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Research article

# Factors influencing the longevity of posterior composite restorations: A dental university clinic study

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ABSTRACT

*Objectives:* This retrospective study aimed to assess the performance of posterior composite resin restorations (PCRRs) and evaluate the influence of patient-specific factors on restoration outcomes.
*Methods:* A total of 189 PCRRs were examined in 54 patients, with evaluations based on Modified USPHS criteria. Patient-specific factors were analyzed. Statistical analyses, including chi-square tests, independent samples t-tests, and ANOVA tests, were conducted.
*Results:* Patients aged over 50 exhibited higher DMFT averages and a higher rate of unsuccessful restorations. Despite higher DMFT scores in females, gender doesn't significantly impact restoration outcomes. Secondary caries correlated with.
plaque scores, significantly affecting restoration survival. Marginal adaptation, retention deficiencies, and secondary caries were primary causes of failure. Multi-surface restorations faced higher failure risk due to elevated plaque scores. Class-V restorations showed a higher failure rate, challenging the number of surfaces and longevity correlation.
*Conclusions:* This study identified key factors influencing posterior composite resin restorations-(PCRRs) in patients over 50, including higher DMFT averages and more unsuccessful restorations. No significant difference was found between brushing; frequency and DMFT rates, possibly due to the absence of non-brushers. Secondary caries; correlated with elevated plaque scores, impacting restoration survival. Primary causes of; failure included marginal adaptation issues, retention deficiencies, and secondary caries, with multi-surface restorations facing a higher risk. However, tooth vitality, beverage and acidic food consumption, and oral hygiene habits did not significantly affect PCRR outcomes.
*Clinical significance:* Patient-specific factors significantly impact PCRRs' long-term performance. Dentists must tailor strategies, emphasizing regular monitoring and preventive measures for extended survival.

## 1. Introduction

In the 20th century, amalgam was a common preference in restorative dentistry. However, concerns about mercury leakage from amalgam and the development of adhesive materials led to a decline in its usage [1]. Nowadays, composite resins have become a preferred material due to their advantages such as color matching, biological compatibility, minimal preparation, and support for

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tooth structure after decay removal [2]. With the advancement of adhesive systems, the recent popularity of the minimal invasive dentistry approach has played a significant role in the increased utilization of composite resins.

Despite the advantages of composite resins, issues can arise due to the shrinkage that occurs during polymerization. As a result, various criteria have been developed for material evaluation. In 1971, Dr. Gunnar Ryge, while working at the United States Public Health Service, established the USPHS scale for restorative material evaluation [3]. However, as it wasn't sensitive enough to evaluate criteria like marginal adaptation and marginal discoloration, the "Modified USPHS/Ryge criteria" were later developed [4,5].

Factors such as patients' caries risk, dietary habits, parafunctional habits, etc., also influence the success of restorations. Therefore, patients' individual characteristics should be taken into consideration.

Contemporary studies aim to understand the causes of failure in composite resin restorations and find solutions. Studies based on patient follow-up are crucial to achieve long-lasting restorations. To comprehend the clinical performance of Posterior Composite Resin Restoration (PCRR) and the impact of patient-related factors, there is a need for data based on patient follow-up.

The objective of this study is to assess the short (less than 5 years) and long-term (more than 5 years) outcomes of PCRRs performed by specialists in our clinic and to examine the influence of potential factors on the survival and causes of failure of these restorations.

## 2. Material and methods

The research protocol (2021/18) was approved by the Research Ethics Committee. In this retrospective longitudinal study, patients who underwent PCRR using nanofil and nanohybrid composite resin (without rubber dam placement) by specialists from the University Department of Restorative Dentistry were identified using the Hospital Information Management System (HIMS) and called for follow-up appointments.

Patients with PCRRs with survival of one to nineteen years were included. Of the approximately 300 patients sought, only 58 returned to follow-up. Among these, four people who underwent procedures such as crown placement or tooth extraction on their PCRR teeth were excluded from the study. All the information used in this study was collected from clinical records. The 'Informed Consent Form for Voluntary Participation in Clinical or Experimental Studies' was explained orally and in writing to those who accepted, and they were signed.

### 2.1. Clinical evaluation

189 PKRRs from 54 patients aged 18–77 years who met the inclusion criteria were evaluated with the Modified USPHS criteria (Table 1) by a physician who was not involved in the construction phase of the restorations (blind). In addition, the gingival health of the patients was evaluated using plaque (Löe and Silness) and gingival indices.

Panoramic and bitewing X-rays were taken as needed. Restorations on front teeth and baby teeth were excluded. All restorations were scored using the F score for DMFT (Decay, Missing, Filling, Tooth) calculation.

### 2.2. Questionnaire assessment

A questionnaire gathered data on patients' systemic illnesses, medication use, dietary habits, oral care routines, and parafunctional

**Table 1**
Modified USPHS criteria.

| | | |
|---|---|---|
| Retantion | Alfa(A) | No loss in restorative material |
| | Bravo(B) | Partial loss in restorative material |
| | Charlie(C) | Complete loss in restorative material |
| **Color Match** | Alfa(A) | Restoration is harmonious with adjacent tooth in terms of tone and translucency |
| | Bravo(B) | Restoration differs from adjacent tooth in tone and translucency, but within normal shade range |
| | Charlie(C) | Restoration differs from adjacent tooth in tone and translucency, outside normal shade range |
| **Margin Discoloration** | Alfa(A) | No discoloration between restoration material and tooth |
| | Bravo(B) | Discoloration present between restoration material and tooth, but not in the pulpal direction |
| | Charlie(C) | Discoloration present between restoration material and tooth, extending into the pulpal direction |
| **Marginal Adaptation** | Alfa(A) | Restoration adaptation closely to the tooth, no visible gap |
| | Bravo(B) | Visible gap where explorer adaptation catches |
| | Charlie(C) | Visible gap exposing dentin |
| **Secondary Caries** | Alfa(A) | No caries |
| | Bravo(B) | Caries present, reparable |
| | Charlie(C) | Caries present, replacement |
| **Surface Structure** | Alfa(A) | Surface resembling enamel |
| | Bravo(B) | Slightly rougher than enamel but clinically acceptable surface |
| | Charlie(C) | Unacceptable rough surface |
| **Anatomical Form** | Alfa(A) | Restorative material follows existing anatomical form continuously |
| | Bravo(B) | Slight clinically acceptable deviation from ideal form |
| | Charlie(C) | Restoration does not follow existing anatomical form |
| **Postoperative Sensitivity** | Alfa(A) | No sensitivity |
| | Bravo(B) | Mild and diminishing sensitivity |
| | Charlie(C) | Continuous sensitivity |

habits, providing insights into how these factors affected restorations (Table 2).

### 2.3. Statistical evaluation

IBM SPSS Statistics (Version 26.0. Armonk, NY: IBM Corp.) was used for analysis. Categorical data were presented as numbers and percentages, while continuous data were expressed as mean and standard deviation. The chi-square test compared categorical data. Mann-Whitney *U* test and Kruskal-Wallis test were applied to continuous data. A significance level of $p < 0.05$ was considered in the research.

## 3. Results

Solely meaningful results derived from the examined parameters and asked questions are presented in this section. The research examined PCRRs that remained in the mouth for 1–19 years and found that the restorations remained in the mouth for an average of more than 5 years.

### 3.1. Results associated with demographic factors

#### 3.1.1. The relationship between survival and the DMFT index with patient age

The average age of the participants is 48.02 ± 13.67. The mean survival of the 189 examined PCRRs is 6.62 ± 5.15. The average DMFT evaluation of the patients is 12.15 ± 5.06 (Table 3).

#### 3.1.2. The relationship between age and gender with DMFT index

There are significant differences in DMFT scores based on participants' gender and age ($p < 0.05$). The average DMFT score is higher among females and individuals aged 50 and above (Table 4).

#### 3.1.3. The relationship between age and RCT

In patients under the age of 50, the number of restorations present is 112 (59.3%), whereas in patients aged 50 and above, the number of restorations is 77 (40.7%). There is no statistically significant difference between the presence of RCT and the age groups of under 50 and above 50 ($p = 0.464$) (Table 5).

