

# Clinical performance of resin composite restorations placed by dental students: a retrospective, cross-sectional, and observational study

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**Aim:** A retrospective, cross-sectional study was carried out to evaluate the performance of resin composite restorations placed by undergraduate dental students with 1 to 15 years of placement based on dental records. **Methods:** Four calibrated operators evaluated 498 restorations (anterior and posterior) of 120 patients according to Ryge's validated criteria (USPHS). **Results:** The criteria that showed the smallest changes between the types of failures were color matching, marginal discoloration and surface texture. