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Original article

Clinical survival of CAD-CAM composite resin crowns in anterior and posterior teeth: A four-year retrospective cohort study

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Abstract

Purpose: Although computer-aided design/computer-aided manufacturing (CAD-CAM) composite resin crowns are widely used, complications such as debonding and fracture have been reported. This study aimed to evaluate the clinical survival of CAD-CAM composite resin crowns, including those applied to anterior teeth, and identify factors influencing long-term prognosis.

Methods: This retrospective cohort study included 402 CAD-CAM composite resin crowns fabricated and cemented at Kagoshima University Hospital between September 2020 and August 2024. Four resin block materials (Materials I–IV) were selected according to the tooth region based on Japan's National Health Insurance classification. Patient characteristics, abutment conditions, antagonist tooth, luting agents, and operators were extracted from medical records. Clinical outcomes were analyzed using Kaplan–Meier survival analysis and multivariate Cox proportional hazards regression.

Results: During a mean follow-up period of 30 months, 41 crowns (10.2%) experienced complications, primarily debonding (n = 22). The cumulative success rate was 82.9%. Crowns on vital teeth demonstrated a significantly higher hazard ratio than those on metal or resin cores ($P < 0.05$). In contrast, crowns fabricated from Material IV for anterior teeth were associated with a significantly lower hazard ratio ($P < 0.05$).

Conclusions: CAD-CAM composite resin crowns demonstrated acceptable midterm clinical performance comparable to that reported in previous studies. Crowns placed on vital teeth were associated with an increased risk of failure, whereas anterior crowns fabricated from Material IV had a reduced risk of failure. These findings suggest that biomechanical factors, accurate tooth preparation, and proper execution of bonding procedures are critical for clinical success.

Keywords: CAD-CAM composite resin crowns, Retrospective study, Risk factor

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1. Introduction

Recently, advances in digital technology have facilitated the widespread adoption of computer-aided design/computer-aided manufacturing (CAD-CAM) systems in dental practice[1–3]. Due to the demand for esthetic dentistry, the development of hypoallergenic resin materials, and rising metal costs, CAD-CAM-fabricated metal-free crowns have become an increasingly common treatment option. Prosthetic crowns fabricated from hybrid resins, zirconia, and lithium disilicate ceramics can be manufactured with high precision using CAD-CAM systems, which are now widely employed in modern restorative dentistry[4,5]. Compared with glass ceramics, CAD-CAM resin blocks demonstrate superior fatigue strength, fracture resistance, and bond strength[6,7]. In addition, CAD-CAM composite resin crowns are associated with less wear on the contralateral tooth than other ceramic crowns[8]. Compared with ceramic crowns, CAD-CAM composite resin crowns are generally less brittle, easier to adjust intraorally, and less technique-sensitive with respect to bonding protocols. Despite these advantages, complications such as debond-

WHAT IS ALREADY KNOWN ABOUT THE TOPIC?

» *Computer-aided design/computer-aided manufacturing (CAD-CAM) composite resin crowns are widely used, but complications such as debonding and fracture have been reported. Early debonding occurs frequently, and abutment preparation and adhesive procedures are key factors. Long-term clinical data, especially for anterior teeth, remain limited.*

WHAT THIS STUDY ADDS?

» *This retrospective cohort study of 402 CAD-CAM composite resin crowns exhibited favorable midterm survival rates, although debonding was the most common complication. A higher risk of failure was observed in crowns placed on vital teeth, emphasizing the importance of adequate tooth preparation and proper adhesive procedures for long-term success.*

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ing, discoloration, and reduced long-term wear resistance have been reported[9,10]. Furthermore, CAD-CAM composite resin crowns may exhibit lower long-term color stability and surface hardness than ceramic restorations, underscoring the need for longitudinal data.

In Japan, prosthetic treatment with CAD-CAM composite resin crowns has been partially covered by the National Health Insurance system since 2014. Initially, National Health Insurance coverage for CAD-CAM composite resin crowns was limited to premolar restorations. Coverage was subsequently expanded to include first molars and, more recently, second molars under specific conditions. More recently, CAD-CAM composite resin crowns have also become eligible for insurance reimbursement for anterior teeth. Because these restorations satisfy esthetic demands while reducing patients' financial burden, their clinical use is expected to continue increasing.