**Table 2**
Survey questions.

| | |
|---|---|
| **1. Do you have any systemic diseases? (Diabetes, hypertension, etc.)** | Yes : ….. |
| | No |
| **2. Are you taking any medication?** | Yes: … |
| | No |
| **3. Do you smoke?** | Yes, less than 5 |
| | Yes, less than 10 |
| | Yes, more than 10 |
| | No |
| **4. How is your tea/coffee consumption?** | A few cups a day/None |
| | 5-10 cups |
| | More than 10 cups |
| **5. How often do you consume carbonated beverages?** | None |
| | A few cups a day |
| | 5 cups or more per day |
| **6. How often do you consume acidic foods (lemon/vinegar/pomegranate salad, pickles, fruit)?** | None |
| | During meals |
| | Between meals |
| **7. What is the frequency of consuming sugary foods between meals?** | Only during main meals |
| | 1-3 times |
| | More than 3 times |
| **8. Do you have a habit of grinding (bruxizm) your teeth at night?** | No |
| | Yes |
| **9. If you have a bruxizm, are you receiving any treatment for it?** | Yes: ….. |
| | No |
| **10. Do you ever notice yourself clenching your teeth during the day?** | Yes: …. …. |
| | No |
| **11. How many times a day do you brush your teeth?** | 1 |
| | 2 |
| | 3 |
| | More than 3 times |
| **12. Do you use dental floss?** | Yes : ….. |
| | No |

**Table 3**
Average age, restoration survival and DMFT of the patients.

| | N | Minimum | Maximum | Mean | S.S. |
|---|---|---|---|---|---|
| **Age** | 54 | 18 | 77 | 48.02 | 13.67 |
| **Restoration Survival** | 189 | 1 | 19 | 6.62 | 5.15 |
| **DMFT** | 54 | 3 | 23 | 12.15 | 5.06 |

**Table 4**
Evaluation of DMFT values by gender and age.

| | | N | Mean | S.S. | Mean Rank | p |
|---|---|---|---|---|---|---|
| **DMFT** | **Male** | 23 | 10.48 | 4.55 | 22.41 | 0.036 |
| | **Female** | 31 | 13.39 | 5.14 | 31.77 | |
| **DMFT** | **Under 50** | 28 | 10.57 | 4.71 | 22.18 | 0.016 |
| | **Over 50** | 26 | 13.85 | 4.96 | 32.10 | |

### 3.2. Gingival and plaque indices: assessing periodontal health

Significant differences were observed among the examined PCRRs in terms of restoration survival based on plaque index assessment ($p = 0.005$). PCRRs with a zero score exhibited a notably longer mean survival ($10.19 \pm 5.29$) compared to others. However, no significant difference was found in restoration survival between PCRRs assessed by gingival index ($p = 0.385$) (Table 6).

Furthermore, there was no statistically significant distinction between gender groups in the evaluation of PKRRs based on gingival and plaque index assessments ($p > 0.05$) (Table 7).

There was no statistically significant difference in terms of gingival (Table 8) and plaque index (Table 9) evaluations according to the frequency of tooth brushing and flossing use of the participants ($p > 0.05$).

### 3.3. Results associated with survey questions

#### 3.3.1. The relationship between gender and survey questions

A total of 23 male and 31 female (23 with a history of pregnancy) patients responded to the survey questions, and the distribution of responses by gender is presented in Table 6. Gender-based analysis revealed statistically significant differences regarding smoking habits, tea/coffee consumption, frequency of consuming sugary foods outside main meals, and teeth clenching habits ($p < 0.05$) (Table 10).

#### 3.3.2. The relationship between DMFT and sugar

There is no statistically significant relationship between sugar consumption and dental DMFT scores ($p = 0{,}465$) (Table 11).

#### 3.3.3. The relationship between DMFT and oral hygiene habits

There was no statistically significant difference in terms of DMFT scores according to the frequency of tooth brushing ($p > 0.05$) (Table 13).

### 3.4. Results associated with modified USPHS criteria

Restorations were present in 70 (37%) male patients and 119 (63%) female patients. Analysis based on gender indicated no statistically significant differences among the evaluated PCRRs in terms of cavity type, retantion, color matching, edge discoloration, edge adaptation, secondary caries, surface structure, anatomical form, and postoperative sensitivity criteria ($p > 0.05$). Similarly, no significant gender-related variation was observed concerning the presence of root canal treatment (RCT) in examined PCRR teeth ($p > 0.05$) (Table 14).

**Table 5**
RCT presence and age relationship.

| | | | RCT PRESENCE | | Total | p |
|---|---|---|---|---|---|---|
| | | | – | RCT | | |
| **Age** | **Under 50** | n | 26 | 2 | 28 | 0,464 |
| | | % | 92.9% | 7.1% | 100.0% | |
| | **Over 50** | n | 23 | 3 | 26 | |
| | | % | 88.5% | 11.5% | 100.0% | |
| **Total** | | n | 49 | 5 | 54 | |
| | | % | 90.7% | 9.3% | 100.0% | |

**Table 6**
Restoration survival by plaque and gingival index scoring.

| | | N | Mean | S.S. | p |
|---|---|---|---|---|---|
| **Plaque Index** | **0** | 7 | 10.19[a] | 5.29 | 0,005 |
| | **1** | 129 | 5.69[b] | 4.73 | |
| | **2** | 53 | 6.00[b] | 5.19 | |
| | **Total** | 189 | 6.61 | 5.19 | |
| **Gingival Indeks** | **0** | 65 | 7.00 | 5.57 | 0,385 |
| | **1** | 102 | 7.63 | 5.75 | |
| | **2** | 22 | 6.20 | 4.29 | |
| | **Total** | 189 | 6.61 | 5.19 | |

*The lowercase letters indicate the differences between cavity types. No differences were found among groups that share the same letter.

**Table 7**
Gingival and plaque index comparison by gender.

| | | Male | Female | p |
|---|---|---|---|---|
| **Gingival Index** | **0** | 2 (8.7%) | 1 (3.2%) | 0.665 |
| | **1** | 14 (60.9%) | 21 (67.7%) | |
| | **2** | 7 (30.4%) | 9 (29.0%) | |
| **Plaque Index** | **0** | 7 (30.4%) | 9 (29.0%) | 0.642 |
| | **1** | 11 (47.8%) | 18 (58.1%) | |
| | **2** | 5 (21.7%) | 4 (12.9%) | |

**Table 8**
Tooth brushing and flossing habits and gingival index relationship.

| | | | GINGIVAL INDEX | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | | |
| **How many times a day do you brush your teeth?** | **1** | N | 1 | 18 | 9 | 28 | 0.763 |
| | | % | 3.6% | 64.3% | 32.1% | 100.0% | |
| | **2** | N | 2 | 17 | 7 | 26 | |
| | | % | 7.7% | 65.4% | 26.9% | 100.0% | |
| **Total** | | N | 3 | 35 | 16 | 54 | |
| | | % | 5.6% | 64.8% | 29.6% | 100.0% | |
| **Do you use dental floss?** | **Yes** | N | 2 | 7 | 1 | 10 | 0.157 |
| | | % | 20.0% | 70.0% | 10.0% | 100.0% | |
| | **No** | N | 1 | 28 | 15 | 44 | |
| | | % | 2.3% | 63.6% | 34.1% | 100.0% | |
| **Total** | | N | 3 | 35 | 16 | 54 | |
| | | % | 5.6% | 64.8% | 29.6% | 100.0% | |

**Table 9**
Tooth brushing and flossing habits and plaque index relationship.

| | | | PLAQUE INDEX | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | | |
| **How many times a day do you brush your teeth?** | **1** | N | 5 | 16 | 7 | 28 | 0.341 |
| | | % | 17.9% | 57.1% | 25.0% | 100.0% | |
| | **2** | N | 11 | 13 | 2 | 26 | |
| | | % | 42.3% | 50.0% | 7.7% | 100.0% | |
| **Total** | | N | 16 | 29 | 9 | 54 | |
| | | % | 29.6% | 53.7% | 16.7% | 100.0% | |
| **Do you use dental floss?** | **Yes** | N | 5 | 4 | 1 | 10 | 0.863 |
| | | % | 50.0% | 40.0% | 10.0% | 100.0% | |
| | **No** | N | 11 | 25 | 8 | 44 | |
| | | % | 25.0% | 56.8% | 18.2% | 100.0% | |
| **Total** | | N | 16 | 29 | 9 | 54 | |
| | | % | 29.6% | 53.7% | 16.7% | 100.0% | |

Tea/coffee consumption frequency and marginal discoloration in participating patients displayed no significant relationship ($p > 0.05$) (Table 15). Similarly, no significant correlation existed between patients' smoking status and marginal discoloration in examined teeth ($p > 0.05$) (Table 15).

