge (adjusted OR 10.25, 95% CI 2.35–44.62; p=0.002), whereas poor knowledge was inversely associated (adjusted OR 0.02, 95% CI 0.00–0.20; p<0.001).
Conclusion: The adoption rate of CAD/CAM was high and associated with clinical experience in unadjusted analyses, but training exposure and knowledge level became the dominant independent predictors. In the case of adopters, experience primarily differentiated time since adoption rather than current use frequency, and implementation barriers differed between adopters and non-adopters in a manner consistent with pre-adoption resource constraints versus post-adoption operational challenges.

INTRODUCTION
CAD/CAM technologies have become integral to contemporary prosthodontic workflows, allowing for digital data acquisition, virtual design, and subtractive or additive fabrication of restorations with increasing efficiency and standardization. In particular, the maturation of chairside systems and integrated digital chains has transitioned CAD/CAM from a predominantly laboratory-based capability to a clinically deployable modality that may impact turnover time, quality control processes, and clinical decision-making in fixed prosthodontics. [8,10,11] Complementing these workflow-level advantages, broader digitalization of restorative dentistry has been promoted by ongoing advances in hardware reliability, software capability, and material science, expanding indications for digitally fabricated crowns and other fixed restorations. [8,9]

However, despite this process of technological maturation, CAD/CAM uptake still appears heterogeneous across settings and professional groups, with wide variations in reports of perceived usefulness, operational barriers, and the feasibility of implementation within routine practice. Cross-sectional surveys conducted across different regions have described generally favorable orientations toward digital dentistry while at the same time highlighting constraints related to initial capital investment, training requirements, and infrastructure dependence. [1,2,3] Such findings suggest that adoption is not solely determined by the availability of the technology itself but also by the interplay between the readiness of the individual, professional environment, and organizational support.

Prosthodontic practice is particularly sensitive to adoption dynamics because CAD/CAM integration may alter several stages of care delivery, including treatment planning, impression-making strategies, communication with laboratories, and material selection. Knowledge and confidence in digital workflows may thus influence both the decision to adopt CAD/CAM technology and the breadth of clinical indications for which the technology will be employed. The available evidence from surveys suggests that clinicians commonly identify training exposure and perceived complexity as determinants of utilization, such that the decision to adopt CAD/CAM technology could mirror not only perceived clinical value but also perceived implementation burden. [3,4] Moreover, barriers to adoption may differ between those clinicians who contemplate implementation versus those who have already integrated CAD/CAM into their practices, in which post-adoption challenges relate to system limitations and to maintenance and troubleshooting rather than purchasing the equipment. [4,5]

Clinical experience is a plausible determinant of CAD/CAM adoption, in that experience can mold risk tolerance, established workflows, referral patterns, and access to continuing professional development. Early-career clinicians may show greater openness to digital modalities by virtue of recent curricular exposure, but may be resource-constrained or have reduced autonomy in procurement decisions. Later-career clinicians may enjoy greater operational autonomy and financial capacity to invest, but may be less apt to reorganize established clinical routines. Current empirical data on how clinical experience relates to adoption are not fully consistent across contexts, and region-specific practice structures may further modify these relationships. [1,2,6]

The literature in prosthodontics also suggests that perceived chairside efficiency, expected gains in precision, and expected patient-centered benefits, such as reduced appointment burden-especially when chairside milling is possible-favor adoption. [8,11] However, these perceived benefits depend on practice configuration-for example, private clinic versus institutional setting-access to laboratories and trained auxiliaries, and stability of digital workflows under routine clinical constraints. [7,8]

The relationship of experience with adoption must therefore be interpreted within the context of knowledge, training exposure, and practice setting as possible confounders or mediators. With the rapid growth in digital dentistry and the continued diffusion of chairside and laboratory CAD/CAM systems, practice-relevant evidence is required on how clinician experience relates to CAD/CAM adoption and utilization intensity within prosthodontic services. This would provide a basis for targeted training strategies and inform implementation planning in settings where adoption is variable. This cross-sectional study, therefore, investigates the relationship between clinical experience and CAD/CAM adoption in prosthodontic practice, further characterizing experience-stratified patterns in duration of use, frequency of use, and key perceived enablers and barriers within the sampled clinicians.

MATERIALS AND METHODS

Study design and setting

A cross-sectional survey using a questionnaire was conducted to find the association of clinical experience with CAD/CAM adoption in prosthodontic practice among prosthodontists and dental practitioners of Saudi Arabia. The online survey format used captures the adoption status, usage patterns, and perceived implementation factors within routine clinical workflows.