Unlike conventional full-metal cast crowns, CAD-CAM composite resin crowns have only recently been introduced into routine clinical practice. Several clinical studies have evaluated their outcomes[11–16], reporting generally favorable performance. Nevertheless, complications including debonding, crown fracture, endodontic complications, and abutment tooth fracture have been documented[12]. Among these, debonding is the most common complication and typically occurs within the first 6 months after crown placement[13]. Fracture patterns of CAD-CAM composite resin crowns differ from those of conventional ceramic restorations and can be broadly classified as minor chipping or more extensive structural fractures with crack propagation toward the cementation interface[7,17]. Because occlusal loading and functional forces differ among tooth types, complication rates may also vary according to the location of the restoration. However, few studies have evaluated the clinical performance of CAD-CAM composite resin crowns applied to anterior teeth. Therefore, the present study aimed to evaluate the survival of CAD-CAM composite resin crowns placed in different tooth regions, including the anterior teeth, and to identify factors associated with a favorable long-term prognosis. The null hypothesis was that there would be no significant differences in the success outcomes between anterior and posterior CAD-CAM composite resin crowns.

2. Materials and Methods

2.1. *Design and settings*

A total of 414 CAD-CAM composite resin crowns were fabricated between September 1, 2020, and August 31, 2024, at the Fixed Prosthetic Clinic, Kagoshima University Hospital, based on data obtained from medical records. The crowns were fabricated by dentists with 2 to 40 years of clinical experience in accordance with the clinical guidelines of the Japanese Prosthodontic Society[18]. To help ensure adequate and consistent occlusal reduction, a clearance gauge was used during tooth preparation when necessary. Following tooth preparation, impressions were made using agar and alginate or silicone impression materials. The crowns were then fabricated from plaster models in either the university hospital dental laboratory or private dental laboratories. The CAD-CAM composite resin crowns were sandblasted with Al_2O_3 and subjected to silane coupling treatment on the inner surface of the crowns on the chairside. Three adhesive resin cements were used for bonding: SA Luting (SA) (Kuraray Noritake Dental, Tokyo, Japan), Super-Bond C&B (SB) (Sun Medical, Shiga, Japan), and Panavia V5 (PV) (Kuraray Noritake Dental, Tokyo, Japan).

The entry point for this study was the time of crown cementation, and the event of interest was the occurrence of clinical complications. Clinical complications were defined as crown or post debonding, crown fracture, endodontic complications (e.g., pulpitis or apical periodontitis requiring treatment), abutment tooth fracture, or secondary caries. Minor interventions, such as occlusal adjustment or polishing, were not considered events. Crowns that remained free of these complications throughout the observation period were classified as successful, whereas crowns that remained *in situ* at the end of the observation period were classified as surviving. If a crown debonded and was subsequently recemented, the debonding was recorded as an event, and follow-up continued to evaluate cumulative survival. Patient data were obtained from medical records and laboratory prescriptions. Review of the medical records confirmed that patients had no active periodontal disease before crown placement or had completed initial periodontal therapy. Cases were excluded if (1) discrepancies existed between the dental technician's ledger and the corresponding medical records, (2) the fabricated CAD-CAM composite resin crown was not cemented, or (3) the date of crown cementation coincided with the final clinical record entry, and no documentation of the subsequent clinical course following cementation was available. After excluding 12 crowns that met the aforementioned exclusion criteria, 402 crowns were included in the final analysis. This study was approved by the Ethics Committee of the Graduate School of Kagoshima University (Approval No. 240228-Eki-kai3). Informed consent was obtained using an opt-out protocol.

2.2. *Retrospective cohort study*

Patient characteristics (age and sex), crown location (anterior, premolar, or molar), cementation method (type of luting agent), abutment tooth type (vital tooth, resin core, or metal core), antagonist tooth type (natural tooth, restored tooth, removable denture, implant, or missing tooth), and the treating dentist's clinical experience (2–40 years) were retrospectively extracted from the medical records. Age was dichotomized at 65 years ($<$ 65 vs. $\geq$ 65 years) because this threshold is widely used in clinical practice. Under the Japanese National Health Insurance system, CAD-CAM resin crown materials are classified into five categories (Materials I–V), according to the type of tooth being restored. Material V was excluded from this study because it primarily consists of polyetheretherketone, which differs fundamentally from composite resin-based materials in composition and mechanical properties.