**Table 10**
Comparison of survey evaluations by gender.

| | | Male | Female | p |
|---|---|---|---|---|
| **Do you have any systemic diseases? (Diabetes, hypertension, etc.)** | Yes | 6 (26.1%) | 11 (35.5%) | 0,560 |
| | No | 17 (73.9%) | 20 (64.5%) | |
| **Are you taking any medication?** | Yes | 5 (21.7%) | 11 (35.5%) | 0,370 |
| | No | 18 (78.3%) | 20 (64.5%) | |
| **Do you smoke?** | Yes, more than 10 | 5 (21.7%) | 0 (0.0%) | 0,009 |
| | Yes, less than 5 | 1 (4.3%) | 1 (3.2%) | |
| | No | 17 (73.9%) | 30 (96.8%) | |
| **How is your tea/coffee consumption?** | More than 10 cups | 6 (26.1%) | 5 (16.1%) | 0,016 |
| | 5-10 cups | 11 (47.8%) | 10 (32.3%) | |
| | A few cups a day/None | 6 (26.1%) | 16 (51.6%) | |
| **How often do you consume carbonated beverages?** | 5 cups or more per day | 1 (4.3%) | 0 (0.0%) | 0,466 |
| | A few cups a day | 6 (26.1%) | 7 (22.6%) | |
| | None | 16 (69.6%) | 24 (77.4%) | |
| **How often do you consume acidic foods (lemon/vinegar/pomegranate salad, pickles, fruit)?** | During meals | 14 (60.9%) | 24 (77.4%) | 0,277 |
| | None | 1 (4.3%) | 0 (0.0%) | |
| | Between meals | 8 (34.8%) | 7 (22.6%) | |
| **What is the frequency of consuming sugary foods between meals?** | 1-3 times | 11 (47.8%) | 22 (71.0%) | 0,048 |
| | Only during main meals | 12 (52.2%) | 9 (29.0%) | |
| **Do you have a habit of clenching (bruxizm) your teeth at night?** | Yes | 17 (73.9%) | 13 (41.9%) | 0,027 |
| | No | 6 (26.1%) | 18 (58.1%) | |
| **If you have a bruxizm, are you receiving any treatment for it?** | Unanswer | 4 (17.4%) | 14 (45.2%) | 0,089 |
| | Yes | 2 (8.7%) | 1 (3.2%) | |
| | No | 17 (73.9%) | 16 (51.6%) | |
| **Do you ever notice yourself clenching your teeth during the day?** | Yes | 8 (34.8%) | 10 (32.3%) | 0,846 |
| | No | 15 (65.2%) | 21 (67.7%) | |
| **How many times a day do you brush your teeth?** | 1 | 14 (60.9%) | 14 (45.2%) | 0,284 |
| | 2 | 9 (39.1%) | 17 (54.8%) | |
| **Do you use dental floss?** | Yes | 5 (21.7%) | 5 (16.1%) | 0,600 |
| | No | 18 (78.3%) | 26 (83.9%) | |

**Table 11**
The relationship between DMFT and sugar consumption.

| | | N | Mean | S.S. | Mean Rank | p |
|---|---|---|---|---|---|---|
| **DMFT** | **Only during main meals** | 21 | 12.43 | 4.567 | 29.00 | 0,465 |
| | **1–3 times** | 33 | 11.97 | 5.417 | 26.55 | |

No significant relationship was observed between sugar consumption timing and frequency, and DMFT scores among participants divided into groups below and above the age of 50 ($p > 0.05$) (Table 12).

**Table 12**
The relationship between sugar consumption and DMFT in patients under 50 and over.

| | | N | Mean | S.S. | Mean Rank | p |
|---|---|---|---|---|---|---|
| **Under 50** | Only during meals | 7 | 9.71 | 3.09 | 14.07 | 0.876 |
| | 1-3 times | 21 | 10.86 | 5.17 | 14.64 | |
| **Over 50** | Only during meals | 14 | 13.79 | 4.66 | 13.46 | 0.980 |
| | 1-3 times | 12 | 13.92 | 5.50 | 13.54 | |

**Table 13**
Tooth brushing frequencies and DMFT relationship.

| | | N | Mean | S.S. | Mean Rank | p |
|---|---|---|---|---|---|---|
| **How many times a day do you brush your teeth?** | 1 | 28 | 12.14 | 4.87 | 27.70 | 0.994 |
| | 2 | 26 | 12.15 | 5.36 | 27.29 | |

Statistically significant differences emerged based on tooth types (premolar/molar) and cavity types harboring restorations ($p < 0.05$) (Table 16). Distinctive premolar (P) and molar (M) classification did not yield significant differences in restoration evaluations based on Modified USPHS criteria, including retantion, color match, marginal discoloration, marginal adaptation, secondary caries, surface structure, anatomical form, and postoperative sensitivity ($p > 0.05$). However, a significant difference was noted concerning the presence of RCT relative to tooth type ($p < 0.05$), with all teeth with RCT located within the premolar group (Table 16).

**Table 14**
Evaluation of cavity type, presence of RCT, modified USPHS criteria of restorations by gender.

| | | Male | Female | p |
|---|---|---|---|---|
| **Cavity Type** | CI | 7 (13.7%) | 18 (20.7%) | 0.477 |
| | CII | 30 (58.8%) | 53 (60.9%) | |
| | CV | 3 (5.9%) | 5 (5.7%) | |
| | MOD | 11 (21.6%) | 11 (12.6%) | |
| **Retantion** | A | 44 (86.3%) | 82 (94.3%) | 0.230 |
| | B | 4 (7.8%) | 2 (2.3%) | |
| | C | 3 (5.9%) | 3 (3.4%) | |
| **Color Match** | A | 31 (60.8%) | 47 (54.0%) | 0.283 |
| | B | 16 (31.4%) | 37 (42.5%) | |
| **Marginal Discoloration** | A | 29 (56.9%) | 51 (58.6%) | 0.522 |
| | B | 18 (35.3%) | 33 (37.9%) | |
| **Marginal Adaptation** | A | 37 (72.5%) | 66 (75.9%) | 0.729 |
| | B | 10 (19.6%) | 17 (19.5%) | |
| | C | 4 (7.8%) | 4 (4.6%) | |
| **Secondary Caries** | A | 46 (90.2%) | 81 (93.1%) | 0.510 |
| | B | 0 (0.0%) | 1 (1.1%) | |
| | C | 5 (9.8%) | 5 (5.7%) | |
| **Surface Texture** | A | 31 (60.8%) | 3 (3.4%) | 0.061 |
| | B | 16 (31.4%) | 69 (79.3%) | |
| **Anatomical Form** | A | 38 (74.5%) | 70 (80.5%) | 0.655 |
| | B | 9 (17.6%) | 14 (16.1%) | |
| | C | 2 (3.9%) | 2 (2.3%) | |
| **Postoperative Sensitivity** | A | 45 (88.2%) | 81 (93.1%) | 0.154 |
| | B | 4 (7.8%) | 2 (2.3%) | |
| | C | 2 (3.9%) | 1 (1.1%) | |
| **Presence of CRT** | – | 21 (91.3%) | 28 (90.3%) | 0.902 |
| | CRT | 2 (8.7%) | 3 (9.7%) | |

### *3.5. Relationship between evaluation criteria and survey questions*

Moreover, no statistically significant relationship was found between marginal discoloration and secondary caries presence ($p > 0.05$). However, a significant relationship emerged between the presence of secondary caries and marginal adaptation and anatomical form in examined restorations ($p < 0.05$) (Table 17).