Participants and eligibility criteria

Eligible participants included those registered, active clinicians exposed to CAD/CAM technology, irrespective of whether their practice utilized the technology. Exclusion criteria included retired status, non-clinical activity status, or those not practicing and never exposed to CAD/CAM. Participation was voluntary.

Survey instrument

A self-developed, structured questionnaire was used. The instrument assessed the following: i) demographics and professional profile: age category, gender, practice setting; ii) clinical experience: less than 5 years, 5 to 10 years, over 10 years; iii) CAD/CAM adoption and utilization intensity: duration of use, frequency of use; iv) knowledge and familiarity with CAD/CAM systems; v) clinical indications and material preferences for CAD/CAM restorations; and vi) training exposure, learning resources, perceived learning curve, system limitations, and barriers/enablers to adoption and scalability of use.

Data collection procedure

The questionnaire was disseminated through online forms; respondents completed it electronically after being informed about the study and giving electronic informed consent. Responses were collected anonymously and analyzed in aggregate without personally identifying information.

Study Variables and Operational Definitions

Clinical experience was the main exposure variable and was divided into three strata: <5 years, 5–10 years, and >10 years. CAD/CAM adoption was the primary outcome variable and was operationalized as self-reported integration of CAD/CAM into practice (adopter vs non-adopter). Secondary outcome measures were duration of use of CAD/CAM, frequency of use, system familiarity, scope of procedures, material preferences, and perceived barriers/enablers.

Sample size estimation

An a priori sample size calculation was performed in G*Power v3.1.9.6 to estimate the minimum number of participants required to detect an association between clinical experience category and CAD/CAM adoption using a chi-square test of independence. A moderate effect size was assumed (Cohen's $w = 0.30$), with $\alpha = 0.05$ and power $(1-\beta) = 0.80$, yielding a minimum required sample size of $n = 88$.

The effect size for a chi-square test can be expressed as:

$$w = \sqrt{\frac{\chi^2}{N}} \Rightarrow N = \frac{\chi^2}{w^2}$$

In the noncentral chi-square framework used by G*Power, the noncentrality parameter is defined as:

$$\lambda = Nw^2 \Rightarrow N = \frac{\lambda}{w^2}$$

where λ is determined by the selected α, desired power, and degrees of freedom for the contingency table.
In the present study, 190 complete responses were obtained and included in the final analysis, which exceeded the minimum required sample size and therefore increased the precision of estimates and the stability of multivariable modelling.

Statistical analysis

Summary statistics for categorical variables were presented as frequencies and percentages, while ordinal data were described using medians and interquartile ranges where appropriate. Associations between clinical experience strata and CAD/CAM adoption were tested using Pearson's chi-square test. A multivariable logistic regression model was then fitted to determine the independent predictors of adoption, with statistical significance set to $p < 0.05$. All analyses were performed using SPSS (v29.0.2.0).

Ethical considerations

Ethical approval was obtained from the relevant Institutional Review Board (approval: FUGRP/2025/420/1249/1131) of Riyadh Elm University. Participation was voluntary, consent was given electronically, and all data were handled confidentially with anonymous analysis and reporting.

RESULTS

The sample was predominantly 20–30 years and clustered in <5 years and 5–10 years' experience strata (Table 1). Age and setting differed significantly by experience (p<0.001), indicating meaningful structural differences in where early- vs later-career clinicians practiced.

Characteristic	Overall n (%)	Less than 5 years n (%)	5-10 years n (%)	More than 10 years n (%)	p-value*
Gender – Female	104 (54.7)	46 (52.9)	54 (61.4)	4 (26.7)	0.015
Gender – Male	73 (38.4)	38 (43.7)	28 (31.8)	7 (46.7)	
Gender – Other/ambiguous	13 (6.8)	3 (3.4)	6 (6.8)	4 (26.7)	
Age (years) – 20-30	118 (62.1)	63 (72.4)	50 (56.8)	5 (33.3)	<0.001
Age (years) – 31-40	42 (22.1)	17 (19.5)	19 (21.6)	6 (40.0)	
Age (years) – 41-50	22 (11.6)	4 (4.6)	15 (17.0)	3 (20.0)	
Age (years) – 51-60	6 (3.2)	3 (3.4)	3 (3.4)	0 (0.0)	
Age (years) – 60+	2 (1.1)	0 (0.0)	1 (1.1)	1 (6.7)	
Practice setting – Private clinic	49 (25.8)	20 (23.0)	21 (23.9)	8 (53.3)	<0.001
Practice setting – Government setting	14 (7.4)	6 (6.9)	7 (8.0)	1 (6.7)	
Practice setting – Dental hospital	89 (46.8)	55 (63.2)	33 (37.5)	1 (6.7)	
Practice setting – Academic setting	38 (20.0)	6 (6.9)	27 (30.7)	5 (33.3)	

Table 1. Participant demographics and practice profile by clinical experience

Overall adoption was 88.9% (Table 2). Adoption differed by experience (p=0.003; Cramer's V=0.25), driven by a substantially lower adoption rate in the <5 years group (OR≈0.15 vs 5–10 years).