Two types of resin blocks are approved for premolar restorations:

- Material I: Filler content ≥ 60 wt%.
- Material II: Meets the criteria for Material I and additionally exhibits a flexural strength ≥ 160 MPa, Vickers hardness ($HV_{0\cdot 2}$) ≥ 55, and water sorption ≤ 32 μg/mm^3 following 7 days of immersion at 37°C.

One resin block type is approved for molar restorations:

- Material III: Filler content ≥ 70 wt% and further demonstrates superior mechanical performance, including a flexural strength ≥ 240 MPa, Vickers hardness ($HV_{0\cdot 2}$) of approximately 75, and water sorption ≤ 20 μg/mm^3.

One resin block type is approved for anterior restorations:

- Material IV: Meets the same mechanical requirements as Material II, including a flexural strength ≥ 160 MPa, Vickers hardness

($HV_{0.2}$) ≥ 55, and water sorption ≤ 32 μg/mm^3. In addition, it satisfies specific structural and esthetic requirements, including a crown length ≥ 14 mm, a maximum primary filler particle size ≤ 5 μm, and a multilayer shade-gradient structure that simulates enamel, dentin, and intermediate shades.

The resin block used for each restoration was identified by reviewing the fabrication records of the dental technicians. Because the type of CAD-CAM composite resin block is determined by tooth type under the Japanese National Health Insurance system, material classification is inherently associated with tooth location. Therefore, material classification was used as a surrogate variable for tooth type in the statistical analyses. The observation period extended from the date of definitive cementation to June 2025. Cases without the event of interest were censored at the end of the observation period.

2.3. Statistical analysis

The Kaplan–Meier method, log-rank test, and multivariate Cox proportional hazards regression were used for the statistical analyses. Cumulative success and survival curves were generated using the Kaplan–Meier method. Kaplan–Meier curves were stratified according to material class (tooth type), luting agent, abutment tooth type, and antagonist tooth, and differences between groups were assessed using the log-rank test ($P < 0.05$). Multivariate Cox proportional hazards regression was performed to evaluate the association between complications and six covariates: age, sex, material class (tooth type), luting agent, abutment tooth type, and antagonist tooth. Statistical analyses were performed using GraphPad Prism version 9.3.1 (GraphPad Software Inc., San Diego, CA, USA). Treating dentist experience was initially considered as a candidate covariate. However, the distribution of cases among operators was highly unbalanced, with several operators treating only a few cases and one operator contributing more than 100 cases. This imbalance resulted in sparse data for many categories and unstable parameter estimates in the Cox proportional hazards model. Therefore, operator experience was excluded from the final multivariable analysis.

Cluster adjustment was also considered. However, patient-level clustering would have required restricting the analysis to a single restoration per patient, substantially reducing the effective sample size and number of events. This resulted in unstable parameter estimates; therefore, cluster adjustment was not applied in the final analysis.

3. Results

This retrospective cohort included 402 crowns (60 in men and 342 in women) from patients aged 20 to 86 years (mean ± SD, 69 ± 14.5 years). The mean observation period was 30 months (range, 10–57 months). A total of 269 premolars were restored using CAD-CAM composite resin crowns, of which 129 were fabricated using Material I blocks and 140 using Material II blocks. In addition, 63 molars were restored with CAD-CAM composite resin crowns fabricated using Material III, and 70 anterior teeth were restored with CAD-CAM composite resin crowns fabricated using Material IV. Among the abutment teeth, 128 were restored with metal cores, 208 with resin cores or resin buildups, and 66 with vital teeth. Regarding luting agents, 61 CAD-CAM composite resin crowns were cemented with SA, 288 with SB, and 53 with PV. Regarding antagonist teeth, 96 crowns opposed natural teeth, 256 opposed restored teeth, 38 opposed removable dentures, 5 opposed implant-supported restorations, and 7 had no antagonist teeth. The distribution of tooth specimens according to sex, age, abutment tooth, cement, tooth type (Material class), antagonist tooth, and operator is shown in **Table 1**.