Furthermore, a significant relationship was identified between the presence of secondary caries and cavity type in examined teeth ($p < 0.05$) (Table 18).

Similarly, a significant relationship was observed between the presence of secondary caries and plaque index values in examined teeth ($p < 0.05$) (Table 19).

The relationship between retantion and the presence of RCT in examined restorations showed no significant correlation ($p > 0.05$). Among the examined RCT teeth, 12 had an A retantion level, while one had a C retantion level (Table 20).

No significant association existed between patients with teeth clenching habits, their treatment status, and restoration retention

**Table 15**
The relationship between marginal discoloration and tea/coffee consumption.

| | | | Marginal Discoloration | | Total | p |
|---|---|---|---|---|---|---|
| | | | A | B | | |
| **How is your tea/coffee consumption?** | **More than 10 cups** | n | 22 | 6 | 28 | 0.108 |
| | | % | 78,6% | 21,4% | 100.0% | |
| | **5–10 cups** | N | 28 | 25 | 53 | |
| | | % | 52,8% | 47,2% | 100.0% | |
| | **A few cups a day/None** | n | 30 | 20 | 50 | |
| | | % | 60% | 40% | 100.0% | |
| **Total** | | n | 80 | 51 | 131 | |
| | | % | 61,1% | 38.9% | 100.0% | |
| | | | **Marginal Discoloration** | | **Total** | **p** |
| | | | **A** | **B** | | |
| **Do you smoke?** | **Yes, more than 10** | n | 9 | 4 | 13 | 0.358 |
| | | % | 69,2% | 30,8% | 100.0% | |
| | **Yes, less than 5** | n | 2 | 3 | 5 | |
| | | % | 40% | 60% | 100.0% | |
| | **No** | n | 69 | 44 | 113 | |
| | | % | 60% | 40% | 100.0% | |
| **Total** | | n | 80 | 51 | 131 | |
| | | % | 61,1% | 38.9% | 100.0% | |

**Table 16**
Relationship between P/M of teeth and Modified USPHS Criteria and Presence of RCT.

| | | Premolar | Molar | p |
|---|---|---|---|---|
| **Cavity Type** | CI | 5 (5,9%) | 35 (33.7%) | 0.001 |
| | CII | 60 (70.6%) | 49 (47.1%) | |
| | CV | 14 (16.5%) | 3 (2.9%) | |
| | MOD | 6 (7.1%) | 17 (16.3%) | |
| **Retantion** | A | 80 (94.1%) | 97 (93.3%) | 0.851 |
| | B | 3 (3.5%) | 3 (2.9%) | |
| | C | 2 (2.4%) | 4 (3.8%) | |
| **Color Match** | A | 44 (53%) | 66 (66.7%) | 0.754 |
| | B | 39 (47%) | 33 (33.3%) | |
| **Marginal Discoloration** | A | 46 (55.4%) | 62 (62.6%) | 0.319 |
| | B | 37 (44.6%) | 37 (37.4%) | |
| **Marginal Adaptation** | A | 74 (87.1%) | 76 (73.1%) | 0.077 |
| | B | 9 (10.5%) | 22 (21.2%) | |
| | C | 2 (2.4%) | 6 (5.8%) | |
| **Secondary Caries** | A | 82 (96.4%) | 96 (92.3%) | 0.230 |
| | B | 1 (1.2%) | 0 (0.0%) | |
| | C | 2 (2.4%) | 8 (7.7%) | |
| **Surface Structure** | A | 57 (68.7%) | 79 (70.7%) | 0.746 |
| | B | 26 (31.3%) | 20 (29.3%) | |
| **Anatomical Form** | A | 77 (50.2%) | 81 (79.4%) | 0.089 |
| | B | 6 (7.1%) | 18 (17.6%) | |
| | C | 1 (1.2%) | 3 (2.9%) | |
| **Postoperative Sensitivity** | A | 81 (98.8%) | 95 (92.3%) | 0.526 |
| | B | 0 (0.0%) | 6 (5.8%) | |
| | C | 1 (1.2%) | 2 (1.9%) | |
| **Teet with RCT** | – | 77(90.6%) | 99 (95.2%) | 0.001 |
| | RCT | 8 (9.4%) | 5 (4.8%) | |

scores ($p > 0.05$) (Table 21).

### 3.6. Failed restorations

When examining the relationship between failed restorations and DMFT index, out of the total restorations examined, 13 received a C score and were considered unsuccessful. The DMFT value is higher in failed teeth ($p = 0.028$) (Table 22).

There is a statistically significant relationship between the patients' ages and restoration success ($p = 0.007$) (Table 23) (see Table 24).

The distribution of cavity types in failed restorations shows that 7.7% are of type C1, 61.5% are of type C2, and 30.8% are of type

**Table 17**
The relationship between secondary caries and marginal discoloration, marginal adaptation and anatomical form.

| | | | SECONDARY CARIES | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| **Marginal Discoloration** | A | n | 110 | 0 | 1 | 111 | 0.128 |
| | | % | 99.10% | 0.00% | 0.90% | 100.00% | |
| | B | n | 68 | 1 | 5 | 74 | |
| | | % | 91.90% | 1.35% | 6.75% | 100.00% | |
| Total | | n | 178 | 1 | 6 | 185 | |
| | | % | 96.20% | 0.54% | 3.24% | 100.00% | |
| **Marginal Adaptation** | A | n | 151 | 0 | 2 | 153 | 0.001 |
| | | % | 98.70% | 0.00% | 1.30% | 100.00% | |
| | B | n | 25 | 0 | 3 | 28 | |
| | | % | 89.30% | 0.00% | 10.70% | 100.00% | |
| | C | n | 2 | 1 | 5 | 8 | |
| | | % | 25.00% | 12.50% | 62.50% | 100.00% | |
| Total | | n | 178 | 1 | 10 | 189 | |
| | | % | 94.20% | 0.50% | 5.30% | 100.00% | |
| **Anatomical Form** | A | n | 156 | 0 | 3 | 159 | 0.001 |
| | | % | 98.10% | 0.00% | 1.90% | 100.00% | |
| | B | n | 21 | 1 | 2 | 24 | |
| | | % | 87.50% | 4.20% | 8.30% | 100.00% | |
| | C | n | 1 | 0 | 3 | 4 | |
| | | % | 25.00% | 0.00% | 75.00% | 100.00% | |
| Total | | n | 178 | 1 | 8 | 187 | |
| | | % | 95.20% | 0.50% | 4.30% | 100.00% | |

**Table 18**
Cavity type and secondary caries relationship.

| | | | SECONDARY CARIES | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| **Cavity Type** | CI | n | 39 | 0 | 1 | 40 | 0.001 |
| | | % | 97.5% | 0.00% | 2.5% | 100.0% | |
| | CII | n | 101 | 0 | 7 | 108 | |
| | | % | 93.5% | 0.00% | 6.5% | 100.0% | |
| | CV | n | 14 | 1 | 2 | 17 | |
| | | % | 82.3% | 5.9% | 11.8% | 100.0% | |
| | MOD | n | 24 | 0 | 0 | 24 | |
| | | % | 100.0% | 0.00% | 0.00% | 100.0% | |
| Total | | n | 178 | 1 | 10 | 189 | |
| | | % | 94.2% | 0.5% | 5.3% | 100.00% | |

**Table 19**
The relationship between secondary caries and plaque index values.

| | | | SECONDARY CARIES | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| **Plaque Index** | **0** | n | 64 | 1 | 0 | 65 | 0.001 |
| | | % | 98.5% | 1.5% | 0.0% | 100.0% | |
| | **1** | n | 95 | 0 | 6 | 101 | |
| | | % | 94.1% | 0.00% | 5.9% | 100.0% | |
| | **2** | n | 18 | 0 | 4 | 22 | |
| | | % | 81.8% | 0.0% | 18.2% | 100.0% | |
| **Total** | | n | 178 | 1 | 10 | 189 | |
| | | % | 94.2% | 0.5% | 5.3% | 100.00% | |

