STUDY ON THE PREVALENCE AND RISK FACTORS FOR CARIES ADJACENT TO POSTERIOR COMPOSITE RESIN RESTORATIONS

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STUDY ON THE PREVALENCE AND RISK FACTORS FOR CARIES ADJACENT TO COMPOSITE RESIN CORONAL RESTORATIONS (Abstract). **Aims** of the study were as follows: to determine the prevalence of caries adjacent to direct posterior composite resin restorations (CARS); to analyze the distribution of caries adjacent to coronal restorations in relation to socio-demographic, individual, and local parameters; to identify significant risk factors associated with caries adjacent to composite resin coronal restorations. **Materials and methods**: The retrospective study included 45 patients (mean age: 23.40 ± 4.027 years; gender: 31 males, 29 females) with 305 direct nanohybrid composite restorations aged 1-5 years. Univariate analysis was used to identify risk factors and odds ratios for the occurrence of CARS. Multivariate analysis was performed to identify combinations of risk factors that significantly increased the probability of CARS. The association between CARS and marginal integrity was assessed by the Spearman test. **Results:** According to FDI criteria, 8.9% of restorations had a score of 12.4 (micro-cavitated CARS extended to dentin), 3.9% had a score of 12.5 (cavitated CARS). Odds ratio for CARS were 2.135 for high caries risk, 2.179 for female gender, and 19.19 for impaired marginal integrity (scores 6.2-6.5) (OR 19.19). **Conclusions:** The prevalence of CARS in micro-cavitated and cavitated stage was 26.6%. Risk factors for CARS in direct posterior composite resins restorations were high cariogenic risk, female gender, and impaired marginal integrity. Risk predictors for caries adjacent to posterior composite resin coronal restorations, identified in multivariate analysis, were female gender and impaired marginal integrity. The risk of developing CARS increases progressively with the degree of marginal integrity impairment. **Keywords:** COMPOSITE RESTORATIONS, CARS, PREVALENCE, RISK FACTORS.

INTRODUCTION

Caries adjacent to restorations are considered the most common biological criteria leading to decisions for repair or replacement, significantly affecting the longevity of the involved teeth and increasing healthcare costs (1). Epidemiological studies report wide variations in the prevalence of caries adjacent to coronal restorations, depending on geographic regions and the demographics of the investigated population groups. A prevalence of 3.6% for caries adjacent to restorations (CARS) was reported in a study involving clinical and radiographic examination of 4,036 restorations in a cohort of 450 patients (2), while another research group found a prevalence of 12% for caries adjacent to coronal restorations made of nanohybrid or micro hybrid composite resins at 15 years post-treatment (3). A system-

atic review reported an average annual failure rate of 1.8% after five years and 2.4% at ten years post-treatment, with most failures attributed to CARS (4). In a population-based study conducted in the North-Eastern region of Romania, prevalence of CARS was between 13.5% (5) and 23.23% (6) of posterior composite-based restorations within 2-5 years post-treatment. Since the primary goal of clinical and therapeutic management of caries adjacent to coronal restorations is to control etiological factors and halt the progression of active lesions through non-operative or minimally invasive preventive methods, understanding the processes involved in the pathogenesis of these carious lesions is essential for selecting and developing the most effective approaches to avoid repeating the restorative cycle. Patient-related risk factors that can significantly contribute to the failure of composite resin coronal restorations include high cariogenic risk, smoking status, and periodontal involvement of teeth with Class II or Class V cavities (7). Material-related factors are critical and can lead to different scenarios of recurrent caries incidence (8). Regarding the influence of composite resin type on the likelihood of marginal defects, hybrid composites, nanofilled composites, and condensable composites exhibit the lowest polymerization shrinkage values (9). The elasticity modulus of composite resins materials can affect the marginal adaptation and stress distribution, resin composite with the highest modulus of elasticity resulting in the highest number of gap-free enamel margins but with an increased incidence of enamel fractures (10, 11). Regarding the clinician's role, their competencies are partially associated with the occurrence of caries adjacent to coronal restorations, influencing significantly the decisions of repair *vs.* replacement (12).

AIM OF STUDY

The objectives of the study were as follows:

- to determine the prevalence of caries adjacent to composite resin coronal restorations;
- to analyze the distribution of caries adjacent to coronal restorations in relation to socio-demographic, individual, and local parameters;
- to identify significant risk factors associated with caries adjacent to composite resin coronal restorations.

MATERIALS AND METHODS

The retrospective study included 45 patients (mean age: 23.40 ± 4.027 years; gender: 31 males, 29 females; p=0.091) who presented for various treatments at the Clinical Base of the Faculty of Dental Medicine, "Grigore T. Popa" U.M.Ph. Iași (Romania). A clinical examination was conducted to evaluate 305 direct nanohybride composite restorations aged between 1 and 5 years. The research was carried out in accordance with the ethical principles of the Declaration of Helsinki and received approval from the Ethics Committee of "Grigore T. Popa" U.M.Ph. Iasi. All patients were informed about the study objectives and provided written informed consent.

Inclusion criteria: occlusal and occluso-proximal posterior composite restorations; cavities classified as ICDAS 05-06; vital molars/premolars; age ≥ 18 years.

Exclusion criteria: non-carious lesions; bruxism; high consumption of cola beverages, coffee, or black tea.

The independent variables evaluated as risk factors for CARS were:

- Black's classification (Class I *vs.* Class II);
- gender (male *vs*. female);
- restoration age (1-2 yrs. *vs*. 3-5 yrs.);

- cariogenic risk (high *vs*. low);
- arch location (maxilla *vs*. mandible);
- dental group (molar *vs*. premolar).

CARS diagnosis and the assessment of CARS stage were performed according to FDI criteria (13). The patient's caries risk was determined by assessing anamnesis and intraoral risk factors, as well as caries disease indicators. The presence of at least two risk factors and one caries disease indicator classified the patient as high cariogenic risk.

Statistical analysis. The statistical analysis was conducted using *SPSS version 29.0*. The analyzed parameters were described using frequency distributions and descriptive statistics. Univariate analysis was performed to identify risk factors and odds ratios for the occurrence of CARS. Multivariate analysis was employed to identify combinations of risk factors that, when present in the same patient, significantly increased the probability of CARS. The identified risk factors were incorporated into a logistic regression model to determine their cumulative effect on risk of CARS. The association between CARS and marginal adaptation was characterized by calculating Spearman's nonlinear correlation coefficients.

RESULTS

Distribution of posterior composite resins direct restorations was as follows (table 1):

- By gender: 47.9% of restorations were evaluated in male patients, while 52.1% were evaluated in female patients.
- By restoration age: 47.5% of restorations were evaluated at 1-2 years post-treatment, while 52.5% were evaluated at 3-5 years post-treatment.
- By arch location: 46.6% of restorations were maxillary, while 53.4% were mandibular.
- By dental group location: 81% of restorations were located in molars, while 19% were in premolars.

TABLE I.

Distribution of direct posterior composite resins restorations related to analyzed parameters

Gender	male	146	47.9
	female	159	52.1
Age	1-2 yrs.	145	47.5
	3-5 yrs.	160	52.5
Arch	MX	142	46.6
	MD	163	53.4
Dental group	PM	58	19.0
	M	247	81.0
Cariogenic risk	low	217	71.1
	high	88	28.9
Black Class	Class I	246	80.7
	Class II	59	19.3
FDI score	12.1	198	64.9
	12.2	26	8.5
	12.3	42	13.8
	12.4	27	8.9
	12.5	12	3.9
Total		305	100.0

• By cavity type: 80.7% were occlusal restorations (Class I), while 19.3% were proximo-occlusal restorations (Class II).

• By patient caries risk: 71.1% of restorations were evaluated in low-caries-risk patients, while 29% were in high-caries-risk patients.

CARS indices distribution (tab. I):

• 64.9% of restorations were classified as score 12.1 (no caries adjacent to restorations)

• 8.5% were classified as score 12.2 (non-cavitated CARS).

• 13.8% were classified as score 12.3 (micro-cavitated CARS clinically limited to enamel, non-intervention or preventive intervention).

• 8.9% were classified as score 12.4 (micro-cavitated CARS clinically extended to dentine, repair needed).

• 3.9% were classified as score 12.5 (cavitated CARS extended to dentin, replacement required).

Study on correlation between CARS and marginal integrity

The Spearman test demonstrated a strong, positive, and statistically significant correlation (r=0.559) between the quality of marginal integrity of composite resin restorations and CARS diagnosis (tab. II). 100% of coronal restorations with score 12.5 were evaluated with marginal integrity score 6.5. 96.5% of coronal restorations that were not diagnosed with CARS (score 12.1) were evaluated with marginal integrity score 6.1 (tab. III).

TABLE II.

Spearman test: correlation between CARS and marginal integrity

	Spearman's rho	p-value	95% CI	Interpretation
Marginal integrity-CARS	0.559	<0.001**	0.474 ÷ 0.633	Positive, strong, statistical significance

TABLE III.

CARS scores distribution related to marginal integrity

		MARGINAL INTEGRITY SCORES										Pearson Chi-squared test
		6.1.		6.2.		6.3.		6.4.		6.5.		
		N	%	N	%	N	%	N	%	N	%	
CARS	12.1.	53	96.4	137	69.5	2	9.5	6	37.5			Chi^2 = 335.920 p <0.001**
	12.2.			20	10.2	6	28.6					
	12.3.	2	3.6	32	16.2	6	28.6	2	12.5			
	12.4.			8	4.1	7	33.3	8	50.0	4	25.0	
	12.5.									12	75.0	
Total		55	100.0	197	100.0	21	100.0	16	100.0	16	100.0	

Univariate and Multivariate Analysis Studies on Risk Factors for CARS

The results of univariate analysis for risk factors of CARS in table IV. Coronal restorations in female patients have a 2.179 times higher risk of CARS occurrence. High caries risk increases the CARS risk by 2.135 times. Restorations with marginal integrity scores of 6.2-6.5 have a 19.19 times higher risk of CARS compared to coronal restorations with unaffected marginal integrity (score 6.1). The results of the multivariate analysis of predictors for caries adjacent to composite resin coronal restorations are presented in table V.

TABLE IV.

Univariate analysis of risk factors for CARS

		CARS				Pearson Chi-squared	OR (95% CI)
		ABSENT		PRESENT			
		N	%	N	%		
Gender	male	108	54.5%	38	35.5%	$Chi^2 = 10.082$	2.179
	female	90	45.5%	69	64.5%	p = 0.001**	(1.342 ÷ 3.538)
Cariogenic risk	low	152	76.8%	65	60.7%	$Chi^2 = 8.684$	2.135
	high	46	23.2%	42	39.3%	p = 0.003**	(1.283 ÷ 3.553)
Black class	Class I	165	83.3%	81	75.7%	$Chi^2 = 2.593$	-
	Class II	33	16.7%	26	24.3%	p = 0.107	
Age	1-2 yrs.	91	46.0%	54	50.5%	$Chi^2 = 0.566$	-
	3-5 yrs.	107	54.0%	53	49.5%	p = 0.452	
Arch location	MX	92	46.5%	50	46.7%	$Chi^2 = 0.002$	-
	MD	106	53.5%	57	53.3%	p = 0.965	
Dental group location	PM	38	19.2%	20	18.7%	$Chi^2 = 0.011$	-
	M	160	80.8%	87	81.3%	p = 0.915	
Marginal integrity	6.1.	53	26.8%	2	1.9%	$Chi^2 = 88.913$	
	6.2.	137	69.2%	60	56.1%	p <0.001**	
	6.3.	2	1.0%	19	17.8%		
	6.4.	6	3.0%	10	9.3%		
	6.5.			16	15.0%		
Marginal integrity	Healthy	53	26.8%	2	1.9%	$Chi^2 = 29.134$	19.190
	Microleakage	145	73.2%	105	98.1%	p <0.001**	(4.574 ÷ 80.507)
Total		198	100.0%	107	100.0%		

Multivariate analysis of CARS risk factors

The Hosmer-Lemeshow goodness-of-fit test indicates that the constructed model is viable. Initially, the prediction accuracy for CARS is 64.9%, while using the model improves the prediction accuracy for CARS to 81.6%. The model explains 44.2% of the variation in CARS (Nagelkerke R coefficient). The predictors included in the model show the following progression:

TABLE V.

Predictors in binary logistic regression model

	Coef. B	p-value	OR	95% C.I. / OR
Age	-0.098	0.025*	0.907	0.832 ÷ 0.987
Gender (1)	0.961	0.004**	2.615	1.368 ÷ 4.996
Cariogenic risk (1)	-0.715	0.070	0.489	0.226 ÷ 1.061
Marginal adaptation		<0.001**		

	Coef. B	p-value	OR	95% C.I. / OR
Marginal adaptation (1)	2.512	<0.001**	12.329	2.853 ÷ 53.276
Marginal adaptation (2)	5.683	<0.001**	293.910	35.499 ÷ 2433.384
Marginal adaptation (3)	4.553	<0.001**	94.938	14.532 ÷ 620.237
Marginal adaptation (4)	25.450	0.998	1.1294E+11	
Constant	-1.474	0.216	0.229	

Equation for binary logistic regression model is as follows: Ln(p/1-p) = -1.474 - 0.098*Age + 0.961*Gender- 0.715* Cariogenic risk + 2.512* Marginal adaptation 6.2. + 5.683* Marginal adaptation 6.3. + 4.553* Marginal adaptation 6.4. + 25.450* Marginal adaptation 6.5.

Based on this equation, the probability of patients developing CARS in the combined presence of the identified risk factors can be calculated, considering the following observations:

- The risk of CARS is 2.615 times higher in women than in men.
- The risk of CARS is 12.329 times higher in patients with marginal adaptation score 6.2 compared to those with marginal adaptation score 6.1.
- The risk of CARS is 293.910 times higher in patients with marginal adaptation score 6.3 compared to those with marginal adaptation score 6.1.
- The risk of CARS is 94.938 times higher in patients with marginal adaptation score 6.4 compared to those with marginal adaptation score 6.1.

DISCUSSION

The identified risk factors in our research included high caries risk, female gender, and marginal adaptation impairment. High caries risk has been classified as a significant risk factor for the occurrence of caries adjacent to composite resin restorations (14). High-risk and non-compliant patients regarding etiological therapy have a significantly higher risk of developing caries adjacent to direct coronal restorations (15). A high caries risk increases the risk of restorative failure by 2-3 times (16). The higher prevalence of caries adjacent to restorations located in molars (*vs*. premolars), as found in our study, is supported by literature data (17). High-caries-risk patients had failure rates of 3.2% at five years and 4.6% at ten years post-treatment, while low-risk patients had significantly lower failure rates of 1.2% at five years and 1.6% at ten years post-treatment (18). Krämmer *et al*. (2015) also reported that direct Class I and II restorations in molars had inferior clinical performance compared to premolar restorations regarding marginal integrity at four years post-treatment (19). The significantly higher prevalence of Class II restorations, noted also in our study, can be explained by the fact that biofilm removal is more difficult at proximal and cervical margins, the enamel in these areas is thin and aprismatic (making acid etching ineffective), access is challenging, and these regions are predominantly subjected to flexural forces (20). A high C-factor can contribute to stress accumulation at the adhesive interface, favoring the occurrence of marginal microleakage (21). In Class II cavities, adapting composite resin to the dentinal margin is difficult, and the formation of microgaps along this margin can, in the medium and long term, lead to post-operative sensitivity and microleakage

associated with caries development adjacent to composite resin coronal restorations (22). We found that the risk of caries adjacent to composite resin restorations progressively increases with the degree of marginal impairment, from OR 12.329 for restorations with marginal adaptation scores of 6.2 to OR 94.938 for restorations with marginal integrity scores of 6.4, compared to coronal restorations with optimal marginal integrity (scores 6.1). The likelihood of caries developing adjacent to posterior composite resin coronal restorations correlates with both the size of marginal gaps at the interface between the cavity walls and the external surfaces of the restoration, as well as with the functional loading specific to occlusal and proximal-occlusal restorations (23). Microgaps may appear over time due to the hydrolytic degradation of the hybrid layer, followed by adhesive failure at the adhesive restorations (24). Polymerization contraction stress can also cause crack formation, marginal microleakage, margin discoloration, and postoperative hypersensitivity (25). Adhesive failure leads to nano-metric-sized microleakages that serve as pathways for bacterial penetration into the hybrid layer, facilitated by occlusal forces and deep-water penetration (26). A limitation of these studies is related to the performance of composite resins in real-world conditions, where dentists are time-constrained and treat populations different from those investigated in dental schools (27).

CONCLUSIONS

The prevalence of CARS in micro-cavitated and cavitated stage was 26.6%. Risk factors of CARS for direct posterior composite resins restorations were high cariogenic risk, female gender, and impaired marginal integrity. Risk predictors for CARS were female gender and impaired marginal integrity. The risk of developing CARS increases progressively with the degree of marginal integrity impairment.

CONFLICT OF INTEREST AND FUNDING

The authors declare that there is no conflict of interest, and they received no specific funding.

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