Table 1. Distribution of the study dataset according to patient and clinical characteristics

Category	Tooth frequency	Success	Complications
Total	402	363	41 (10.2%)
Sex			
Male	60	56	4 (6.7%)
Female	342	305	37 (10.8%)
Age			
<65	226	198	28 (12.4%)
≥65	176	163	13 (7.4%)
Abutment tooth			
Resin	208	196	12 (5.8%)
Metal	128	113	15 (11.7%)
Vital teeth	66	52	14 (21.2%)
Cement			
Panavia V5	53	48	5 (9.4%)
SA luting	61	57	4 (6.6%)
Superbond C&B	288	256	32 (11.1%)
Tooth type (Material class)			
Premolar (I)	129	111	18 (14.0%)
Premolar (II)	140	128	14 (10.0%)
Molar (III)	63	58	5 (7.9%)
Anterior (IV)	70	66	4 (5.7%)
Antagonist tooth			
Natural tooth	96	87	9 (9.4%)
Restored tooth	256	227	29 (11.3%)
Removable denture	38	36	2 (5.3%)
Implant	5	4	1 (20.0%)
Missing tooth	7	7	0 (0%)
Operator			
A	11	10	1 (9.1%)
B	137	119	18 (13.1%)
C	11	11	0 (0%)
D	33	32	1 (3.0%)
E	110	102	8 (7.3%)
F	5	4	1 (20.0%)
G	14	12	2 (14.3%)
H	7	7	0 (0%)
I	18	12	6 (33.3%)
J	14	12	2 (14.3%)
K	12	11	1 (8.3%)
L	30	29	1 (3.3%)

Of the 402 CAD-CAM composite resin crowns, 41 (10.2%) experienced complications, including crown or post debonding and crown or root fractures. Among these, 22 crowns experienced debonding, of which 7 occurred within the first 6 months after cementation (**Table 2**).

During the observation period, the cumulative survival and success rates of the CAD-CAM composite resin crowns, calculated using the Kaplan–Meier method, were 94.3% and 82.9%, respectively (**Fig.

Table 2. Temporal distribution of complications, including early debonding events

Follow-up period	Number of cases	Success	Complications	Distribution of complications		
				Debonding	Crown fracture	Other complications
≤6 months	12	0	12	7	3	2
≤1 year	39	33	6	3	0	3
≤2 years	117	106	11	6	3	2
≤3 years	94	89	5	4	0	1
≤4 years	75	70	5	1	2	2
≤5 years	40	38	2	1	0	1

1). The cumulative survival and success curves according to Material class and abutment tooth condition are shown in **Figures 2 and 3**, respectively. The cumulative survival and success rates for each subgroup are summarized in **Table 3**. No significant differences were observed among the Material classes in the Kaplan–Meier analysis (log-rank test, $P = 0.6997$). In addition, no significant differences were observed according to antagonist tooth condition ($P = 0.119$).

Factors influencing crown success were evaluated using Cox proportional hazards analysis, and the results are presented in **Table 4**. A significantly higher hazard ratio was observed for crowns placed on vital teeth than for those placed on metal cores or resin cores/resin buildups. In addition, Material IV (anterior teeth) was significantly associated with a lower hazard ratio. No significant associations were found for sex, age, luting agent, or antagonist tooth type.

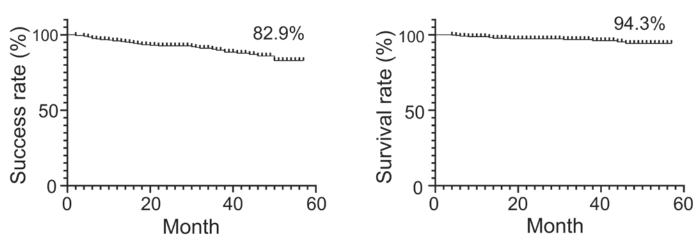

Fig. 1. Kaplan–Meier curves showing the overall cumulative success and survival rates of CAD-CAM composite resin crowns. Success was defined as the absence of biological or technical complications, whereas survival was defined as the absence of crown loss.