**Table 20**
Relationship between retantion and RCT.

| | | | Presence of RCT | | Total | p |
|---|---|---|---|---|---|---|
| | | | – | RCT | | |
| **Retantion** | **A** | n | 165 | 12 | 177 | 0.487 |
| | | % | 93.2% | 6.8% | 100.00% | |
| | **B** | n | 6 | 0 | 6 | |
| | | % | 100.00% | 0.00% | 100.00% | |
| | **C** | n | 5 | 1 | 6 | |
| | | % | 83.3% | 16.7% | 100.00% | |
| **Total** | | n | 183 | 6 | 189 | |
| | | % | 96.40% | 3.60% | 100.00% | |

**Table 21**
The relationship between retention and clenching/bruxizm.

| | | | Retantion | | | Total | p |
|---|---|---|---|---|---|---|---|
| | | | A | B | C | | |
| Receiving Clenching/Bruxizm Treatment | Yes | n | 7 | 0 | 0 | 7 | 0.487 |
| | | % | 100.00% | 0.00% | 0.00% | 100.00% | |
| | **No** | n | 52 | 4 | 2 | 58 | |
| | | % | 89.70% | 6.90% | 3.40% | 100.00% | |
| **Total** | | n | 59 | 4 | 2 | 65 | |
| | | % | 90.70% | 6.20% | 3.10% | 100.00% | |

C5. No failed restorations are found in MOD cavity type (Table 24).

When comparing the tooth type (Premolar (P)/Molar (M)) with restoration longevity, there is no statistically significant difference ($p > 0.05$). The average restoration survival for premolar teeth is $7.10 \pm 5.33$, whereas for molar teeth, it is $6.26 \pm 5.03$.

Among the examined restorations, 47.1% have a restoration survival of less than 5 years, 22.2% have a survival of 5–10 years, 18% have a survival of 11–15 years, and 12.7% have been present in the oral cavity for more than 15 years.

According to the Modified USPHS criteria, the C score distribution for failed restorations is as follows: 61.5% for marginal integrity, 76.7% for secondary caries formation, 30.8% for anatomical form, and 23.1% for postoperative sensitivity.

**Table 22**
Failed restoration and DMFT relationship.

| | N | Mean | Std.Deviation | p |
|---|---|---|---|---|
| Successful | 176 | 11.90 | 5.07 | 0.028 |
| Failed | 13 | 15.25 | 4.35 | |

**Table 23**
The relationship between patients' age and restoration success.

| | N | Mean | Std. Deviation | p |
|---|---|---|---|---|
| Successful | 176 | 46.09 | 12.89 | 0.007 |
| Failed | 13 | 56.46 | 14.28 | |

**Table 24**
Restoration survival according to cavity types.

| | N | Mean | S.D. | p |
|---|---|---|---|---|
| CI | 40 | 7.84[a] | 5.53 | 0,002 |
| CII | 109 | 6.70[b] | 5.14 | |
| CV | 17 | 10.50[c] | 5.58 | |
| MOD | 23 | 3.50[d] | 2.68 | |
| Total | 189 | 6.62 | 5.15 | |

*The lowercase letters indicate the differences between cavity types. No differences were found among groups that share the same letter.

### *3.7. Results regarding cavity type*

In the study, 21.2% of the examined restorations were classified as Class I (CI), 57.7% as Class II (CII), 9% as Class V (CV), and 12.2% as Mesiodistal (MOD) cavity type. An examination of the relationship between restoration survival and cavity type revealed a significant difference ($p < 0.05$) (Table 22). Each of the four cavity types exhibited distinct variations; the longest restoration lifespan was observed in CV, whereas the shortest restoration lifespan was evident in MOD cavities (Table 25). Analyzing the distribution of cavity types in failed restorations, 7.7% were of type C1, 61.5% were C2, and 30.8% were C5. No failed restorations were identified in the MOD cavity type.

The relationship between gingival and plaque indices and cavity types showed no significant differences ($p > 0.05$) (Table 25).

Gender exhibited no statistically significant differences in relation to cavity types ($p > 0.05$) (Table 26).

The presence of RCT did not significantly differ among restorations based on cavity types ($p > 0.05$), with 13 teeth having RCT, mostly of CII cavity type (Table 27).

## 4. Discussion

The monitoring of restorations plays a vital role in creating awareness among patients, facilitating early diagnosis and treatment of emerging issues, and contributing to economic benefits by preventing potential failures. Patient-specific factors are pivotal in predicting restoration outcomes. These factors suggest that patients with a high caries risk are more susceptible to restoration failures [6]. Opdam et al.'s [7] study indicated that patients with a high DMFT index have a 2.45 to 4.40 times greater risk of restoration failure compared to those with a low index. This highlights the influence of caries risk on restoration longevity irrespective of age [8].

Conversely, Ceylan et al. [9] found a DMFT of 5.97 in 2766 young individuals, whereas Karabekiroğlu and Ünlü [10] reported a DMFT of 8.23 in 154 young individuals. The reduced participation in our study might be linked to patient reluctance during the Covid-19 pandemic and a decreased likelihood of treatment-seeking in individuals without dental issues. In our study, the mean DMFT index of the 54 patients was determined as 12.15, indicating a high caries risk in the examined patient group. Although not statistically significant, the higher caries risk in patients might be associated with sugary snacks consumed 1–3 times between meals, exceeding the

**Table 25**
Investigation of gingival and plaque index evaluations according to cavity types.

| | | CI | CII | CV | MOD | p |
|---|---|---|---|---|---|---|
| **Gingival Index** | **0** | 3 (7.5%) | 4 (3.7%) | 0 (0.0%) | 0 (0.0%) | 0.410 |
| | **1** | 27 (67.5%) | 68 (62,4%) | 17 (100.0%) | 17 (73.9%) | |
| | **2** | 10 (25%) | 37 (33.9%) | 0 (0.0%) | 6 (26.1%) | |
| **Plaque Index** | **0** | 20 (50.0%) | 29 (26.6%) | 13 (76.5%) | 3 (13%) | 0.009 |
| | **1** | 18 (45.0%) | 68 (62.4%) | 4 (23.5%) | 12 (34.8%) | |
| | **2** | 2 (5.0%) | 12 (11.0%) | 0 (0.0%) | 8 (52.2%) | |

**Table 26**
Gender and cavity type relationship.

| | | Male | Female | p |
|---|---|---|---|---|
| **Cavity Type** | CI | 13 (18.6%) | 27 (22.7%) | 0.403 |
| | CII | 40 (57.1%) | 69 (58.0%) | |
| | CV | 4 (5.7%) | 13 (10.9%) | |
| | MOD | 13 (18.6%) | 10 (8.4%) | |

**Table 27**
The relationship between cavity type and presence of KKT in teeth.

| | | | RCT | | Total | p |
|---|---|---|---|---|---|---|
| | | | – | RCT | | |
| **CAVITY TYPE** | **CI** | n | 40 | 0 | 40 | 0.329 |
| | | % | 100.0% | 0.0% | 100.0% | |
| | **CII** | n | 98 | 11 | 109 | |
| | | % | 89.9% | 10.1% | 100.0% | |
| | **CV** | n | 17 | 0 | 17 | |
| | | % | 100.0% | 0.0% | 100.0% | |
| | **MOD** | n | 21 | 2 | 23 | |
| | | % | 91.3% | 8.7% | 100.0% | |
| **Total** | | n | 176 | 13 | 189 | |
| | | % | 96.4% | 3.6% | 100.0% | |

consumption rate during main meals.

Due to a lack of sufficient scientific studies on factors such as gender, age, tooth brushing, and socioeconomic status that contribute to the risk profile, further research is needed [11]. In our study, females (13.39) exhibited higher DMFT scores compared to males (10.48). The majority of our female patients might undergo phases like pregnancy, which disrupt calcium balance and deteriorate oral hygiene due to hormonal changes, possibly leading to increased restoration needs (n = 119). A similar study linked higher caries rates in females to earlier tooth eruption, resulting in longer exposure to cariogenic factors [12].

In our study, a total of 189 PCRR were examined, with 119 in females and 70 in males. Gender was found to have no significant impact on the distribution of restoration scores. Similar findings were reported by Borgia et al. [13], who also found that gender did not influence clinical outcomes. However, despite women having higher DMFT scores in our study, certain habits like smoking, tea/coffee consumption, sugary snack intake between meals, and nighttime teeth clenching were more prevalent among men. This observation might elucidate the lack of a significant gender effect on restoration scores.

Individuals aged over 50 (13.85) had higher DMFT scores than those under 50 (10.57). This aligns with findings in other research indicating a correlation between increasing age, higher restoration failure rates, and increased prevalence of oral and general health issues [14,15]. Another study by Kamberi et al. [16] reported a significant rise in DMFT rates with age.

In the subset of participants aged fifty and above, there was a discernible tendency towards a heightened frequency of inter-meal sugary snack consumption in comparison to consumption during primary meals. Although statistical significance wasn't achieved, this observation potentially signifies an associative connection between escalated intake of sugary snacks during intervals and the elevated prevalence of DMFT rates within this particular age demographic. Moreover, the augmented incidence of sugary snack consumption during inter-meal periods among individuals surpassing the age of fifty could plausibly contribute to the age-associated escalation in DMFT indices.

There was no statistically significant difference between brushing frequency and DMFT rates. The absence of participants who reported not brushing their teeth might have contributed to this outcome. Existing literature has positioned individuals who do not brush at all within the moderate risk group [17]. Among our participants, 51.9% reported brushing once a day, particularly before sleep. Brushing before bedtime can be effective in reducing plaque and caries formation, potentially accounting for the lack of significance in the difference between twice-daily and once-daily brushing.

Among participants who brushed at least once daily, secondary caries were observed at a notably higher rate in CV PCRRs with elevated accessibility. This pattern suggests the potential influence of marginal leakage in CV PCRRs.

Among patients aged 18 to 77, those with failed restorations exhibited a higher mean age (56.46) compared to patients with successful restorations (46.09). Despite a greater number of restorations in patients under 50 (112), restoration failure was more prevalent among patients aged 50 and above. Advanced age-related increased caries risk and reduced care have been associated with a heightened risk of failure in Class II restorations in elderly patients [18].

Primary reasons for failure in posterior composites frequently include secondary caries, fractures, marginal discrepancies, and wear [19,20]. Nonetheless, studies have also highlighted secondary caries as a primary failure cause [21–23], along with the presence of fractures [19,23,24].

In our study, the predominant failures were observed in marginal adaptation, retention deficiencies, and secondary caries formation. A significant relationship between marginal adaptation (C score 62.5%) and anatomical form (C score 75%) with secondary caries was identified in restorations with secondary caries. While some recent studies have suggested that secondary caries might not

be related to cavity margin integrity or leakage resulting from void formation [25,26], this outcome could be expected considering the above-average oral hygiene of the participants in these studies. In our study, given the participants' poor oral hygiene and dental care along with their high caries risk, the deterioration of marginal adaptation in restorations over time leading to secondary caries is an anticipated result.

Our retantion evaluation mainly relied on the A score (53.8%), while the identification of failures in other criteria(marginal adaptation, secondary caries) suggests that although the PCRRs are present in the oral cavity, they might be at risk of failure based on other criteria in the future.

In various follow-up-based studies, secondary caries rates have been reported as 7.8% [27], 7.5% [28], 12% [29], and 9.7% [30], while in our study, this rate is 5.8%. The likelihood of restoration failure due to caries is observed to be 2.5 times higher in high caries risk groups compared to low caries risk groups [29]. In an eight-year prospective randomized study, Pallesen et al. (2013) reported that 63% of recurring carious lesions were in the high caries risk group [20], while in a 27-year follow-up study, Pallesen and van Dijken (2015) reported this rate as 45% [31]. Despite our study's high caries risk patient group, the lower incidence of secondary caries compared to other studies is attributed to the shorter average longevity in the oral cavity.

In this study, the parameters exhibiting the highest B scores in restorations were found to be marginal discoloration and color match. These findings, consistent with other literature studies, confirm that marginal color alteration is the most commonly encountered issue [32,33]. However, a significant relationship between tea/coffee and cigarette consumption and marginal discoloration in restorations was not established. Nevertheless, long-term effects of cigarette and colored beverage consumption on restorations are presumed. Notably, in patients with heavy tea/cigarette consumption, marginal discolorations were observed within a short period, such as one year. Additionally, despite low consumption rates of acidic beverages, patients reporting their intake displayed pronounced roughness on restoration surfaces. This observation indicates a potential scenario that could lead to discoloration over time, even if the consumption of said beverages is infrequent.

Our study indicates that the average survival of restorations classified as failures (7.7 years) was comparable to or even longer than the average survival of all restorations (6.62 years). This suggests that enhancing oral and dental care while reducing potential risk factors could extend restoration survivals. During our examinations, 176 (93.1%) of the PCRRs were still functional. These rates were notably higher than those reported by Opdam et al. (2010) at 85% [27], Rosa Rodolpho et al. (2011) at 70% [28], and Laegreid et al. (2012) at 87.7% [34]. In a study where Class II restorations were performed using various composites, a 97.9% success rate was reported at the 10-year mark [32]. The elevated success rate compared to other studies might be attributed to the presence of short-lived restorations and a limited number of restorations. The increased risk of failure in long-term restorations has been previously mentioned [35]. The relatively short survival of nearly half (47.1%) of the examined restorations in our study being less than 5 years in the oral cavity accounts for the low failure rate.

Wear, fractures, and cracks are often indicative of bruxism habits, which can impact the durability of restorations [36]. Patients with nocturnal bruxism were found to mostly continue this habit during the daytime as well. However, a significant relationship between bruxism and restoration failure was not established, suggesting that nocturnal bruxism might manifest differently depending on the patient's condition.

Regarding the connection between severe dental wear and restoration failures, fractures emerged as the predominant mode of failure [37]. In our investigation of restorations spanning 1–19 years, the prevalence of fractured restorations was 6.35%. In contrast, existing literature reported rates of 2.8% [27], 20% [28], and 13% [29]. Among individuals exhibiting nocturnal bruxism, six restorations displayed fractures, primarily within this subgroup. Notably, these patients were not subjected to bruxism-related treatments. Particularly in restorations with a C score ($n = 4$), the absence of interventions for parafunctional habits was perceived as a potential contributor to these failures. Additionally, in patients with C retantion scores, the exposure of dentin due to wear lent support to this scenario, despite the absence of statistically significant disparities. Although our results are not statistically significant, long-term assessments may provide more information.

Root canal-treated teeth exhibit distinct biomechanics compared to vital teeth. Among 13 endodontically treated teeth, only one restoration received a C score for retention, suggesting that vitality may not significantly impact restoration retention. While restoration failures were more common in patients aged 50 and above, a direct age-to-root canal treatment correlation was inconclusive.

Notably, immediate post-treatment sensitivity was absent, and patients tended to forget these symptoms over time. The involvement of experienced dentists in performing the examined PCRRs likely contributed to the reported low sensitivity. Analysis of postoperative sensitivity revealed notable findings in marginal adaptation, retantion, anatomical form, and secondary caries in PCRRs assessed with a C score. This implies that problems such as marginal mismatch, fractures, and secondary caries could be misconstrued as sensitivity by patients.

In our study, a total of 189 PCRRs were examined, including 85 P and 104 M. When comparing the PCRR counts in our study to other literature, Opdam et al. (2010) and da Rosa Rodolpho et al. (2011) considered 234P-513 M [27] and 168P-194 M PCRRs [28], respectively. The average number of restorations per patient was 3.5. In Opdam's study, 103 patients had 1-4 restorations, while 93 patients had 5-8 restorations [27]. Da Rosa Rodolpho's study involved an average of 56 patients with 6 restorations [28], and another study found an average of 44 patients with 7 restorations [29].

Although restoration lifespans were longer in P teeth (average $7.10 \pm 5.33$) compared to M teeth (average $6.26 \pm 5.03$), no significant difference was observed between restoration survival and the P/M ratio.