Clinical experience	Total n	Adopters n (%)	Non-adopters n (%)	Unadjusted OR vs 5–10 (95% CI)
Less than 5 years	87	70 (80.5)	17 (19.5)	0.15 (0.05–0.41)
5-10 years	88	85 (96.6)	3 (3.4)	Reference
More than 10 years	15	14 (93.3)	1 (6.7)	0.49 (0.04–5.63)
χ^2 test / effect size		χ^2=12.10 (df=2), p=0.003	Cramer's V=0.25	

Table 2. CAD/CAM adoption by clinical experience (primary association)

Knowledge was significantly patterned by experience (p=0.001), with 5–10 years showing the highest "Excellent" ratings (Table 3). Perceived impact of software/hardware limitations and expectations about future uptake also varied by experience, indicating that "experience" influenced both capability perceptions and technology outlook.

Characteristic	Overall n (%)	Less than 5 years n (%)	5-10 years n (%)	More than 10 years n (%)	p-value*
Knowledge rating – Excellent	124 (65.3)	45 (51.7)	71 (80.7)	8 (53.3)	0.001
Knowledge rating – Average	52 (27.4)	32 (36.8)	15 (17.0)	5 (33.3)	
Knowledge rating – Poor	14 (7.4)	10 (11.5)	2 (2.3)	2 (13.3)	
"Experts only" attitude – Agree	120 (63.2)	48 (55.2)	69 (78.4)	3 (20.0)	<0.001
"Experts only" attitude – Neutral	49 (25.8)	30 (34.5)	15 (17.0)	4 (26.7)	
"Experts only" attitude – Disagree	21 (11.1)	9 (10.3)	4 (4.5)	8 (53.3)	
Perceived workload reduction – Yes	182 (95.8)	81 (93.1)	86 (97.7)	15 (100.0)	0.184
Perceived workload reduction – No	7 (3.7)	5 (5.7)	2 (2.3)	0 (0.0)	

Perceived workload reduction – Don't know	1 (0.5)	1 (1.1)	0 (0.0)	0 (0.0)	
Learning curve – Very challenging and time-consuming	53 (27.9)	27 (31.0)	21 (23.9)	3 (20.0)	0.166
Learning curve – Moderately challenging	74 (38.9)	27 (31.0)	39 (44.3)	9 (60.0)	
Learning curve – Neutral	42 (22.1)	21 (24.1)	19 (21.6)	2 (13.3)	
Learning curve – Easy to learn	16 (8.4)	9 (10.3)	6 (6.8)	1 (6.7)	
Learning curve – Very easy, I had no issues	5 (2.6)	3 (3.4)	3 (3.4)	0 (0.0)	
Software/hardware limitations impact – Yes, significantly	112 (58.9)	43 (49.4)	64 (72.7)	8 (53.3)	0.002
Software/hardware limitations impact – Yes, somewhat	39 (20.5)	22 (25.3)	15 (17.0)	5 (33.3)	
Software/hardware limitations impact – Not sure	26 (13.7)	20 (23.0)	4 (4.5)	1 (6.7)	
Software/hardware limitations impact – No, not at all	13 (6.8)	2 (2.3)	5 (5.7)	1 (6.7)	
Future prospects – Become standard	42 (22.1)	27 (31.0)	10 (11.4)	6 (40.0)	<0.001
Future prospects – Grow but traditional still used	113 (59.5)	52 (59.8)	53 (60.2)	7 (46.7)	
Future prospects – Plateau/niche	35 (18.4)	8 (9.2)	21 (23.9)	1 (6.7)	
Future prospects – Decline	0–? (observed)	0.0	4.5	6.7	

Table 3. Knowledge and perceptions of CAD/CAM by experience

Among adopters, time since adoption strongly tracked experience ($p<0.001$), with >10 years clinicians overwhelmingly reporting >3 years of CAD/CAM use (Figure 1). However, current usage frequency did not differ meaningfully across experience strata ($p\approx0.95$), implying experience mainly shifted *when* CAD/CAM was adopted rather than *how intensively* it was used once adopted (Figures 2 and 3 respectively).