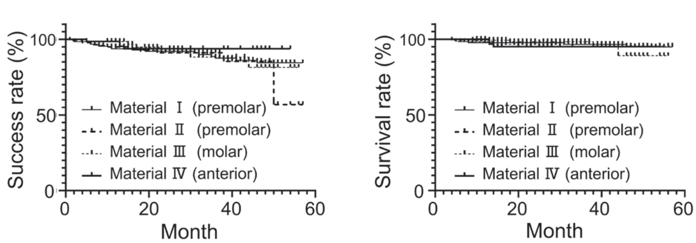

Fig. 2. Kaplan–Meier curves showing the cumulative success and survival rates of CAD-CAM composite resin crowns according to Material class. Material class was defined according to the Japanese National Health Insurance categories, with each class corresponding to specific indications for anterior, premolar, or molar restorations.

4. Discussion

In this retrospective cohort study, the clinical performance of CAD-CAM composite resin crowns was evaluated over a mean follow-up period of 30 months. The cumulative survival and success rates were 94.3% and 82.9%, respectively, indicating generally favorable clinical outcomes consistent with previous reports[19,20]. Debonding was the most frequently observed complication. Kaplan–Meier analysis showed no significant differences in success among the Material classes (tooth types). In contrast, multivariate Cox proportional hazards analysis demonstrated that crowns placed on vital teeth were associated with a significantly higher risk of complications, whereas crowns fabricated from Material IV (anterior teeth) exhibited a significantly lower hazard ratio. These findings suggest that, although unadjusted analyses did not identify differences among Material classes, adjustment for potential confounding variables revealed significant associations with specific clinical factors, underscoring the importance of considering underlying clinical conditions when interpreting treatment outcomes.

The discrepancy between the Kaplan–Meier and Cox analyses may be attributed to differences in their statistical approaches. Kaplan–Meier analysis provides a nonparametric, unadjusted comparison of survival distributions, whereas Cox proportional hazards analysis adjusts for multiple covariates and can therefore identify associations that may not be apparent in univariate analyses[21,22]. In the present study, the inability of the Kaplan–Meier analysis to account for potential confounding factors may have reduced its ability to detect differences among Material classes. Furthermore, the distribution of complication types differed substantially across Material classes. In Material IV, only one case of debonding was observed, whereas three cases involved crown fracture. In contrast, Material II exhibited a higher proportion of debonding events (9 of 14 complications) and fewer crown fractures (4 cases). These findings

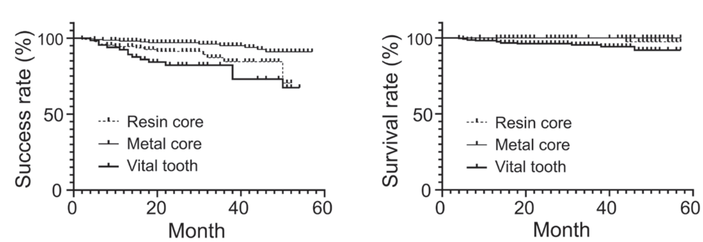

Fig. 3. Kaplan–Meier curves showing the cumulative success and survival rates of CAD-CAM composite resin crowns according to abutment tooth condition. Abutment tooth condition was categorized as resin core-restored teeth, metal core-restored teeth, or vital teeth.

Table 3. Cumulative success and survival rates according to clinical subgroups

Category	Success rate (%)	Survival rate (%)
Total	94.3	82.9
Abutment tooth		
Resin	96.1	91.0
Metal	95.6	70.4
Vital teeth	87.2	67.4
Cement		
Panavia V5	97.4	85.4
SA luting	100.0	93.3
Superbond C&B	91.9	78.7
Tooth type (Material class)		
Premolar (I)	94.8	84.4
Premolar (II)	95.5	56.9
Molar (III)	89.1	81.5
Anterior (IV)	95.1	93.7
Antagonist tooth		
Natural tooth	79.0	95.0
Restored tooth	82.8	92.7
Removable denture	89.7	100.0
Implant	80.0	100.0
Missing tooth	100.0	100.0

Table 4. Multivariate Cox proportional hazards analysis of factors associated with complications