The lack of significant difference between P/M teeth in the assessment according to modified USPHS criteria explains the similarity in restoration survival. However, cavity types differ based on the P/M ratio. CII restorations were present in 70.6% of P teeth and 47.1% of M teeth. The presence of secondary caries was significantly higher in P teeth. This can be associated with the higher occurrence of CII restorations in P teeth, leading to an increased risk of secondary caries and the need for secondary caries removal

with the progression of caries. Additionally, P teeth are known to be more prone to trauma due to their anatomical location.

Opdam et al. (2014) highlighted that the number of restored surfaces is a significant factor in the lifespan of restorations [35]. In line with this, our study found an inverse relationship between the number of restored surfaces and restoration lifespan. Single-surface restorations (CI and CV) were found to have the longest survival. On the other hand, MOD restorations (3.50 ± 2.68) had a shorter survival. This could be attributed to the recent placement of MOD restorat ions, and the absence of MOD PCRRs among failed restorations supports this observation. Previous studies have reported that restorations involving two or more surfaces have a failure rate 2.5 times greater than single-surface restorations [29], and another study observed a 2.8 times higher failure rate [1]. Similarly, restorations with three or more surfaces were associated with a 3.3 times higher risk of failure compared to Class I restorations [38], and restorations with four or more surfaces had a fourfold higher risk of failure. This increase in failure risk can be attributed to the larger restoration size and increased technical sensitivity.

In our study, among 189 PCRRs, 132 (109 CII, 23 MOD) had multiple surfaces. An increase in the number of surfaces in such restorations implies a higher risk of failure, such as fracture and secondary caries [28,35,39]. Moreover, significant differences were evident in plaque index scores, revealing that CII and MOD restorations exhibited a plaque index score of 1, while CI and CV restorations scored 0. Elevated plaque index scores indicated an escalated risk of secondary caries, particularly prominent in C scores. Additionally, Ravasini et al. (2018) documented that patients with an O'Leary plaque index below 10% and CI restorations had a reduced failure rate [40].

Contrastingly, our study found that CV restorations displayed the highest failure rate at 23.53%. This observation questions the direct establishment of a relationship between the number of surfaces and failure. This perspective aligns with Kubo et al. (2011), who suggested that composite restorations in adults could endure for at least 60% over 10 years, irrespective of cavity type [41]. However, Köhler et al. (2000) and Lindberg et al. (2007) offered a divergent viewpoint, stating that the number of restored surfaces did not impact restoration longevity [42,43]. Consequently, the divergent outcomes on the long-term performance of multi-surface restorations mirror the inconsistencies in the existing literature.

Central to this discussion is the idea that the preservation rate of sound tooth structure might hold more significance in determining restoration longevity than the number of restored surfaces. Nevertheless, our study's limited number of CV restorations and the prevalence of C scores among CV PCRRs within a single patient has increased the failure rate. The prominence of C scores, particularly in CV cavity types, underscores their contribution to high failure rates. The observation that the CV restorations with the long-term exhibited a high failure rate also serves as evidence of the long-term impact of individual factors. Noteworthy studies by Demarco et al. (2012), van de Sande et al. (2013), and Pallesen and van Dijken (2015a) highlight decay risk and bruxism as pivotal factors influencing restoration success [1,29,44].

In our study, restorations with a plaque index score of zero had the longest mean survival (10.19 ± 5.29), indicating a significant relationship between plaque score and restoration durability. However, no significant correlation was found between gingival index scores and restoration longevity, as most restorations had a gingival index score of 1. Similarly, no association emerged between restoration types and gingival index scores. Thus, the plaque index appears to be a more effective factor for assessing restoration survival. Remarkably, patients with regular brushing habits but limited flossing exhibited favorable short-term outcomes. The relatively low flossing usage rate (18.5%) may arise from insufficient oral care knowledge or awareness. Most patients tended to use floss only in cases of food impaction, indicating that flossing has yet to become a habitual practice for many.

## 5. Conclusion

This study has some limitations. It is noted that the type of composite resin used in PCRRs has changed over the years, with various types (nanohybrid and nanofill) being utilized. In conclusion, this study assessed the relationship between patient-related factors and the survival and success of PCRRs. The findings highlight the significant impact of plaque index and the cavity type of the restoration on the longevity of PCRRs. Additionally, unsuccessful PCRRs were more frequently observed in older patients and those with higher DMFT scores. Patients with regular brushing habits but limited flossing show favorable short-term outcomes. In this context, the study emphasizes the significance of assessing patients' risk factors in the recommended contemporary, patient-centered caries management approach. These findings shed light on the development of contemporary strategies for caries management in today's dental practice.

During the preparation of this study, the author used chat.openai.com to improve the narrative. After using this tool/service, the author(s) have reviewed and edited the content as necessary and take full responsibility for the content of the publication.

## Ethics

Ethics Committee Approval: The research protocol was approved by the Faculty of.
Dentistry Ethics Committee, Selcuk University, Konya, Turkey (approval 2021/18).

## Data availability

Sharing research data helps other researchers evaluate your findings, build on your work and to increase trust in your article. We encourage all our authors to make as much of their data publicly available as reasonably possible. Please note that your response to the following questions regarding the public data availability and the reasons for potentially not making data available will be available alongside your article upon publication.

Has data associated with your study been deposited into a publicly available repository.

No.

## CRediT authorship contribution statement

**Sultan Gizem Ulku:** Writing – original draft, Supervision, Resources, Methodology, Formal analysis, Data curation. **Nimet Unlu:** Writing – review & editing, Supervision.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References