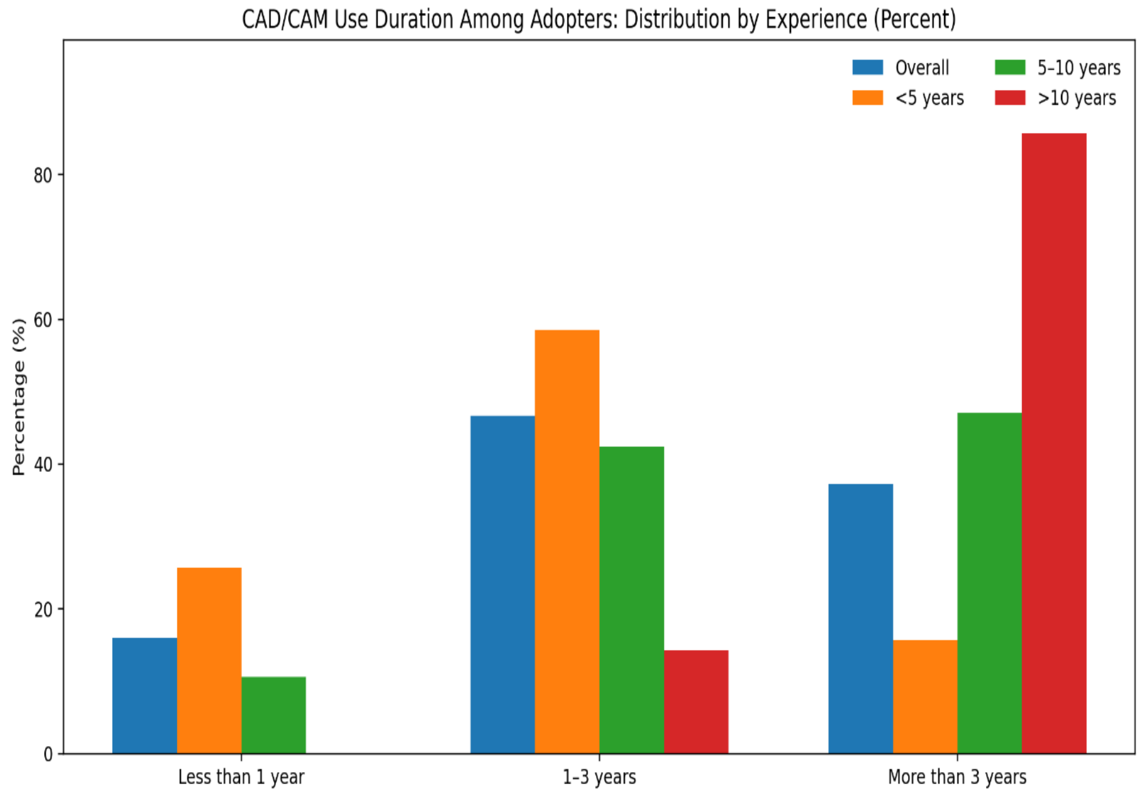

Figure 1. CAD/CAM use duration among adopters: Distribution by Experience (Percent)

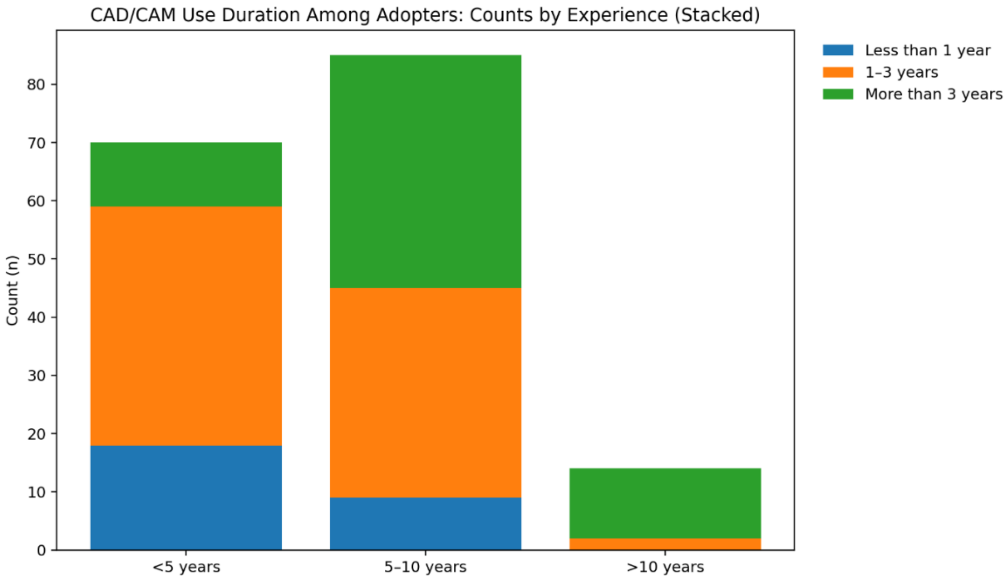

Figure 2. CAD/CAM use duration among adopters: Counts by Experience (Stacked)

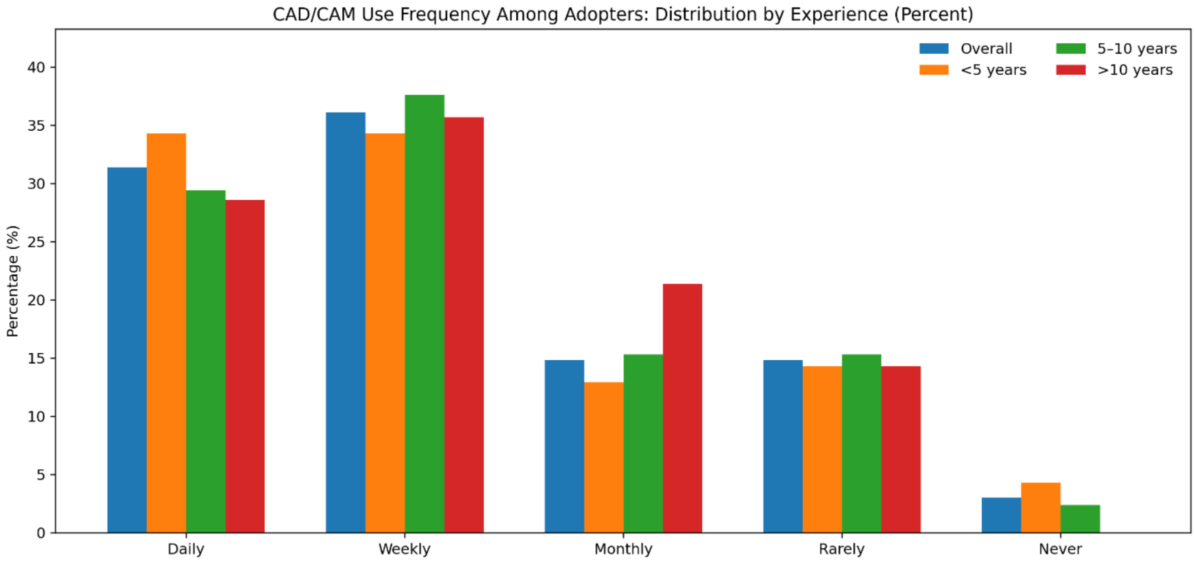

Figure 3. CAD/CAM use frequency among adopters: Distribution by Experience (Percent)

Among adopters, time since adoption strongly tracked experience (p<0.001), with >10 years clinicians overwhelmingly reporting >3 years of CAD/CAM use (Table 4). However, current usage frequency did not differ meaningfully across experience strata (p≈0.95), implying experience mainly shifted when CAD/CAM was adopted rather than how intensively it was used once adopted.

Characteristic	**Overall n (%)**	**Less than 5 years n (%)**	**5-10 years n (%)**	**More than 10 years n (%)**	**p-value***
CAD/CAM use duration (adopters) – Less than 1 year	27 (16.0)	18 (25.7)	9 (10.6)	0 (0.0)	<0.001
CAD/CAM use duration (adopters) – 1-3 years	79 (46.7)	41 (58.6)	36 (42.4)	2 (14.3)	
CAD/CAM use duration (adopters) – More than 3 years	63 (37.3)	11 (15.7)	40 (47.1)	12 (85.7)	
Use frequency (adopters) – Daily	53 (31.4)	24 (34.3)	25 (29.4)	4 (28.6)	0.952
Use frequency (adopters) – Weekly	61 (36.1)	24 (34.3)	32 (37.6)	5 (35.7)	
Use frequency (adopters) – Monthly	25 (14.8)	9 (12.9)	13 (15.3)	3 (21.4)	
Use frequency (adopters) – Rarely	25 (14.8)	10 (14.3)	13 (15.3)	2 (14.3)	
Use frequency (adopters) – Never	5 (3.0)	3 (4.3)	2 (2.4)	0 (0.0)	
Use frequency (ordinal score) – Kruskal–Wallis	Median (IQR): 3 (1–4)	3 (1–4)	3 (1–4)	3 (1–4)	0.985

Table 4. CAD/CAM utilization intensity among adopters

Experience strongly influenced system familiarity (especially CEREC/3Shape awareness) and broadened procedure scope (dentures, implants, veneers were much higher beyond <5 years) (Table 5). Material preferences were dominated by zirconia overall, with comparatively higher lithium disilicate selection among later-career clinicians.

Domain	Item	Overall n (%)	Less than 5 years n (%)	5-10 years n (%)	More than 10 years n (%)	Test	p-value*	Cramer's V
Systems familiarity	Systems familiarity – CEREC	135 (71.1)	47 (54.0)	78 (88.6)	10 (66.7)	Pearson χ^2	<0.001	0.36
Systems familiarity	Systems familiarity – 3Shape	80 (42.1)	23 (26.4)	53 (60.2)	4 (26.7)	Pearson χ^2	<0.001	0.31
Systems familiarity	Systems familiarity – E4D	6 (3.2)	0 (0.0)	6 (6.8)	0 (0.0)	Pearson χ^2 (cell +0.5)	0.031	0.16
Systems familiarity	Systems familiarity – Plan Meca	4 (2.1)	0 (0.0)	4 (4.5)	0 (0.0)	Pearson χ^2 (cell +0.5)	0.094	0.13
Systems familiarity	Systems familiarity – Straumann	9 (4.7)	3 (3.4)	6 (6.8)	0 (0.0)	Pearson χ^2 (cell +0.5)	0.566	0.06
Systems familiarity	Systems familiarity – Not aware	22 (11.6)	21 (24.1)	1 (1.1)	0 (0.0)	Pearson χ^2	<0.001	0.32
Systems familiarity	Systems familiarity – Other	19 (10.0)	0 (0.0)	15 (17.0)	4 (26.7)	Pearson χ^2	<0.001	0.33
CAD/CAM indications	Common CAD/CAM procedures – Crown	175 (92.1)	74 (85.1)	86 (97.7)	15 (100.0)	Pearson χ^2	0.003	0.25
CAD/CAM indications	Common CAD/CAM procedures – Bridges	150 (78.9)	60 (69.0)	76 (86.4)	14 (93.3)	Pearson χ^2	0.007	0.23
CAD/CAM indications	Common CAD/CAM procedures – Dentures	84 (44.2)	22 (25.3)	52 (59.1)	10 (66.7)	Pearson χ^2	<0.001	0.34
CAD/CAM indications	Common CAD/CAM procedures – Inlays/onlays	70 (36.8)	19 (21.8)	44 (50.0)	7 (46.7)	Pearson χ^2	<0.001	0.30
CAD/CAM indications	Common CAD/CAM procedures – Implant-supported restorations	68 (35.8)	16 (18.4)	44 (50.0)	8 (53.3)	Pearson χ^2	<0.001	0.33
CAD/CAM indications	Common CAD/CAM procedures – Veneers	55 (28.9)	12 (13.8)	35 (39.8)	8 (53.3)	Pearson χ^2	<0.001	0.34
Preferred materials	Preferred CAD/CAM crown material – Zirconia	139 (73.2)	62 (71.3)	69 (78.4)	8 (53.3)	Pearson χ^2 (variable-level)	0.120	
Preferred materials	Preferred CAD/CAM crown material – Lithium disilicate	40 (21.1)	14 (16.1)	18 (20.5)	8 (53.3)	Pearson χ^2 (variable-level)		
Preferred materials	Preferred CAD/CAM crown material – Resin	7 (3.7)	6 (6.9)	1 (1.1)	0 (0.0)	Pearson χ^2 (variable-level)		
Preferred materials	Preferred CAD/CAM crown material – Other/unclear	4 (2.1)	5?	?	?	Pearson χ^2 (variable-level)		

Table 5. Technical profile by experience: systems familiarity, CAD/CAM indications, and material preferences

Non-adopters were disproportionately defined by cost and support constraints (high initial investment, low reimbursement, limited support; Table 6). Adopters, in contrast, were more likely to report workflow/precision challenges (i.e., barriers encountered after adoption). Formal training showed the strongest association with adoption (OR≈51).

Domain	Option	Overall n (%)	Adopters n (%)	Non-adopters n (%)	Unadjusted OR (95% CI)	Test	p-value*
Formal training	Received formal CAD/CAM training (Yes)	160 (84.2)	156 (92.3)	4 (19.0)	51.00 (14.95–174.03)	Fisher	<0.001
Need for additional training	Yes	166 (87.4)	147 (87.0)	19 (90.5)		Pearson χ^2	0.629
Need for additional training	No	24 (12.6)	22 (13.0)	2 (9.5)			

Perceived lab availability gap	Yes,to some extent	115 (60.5)	99 (58.6)	16 (76.2)		Pearson χ^2	0.241
Perceived lab availability gap	Not sure	56 (29.5)	53 (31.4)	3 (14.3)			
Perceived lab availability gap	No	19 (10.0)	17 (10.1)	2 (9.5)			
Learning resources (multi-select)	Professional journals	93 (48.9)	91 (53.8)	2 (9.5)	11.08 (2.50–49.08)	Fisher	<0.001
Challenges (multi-select)	High initial investment cost	38 (20.0)	27 (16.0)	11 (52.4)	0.17 (0.07–0.45)	Fisher	<0.001
Challenges (multi-select)	Technical issues with the system	114 (60.0)	108 (63.9)	6 (28.6)	4.43 (1.63–12.00)	Fisher	0.004
Barriers (multi-select)	High initial investment cost	44 (23.2)	29 (17.2)	15 (71.4)	0.08 (0.03–0.23)	Fisher	<0.001
Barriers (multi-select)	Insufficient technical support	22 (11.6)	15 (8.9)	7 (33.3)	0.19 (0.07–0.56)	Fisher	0.003
Adoption drivers (multi-select)	Reduced cost of systems	66 (34.7)	54 (32.0)	12 (57.1)	0.35 (0.14–0.89)	Fisher	0.041
Desired advancements (multi-select)	Low equipment cost	37 (19.5)	27 (16.0)	10 (47.6)	0.21 (0.08–0.54)	Fisher	0.002

Table 6. Training, learning sources, perceived challenges, barriers, and "what would increase adoption" (adopters vs non-adopters)

After adjustment, formal training and higher self-rated knowledge remained the dominant independent predictors of adoption (Table 7). The <5-years group still showed lower odds vs 5–10 years (borderline), suggesting that the experience–adoption relationship was partially mediated through training/knowledge access.

Predictor	Adj OR (95% CI)	p
Experience: <5y vs 5–10y	0.20 (0.04–1.01)	0.052
Experience: >10y vs 5–10y	0.25 (0.02–3.91)	0.319
Formal training (Yes vs No)	24.01 (4.93–116.92)	<0.001
Knowledge: Excellent vs Average	10.25 (2.35–44.62)	0.002
Knowledge: Poor vs Average	0.02 (0.00–0.20)	<0.001

Table 7. Multivariable model predicting CAD/CAM adoption (logistic regression)

DISCUSSION

Our obtained findings suggest that, with training and knowledge accounted for, experience alone does not explain CAD/CAM adoption in prosthodontic practice and that the association between experience and adoption is partly mediated through differential access to training pathways and technology-related competence. Implementation strategies that focus on structured competency development, rather than relying on passive diffusion over years of practice, are thus more likely to succeed. The lack of significant differences in utilization frequency across experience categories following adoption suggests that, once adopted, CAD/CAM becomes a routine part of the clinical workflow regardless of career stage and that policy and institutional investment might reasonably focus on strategies to reduce barriers to entry into adoption.

This bifurcation in identified barriers-resource and support constraints among non-adopters, technical and workflow issues among adopters-suggests that intervention programs in the future should be differentiated: (i) pre-adoption interventions focused on strategies to mitigate cost, ensure access to equipment, and provide reliable technical support, and (ii) post-adoption interventions directed at troubleshooting, optimizing workflow, and maintaining system reliability. Overall, such findings support the utility of targeted continuing professional development, standardized training curricula, and implementation support frameworks tailored to clinician readiness and practice infrastructure as a means to enhance equitable adoption and stabilize long-term use without overstating unmeasured clinical outcome benefits.

A salient quantitative finding was that experience strata were more strongly associated with the timing of adoption, rather than contemporaneous intensity of use. This pattern suggests that, once CAD/CAM has been integrated, its use tends to stabilize as part of routine workflow, independent of years in practice [9-11]. This is in line with the idea that the technology has reached a threshold of operational maturity at which day-to-day use becomes more dependent on workflow integration and the availability of the digital chain than on career stage [12,13]. From a prosthodontic manufacturing perspective, the diversification of CAD/CAM streams-from chairside monolithic restorations to lab-mediated complex prostheses-has provided multiple points of entry for adoption, plausibly facilitating continued utilization across diverse practice environments [14,15].

Multivariable analyses suggested that formal training and higher self-rated knowledge were the dominant independent predictors of adoption, with the crude experience–adoption gradient attenuated after adjustment for these factors. This finding is biologically and operationally plausible: digital workflows require proficiency in scanning, margin delineation, design parameters, and an understanding of milling/printing constraints, competencies more directly addressed through structured training than through clinical seniority alone [12,16]. Additionally, material-related considerations—such as the selection and processing of zirconia and lithium disilicate within chairside or laboratory workflows—can influence perceived feasibility and confidence, and these factors are likely strengthened by training and experience with biomaterial-specific protocols.

The near-universal perception of workload reduction, set against continued emphasis of system limitations and operational barriers, underlines an important nuance in the implementation: perceived clinical advantage does not delete the practical burdens of system ownership and maintenance. This duality aligns with the broader literature, which suggests that CAD/CAM advantages are realized when the full digital chain-data acquisition, software workflow, and manufacturing-is stable and appropriately supported [13,14]. In practice, operational issues may be compounded by scanner performance variability, software updates, calibration drift, and differences in the handling of data across platforms, all of which can impact perceived reliability and, in turn, the satisfaction with adoption that is sustained [17,20]. Findings on impressions and intraoral scanning are the most conceptually relevant. Digital impression systems have been discussed extensively in terms of trueness and precision, or implications for workflow, with evidence to show performance depends on scanning strategy, arch length, and device-specific factors [18,19]. Where clinicians perceived there to be clinically relevant limitations to software/ hardware, this fits with the perspective that constraints of scanner and workflow can create friction, notably in complete-arch applications or where high dimensional fidelity is required [18]. These considerations likely influence perceived ease of use, which is central to technology acceptance [21].

Furthermore, the uptake of intraoral scanning in restorative dentistry has been influenced not just by discussion of accuracy but also by advances in optics and device ergonomics, which may explain why once adopted, scanning becomes routinized and is less sensitive to practitioner seniority [20]. The fact that barriers diverged between adopters and non-adopters suggests stage-specific determinants of adoption. Non-adopters tended to cluster around pre-adoption constraints (cost, access to reliable technical support, infrastructure), whereas adopters more frequently reported post-adoption issues (technical problems and workflow bottlenecks).

This pattern is coherent with established models of user acceptance and behavior, in which perceived usefulness and ease of use influence intention and adoption, while facilitating conditions and performance expectancy influence sustained use and satisfaction [21,22]. The theory of planned behavior offers a complementary explanation: the intention to adopt a technology is molded by attitudes, perceived social norms, and perceived behavioral control; in this context, availability of training and technical support plausibly increased perceived behavioral control, permitting adoption where baseline attitude was favorable across groups [23].

Taken together, these frameworks support the interpretation that "experience" acts through the differential exposure to training opportunities, enabling environments, and confidence in managing digital workflows rather than as an independent causal determinant of CAD/CAM use. From the implementation perspective, findings suggest that strategies to augment adoption should be tailored to clinician readiness and infrastructure of practice. In the case of early-career clinicians, improving access to structured hands-on training, mentorship, and supervised workflow integration may lower barriers to entry without assuming that youth alone guarantees adoption [12,17].

Interventions for established practitioners may instead focus on minimizing disruption to existing workflows, enhancing perceived behavioral control through dependable technical support, and reducing uncertainty and perceived risk by establishing evidence-based guidance regarding materials and indications [16,23]. Importantly, as utilization frequency did not differ meaningfully after adoption, interventions targeted at initiating adoption may yield greater marginal gains than those at increasing intensity among current users, provided that support after adoption adequately reduces technical friction and sustains user satisfaction [22].

Limitations

The study design was cross-sectional and depended on self-reported survey data, which limits causal inference and introduces potential recall and social desirability biases. The sample was recruited via an online questionnaire, which may reflect selection bias toward digitally engaged clinicians. The relatively small >10 years stratum and the modest number of nonadopting individuals reduced precision for certain estimates, as reflected in wide confidence intervals in regression modeling. Adoption and utilization were not validated against objective practice records; clinical outcomes, restorative performance measures, and patient-centered endpoints were not evaluated; thus, findings pertain only to patterns and perceptions of adoption within the sampled setting.

CONCLUSION

CAD/CAM adoption was common and varied across experience strata in this cross-sectional assessment of prosthodontic practice but, at the unadjusted level, training exposure and knowledge level accounted for most of the independent association with adoption. Among adopters, experience correlated more with maturity of CAD/CAM use (time since adoption) than with current usage frequency, and perceived barriers delineated resource constraints among nonadopters from operational challenges among adopters. These results suggest that strengthening structured training access and implementation support is central to CAD/CAM integration, more so than clinical experience alone.

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