Category	HR	95% CI	*P* value
Sex			
Female	1 (reference)		
Male	0.8652	0.2458 - 2.330	0.7962
Age			
65≤	1 (reference)		
<65	0.9845	0.9613 - 1.008	0.1996
Abutment tooth			
Resin	1 (reference)		
Metal	2.475	1.094 - 5.687	0.0295
Vital teeth	5.408	2.266 - 13.12	0.0001
Cement			
Panavia V5	1 (reference)		
SA luting	0.9183	0.2220 - 3.569	0.9010
Superbond C&B	1.819	0.7128 - 5.628	0.2473
Tooth type (Material class)			
Premolar (I)	1 (reference)		
Premolar (II)	0.5511	0.2451 - 1.222	0.1435
Molar (III)	0.6202	0.1947 - 1.662	0.3735
Anterior (IV)	0.2396	0.0631 - 0.735	0.0198
Antagonist tooth			
Natural tooth	1 (reference)		
Restored tooth	0.8917	0.3890 - 1.863	0.7717
Removable denture	0.4814	0.07429 - 1.775	0.3420
Implant	1.255	0.06540 - 7.397	0.8356
Missing tooth	<0.001	-	0.9999

suggest that the pattern of complications varied according to Material class. Therefore, the lower hazard ratio observed for Material IV in the Cox analysis may primarily reflect a reduced incidence of debonding rather than a uniformly lower risk of all complications. This observation highlights the heterogeneity of failure modes and suggests that composite outcome measures may obscure clinically meaningful differences in the types of complications.

Debonding was the most frequently observed complication in this study, accounting for 22 of the 41 crowns with complications. This finding is consistent with previous reports identifying debonding as the predominant complication of CAD-CAM composite resin crowns[12]. Regarding the timing of occurrence, previous studies have reported that a substantial proportion of complications develop within the first 6 months after placement[13], whereas approximately half of the complications in the present study occurred within the first year. To enhance adhesion, alumina sandblasting of the intaglio surface followed by silane coupling treatment was performed in accordance with established guidelines[23,24]. According to the clinical records, these procedures were applied in nearly all cases. Nevertheless, these surface treatments alone appear insufficient to completely prevent debonding. The higher incidence of complications among crowns cemented with SB may reflect its more frequent clinical use, likely attributable to its strong dentin bonding performance[25] and clinicians' familiarity with the material. However, the type of luting agent was not significantly associated with complications in the multivariate Cox proportional hazards analysis, suggesting that the apparent differences may be attributable to the underlying distribution of cases rather than the intrinsic properties of the cement.

Crown fractures were observed in eight cases, including three anterior teeth (Material IV), four premolars (Materials I and II), and one molar (Material III). All fractures were classified as structural failures requiring replacement of the restoration. Crown fracture is considered a multifactorial complication. Previous studies have shown that the fracture resistance of CAD-CAM restorations is influenced by restoration thickness, material properties, occlusal loading conditions, and preparation design[26]. In particular, reduced occlusal thickness has been associated with decreased fracture resistance[7]. Furthermore, fatigue loading and crack propagation under repeated occlusal forces contribute substantially to the failure of CAD-CAM composite resin crowns[27]. From a materials perspective, the mechanical properties of CAD-CAM composite resin blocks are influenced by filler content and microstructure, with higher filler loading generally associated with greater stiffness and hardness[4,28]. However, the present findings suggest that material properties alone do not adequately explain the occurrence of crown fractures in clinical practice. Instead, clinical factors, including restoration design, occlusal conditions, and bonding quality, are likely to play a more substantial role in fracture behavior.

Root fractures were observed in six cases, including five premolars and one molar. Among these, four abutment teeth had been restored with metal cores, whereas two had resin cores or resin build-ups. Previous studies have suggested that the type of core material is not an independent determinant of root fracture risk[29]. Rather, root fracture is primarily associated with tooth- and patient-related factors. Excessive occlusal loading, parafunctional habits such as bruxism, and tooth anatomy have all been identified as contributing factors[30]. In addition, a reduced amount of residual tooth structure is considered a critical risk factor[31]. Therefore, the root fractures observed in the present study are more likely to reflect the biomechanical condition of the abutment tooth than the characteristics of the CAD-CAM composite resin crown.

In the Cox proportional hazards analysis, no significant associations were identified for sex, age, luting agent, or antagonist tooth condition. However, these findings should be interpreted in the context of the unequal distribution of cases across categories. The study cohort was predominantly female, and SB was used substantially more frequently than SA or PV. In addition, most cases involved restored antagonist teeth, whereas implant-supported antagonists and the absence of an antagonist were uncommon. These imbalances may have reduced the precision of the estimated hazard ratios and limited the statistical power to detect modest associations. Consequently, the lack of statistical significance for these variables should not be interpreted as evidence that they have no clinically meaningful effect.