[1] F.F. Demarco, M.B. Corrêa, M.S. Cenci, R.R. Moraes, N.J. Opdam, Longevity of posterior composite restorations: not only a matter of materials, Dent. Mater. 28 (1) (2012) 87–101.
[2] M. Gladwin, M. Bagby, Clinical aspects of dental materials, in: Theory, Practice, and Cases, Lippincott Williams & Wilkins, Philadelphia, 2008.
[3] J.F. Cvar, G. Ryge, Reprint of criteria for the clinical evaluation of dental restorative materials, Clin. Oral Invest. 9 (4) (2005) 215–232, https://doi.org/10.1007/s00784-005-0018-z.
[4] D. Gemalmaz, M. Özcan, H.N. Alkumru, A clinical evaluation of ceramic inlays bonded with different luting agent, J. Adhesive Dent. 3 (2001) 273–283.
[5] K.H. Friedl, G. Schmalz, A. Hiller, A. Saller, In vivo evaluation of a felspathic ceramic system: 2 year results, J. Dent. 24 (1–2) (1996) 25–31.
[6] Pinto G. dosS, L.J. Oliveira, A.R. Romano, L.R. Schardosim, M.L. Bonow, M. Pacce, M.B. Correa, F.F. Demarco, D.D. Torriani, Longevity of posterior restorations in primary teeth: results from a paediatric dental clinic, J. Dent. 42 (10) (2014) 1248–1254.
[7] N.J.M. Opdam, E.M. Bronkhorst, J.M. Roeters, B.A. Loomans, A retrospective clinical study on longevity of posterior composite and amalgam restorations, Dent. Mater.: Official Publication of the Academy of Dental Materials 23 (1) (2007) 2–8.
[8] F. Trachtenberg, N.N. Maserejian, M. Tavares, J.A. Soncini, C. Hayes, Extent of tooth decay in the mouth and increased need for replacement of dental restorations: the New England Children's Amalgam Trial, Pediatr. Dent. 30 (5) (2008) 388–392, 2008.
[9] S. Ceylan, C.H. Açikel, K.M. Okçu, S. Kiliç, O.F. Tekbas, K. Ortakoğlu, Evaluation of the dental health of the young adult male population in Turkey, Mil. Med. 169 (11) (2004) 885–889.
[10] S. Karabekiroğlu, N. Ünlü, Evaluation of basic parameters of dental caries in young adults with high caries risk, EÜ Dişhek Fak Derg 35 (2) (2014) 26–31.
[11] M. Angulo, E. Zinemanas, L. Pivel, E. Jorysz, R.C. Krasse, Caries incidence, effect of pre- ventive measures and caries prediction in Uruguayan children, Acta Odontol. Scand. 53 (1995) 16.
[12] B. Yılmaz, Atatürk Üniversitesi Diş Hekimliği Fakültesine başvuran hastaların diş sağlığı düzeyi, Atatürk Üni Diş Hek Fak Derg. 3 (1993) 13–15.
[13] E. Borgia, R. Baron, J.L. Borgia, Quality and survival of direct light-activated composite resin restorations in posterior teeth: a 5- to 20-year retrospective longitudinal study, J. Prosthodont. : official journal of the American College of Prosthodontists 28 (1) (2019) e195–e203.
[14] S. Gökalp, G. Doğan, M. Uzamış Tekçicek, A. Berberoğlu, Ş. Ünlüer, Erişkin ve yaşlılarda ağız-diş sağlığı profili Türkiye-2004, Hacettepe Dişhekimliği Fakültesi Derg. (Clinical Dentistry and Research) 31 (4) (2007) 11–18.
[15] Z.Z. Akarslan, B. Sadık, E. Sadık, H. Erten, Dietary habits and oral health related behaviors in relation to DMFT indexes of a group of young adult patients attending a dental school, Med Oral Patol Cir Bucal 13 (12) (2008) 800–807.
[16] B. Kamberi, F. Koçani, A. Begzati, J. Kelmendi, D. Ilijazi, N. Berisha, et al., Prevalence of dental caries in Kosovar adult population, Int J Dent (2016) 4290291.
[17] S. Karaoglanoglu, N. Aydin, E.A. Oktay, Y.Z. Duymus, A. Sahin, T.F. Topcu, Dis fircalama ve sigara ïcme aliskanligının DMFT oranina etkisinin demografik verilere gore degerlendirilmesi, Turkiye Klinikleri J Dental Sci 24 (2) (2018) 84–92, https://doi.org/10.5336/dentalsci.2018-60569.
[18] M. Laske, N.J.M. Opdam, E.M. Bronkhorst, J.C.C. Braspenning, M.C. Huysmans, Ten-year survival of class II restorations placed by general practitioners, JDR Clinical and Translational Research 1 (3) (2016) 292–299.
[19] J. Manhart, H. Chen, G. Hamm, R. Hickel, Buonocore Memorial Lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition, Operat. Dent. 29 (5) (2004) 481–508.
[20] U. Pallesen, J.W. van Dijken, J. Halken, A.L. Hallonsten, R. Höigaard, Longevity of posterior resin composite restorations in permanent teeth in Public Dental Health Service: a prospective 8 years follow up, J. Dent. 41 (4) (2013) 297–306.
[21] Kiremitci Arlin, Tugba Alpaslan, Sevil Gurgan, Six-year clinical evaluation of packable composite restorations, Operat. Dent. 34 (1) (2009) 11–17.
[22] Helena Forss, Eeva Widström, Reasons for restorative therapy and the longevity of restorations in adults, Acta Odontol. Scand. 62 (2) (2004) 82–86.
[23] J.W. van Dijken, Ulla Pallesen, Four-year clinical evaluation of class II nano-hybrid resin composite restorations bonded with a one-step self-etch and a two-step etch-and-rinse adhesive, J. Dent. 39 (1) (2011) 16–25.
[24] J.W. van Dijken, U. Pallesen, Four-year clinical evaluation of Class II nano-hybrid resin composite restorations bonded with a one-step self-etch and a two-step etch-and-rinse adhesive, J. Dent. 39 (2011) 16–25.
[25] R. Frankenberger, C. Reinelt, N. Krämer, Nanohybrid vs. fine hybrid composite in extended class II cavities: 8-year results, Clin. Oral Invest. 18 (1) (2014) 125–137.
[26] F.F. Demarco, K. Collares, M.B. Correa, M.S. Cenci, R.R. Moraes, N.J. Opdam, Should my composite restorations last forever? Why are they failing? Braz. Oral Res. 31 (1) (2017) 56.
[27] N.J.M. Opdam, E.M. Bronkhorst, B.A. Loomans, M.C. Huysmans, 12-year survival of composite vs. amalgam restorations, J. Dent. Res. 89 (10) (2010) 1063–1067.
[28] P.A. Da Rosa Rodolpho, T.A. Donassollo, M.S. Cenci, et al., 22-Year clinical evaluation of the performance of two posterior composites with different filler characteristics, Dent. Mater. 27 (10) (2011) 955–963.
[29] F.H. van de Sande, N.J. Opdam, P.A. Rodolpho, M.B. Correa, F.F. Demarco, M.S. Cenci, Patient risk factors' influence on survival of posterior composites, J. Dent. Res. 92 (7 Suppl) (2013) 78S–83S.
[30] J.W. van Dijken, U. Pallesen, A randomized controlled three year evaluation of "bulk-filled" posterior resin restorations based on stress decreasing resin technology, Dent. Mater. : official publication of the Academy of Dental Materials 30 (9) (2014) e245–e251.
[31] U. Pallesen, J.W. van Dijken, A randomized controlled 30 years follow up of three conventional resin composites in Class II restorations, Dent. Mater. : official publication of the Academy of Dental Materials 31 (10) (2015) 1232–1244.
[32] E. Lempel, Á. Tóth, T. Fábián, K. Krajczár, J. Szalma, Retrospective evaluation of posterior direct composite restorations: 10-year findings, Dent. Mater. : official publication of the Academy of Dental Materials 31 (2) (2015) 115–122.
[33] V.V. Gordan, C.W. Garvan, P.K. Blaser, E. Mondragon, I.A. Mjör, A long-term evaluation of alternative treatments to replacement of resin-based composite restorations: results of a seven-year study, JADA (J. Am. Dent. Assoc.) 140 (12) (2009) 1476–1484.
[34] T. Laegreid, N.R. Gjerdet, A.K. Johansson, Extensive composite molar restorations: 3 years clinical evaluation, Acta Odontol. Scand. 70 (4) (2012) 344–352.
[35] N.J.M. Opdam, F.H. van de Sande, E. Bronkhorst, M.S. Cenci, P. Bottenberg, U. Pallesen, et al., Longevity of posterior composite restorations: a systematic review and meta-analysis, J. Dent. Res. 93 (10) (2014) 943–949.

[36] F.H. van de Sande, Hora est 5. Levensduur van composietrestauraties in posterieure gebitselementen [A PhD completed 5. Restoration survival in the composite resin age], Ned. Tijdschr. Tandheelkd. 123 (9) (2016) 429–431.
[37] J.T. Hamburger, N.J.M. Opdam, E.M. Bronkhorst, M.C. Huysmans, Indirect restorations for severe tooth wear: fracture risk and layer thickness, J. Dent. 42 (4) (2014) 413–418.
[38] M.S. McCracken, V.V. Gordan, M.S. Litaker, E. Funkhouser, J.L. Fellows, D.G. Shamp, V. Qvist, J.S. Meral, G.H. Gilbert, National dental practice-based research network collaborative group. A 24-month evaluation of amalgam and resin-based composite restorations: findings from the national dental practice-based research network, J. Am. Dent. Assoc. 144 (6) (2013) 583–593.
[39] J. da Costa, Summary of: the survival of Class V restorations in general dental practice: part 3, five-year survival, Br. Dent. J. 212 (9) (2012) 440–441.
[40] F. Ravasini, D. Bellussi, M. Pedrazzoni, T. Ravasini, P. Orlandini, M. Meleti, M. Bonanini, Treatment outcome of posterior composite indirect restorations: a retrospective 20-year analysis of 525 cases with a mean follow-up of 87 months, Int. J. Periodontics Restor. Dent. 38 (5) (2018) 655–663.
[41] S. Kubo, A. Kawasaki, Y. Hayashi, Factors associated with the longevity of resin composite restorations, Dent. Mater. J. 30 (3) (2011) 374–383.
[42] B. Köhler, C.G. Rasmusson, P. Odman, A five-year clinical evaluation of Class II composite resin restorations, J. Dent. 28 (2) (2000) 111–116.
[43] A. Lindberg, J.W. van Dijken, M. Lindberg, Nine-year evaluation of a polyacid-modified resin composite/resin composite open sandwich technique in Class II cavities, J. Dent. 35 (2) (2007) 124–129.
[44] U. Pallesen, J.W. van Dijken, A randomized controlled 27 years follow up of three resin composites in Class II restorations, J. Dent. 43 (12) (2015) 1547–1558.