An important consideration when interpreting the present findings is the inherent collinearity between material class and tooth type. Under the Japanese National Health Insurance system, Material IV is indicated for anterior teeth, Materials I and II for premolars, and Material III for molars[18]. Therefore, the lower hazard ratio observed for Material IV should be interpreted with caution. In the present dataset, Material IV was used predominantly for anterior teeth, which are subjected to substantially lower occlusal forces than posterior teeth. Biomechanical studies have consistently demonstrated that bite force in the anterior region is markedly lower than that in the molar region because of the biomechanical disadvantage associated with the anterior position[32]. Consequently, the apparent association between Material IV and a lower hazard ratio may primarily reflect the biomechanical characteristics of anterior teeth rather than a material-specific protective effect. Thus, the independent effect of Material IV remains uncertain. A recent clinical study of anterior CAD-CAM composite resin crowns reported favorable 5-year outcomes, with survival rates comparable to those observed in the present study. These findings further support the interpretation that anterior restorations are exposed to lower functional loading, which may contribute to their favorable prognosis. Taken together with the present results, these data suggest that the lower hazard ratio associated with Material IV is more likely attributable to tooth type–related biomechanical conditions than to superior material performance[33]. Recent clinical studies have also identified debonding as one of the most common complications of CAD-CAM composite resin crowns and have shown that its occurrence is influenced by multiple clinical factors, including preparation geometry, occlusal loading, and the amount of remaining tooth structure. In the present study, debonding accounted for more than half of all complications. Insufficient occlusal thickness in vital teeth may have contributed to these failures, consistent with previous reports. Collectively, these findings indicate that debonding is a multifactorial complication that cannot be explained solely by material properties but is also influenced by restorative- and tooth-related clinical factors[34].

The clinical experience of the treating dentists was not included in the final Cox proportional hazards model because case distribution among operators was highly unbalanced, resulting in sparse data and unstable estimates. This imbalance may have limited our ability to adequately evaluate operator-related effects.

This study has several limitations. First, because this was a retrospective single-center cohort study, the selection of CAD-CAM composite resin crowns was based primarily on patient preference and the attending clinician's judgment rather than on predefined clinical criteria. Second, some imbalance in case distribution was unavoidable. Furthermore, because multiple restorations were included for some patients, the observations were not completely independent, and patient-level clustering may have been present. Cluster-adjusted analyses could not be performed because restricting the dataset to a single restoration per patient substantially reduced the effective sample size and resulted in unstable estimates. Consequently, residual clustering may have influenced the precision of the estimated associations. Third, although material class was analyzed, the specific commercial products and detailed compositions of the CAD-CAM blocks were not evaluated. Finally, although antagonist tooth condition was assessed, the occlusal scheme could not be reliably determined from the clinical records. Likewise, preparation geometry and abutment tooth morphology were not evaluated, despite previous studies demonstrating that these factors strongly influence the risk of debonding[35]. These limitations should be considered when interpreting the present findings.

From a clinical perspective, the present findings suggest that careful case selection, appropriate tooth preparation, and meticulous bonding procedures are essential for improving the prognosis of CAD-CAM composite resin crowns. Particular attention may be warranted when these restorations are placed on vital teeth because they exhibited a higher hazard ratio in the present study. Furthermore, as debonding was the most frequent complication, optimizing retention and adhesive protocols remains a clinical priority. Continued advances in CAD-CAM technology, adhesive systems, and restoration design may further reduce complications and improve the long-term predictability of these restorations.

5. Conclusions

CAD-CAM composite resin crowns demonstrated generally favorable mid-term clinical outcomes. Debonding was the most frequently observed complication, and crowns placed on vital teeth were associated with a significantly increased risk of complications. These findings indicate that the prognosis of CAD-CAM composite resin crowns is influenced not only by the restorative material itself but also by tooth-related and procedural factors, particularly abutment condition, tooth preparation, and bonding protocols.

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Conflict of interest statement

The authors declare no conflict of interest.

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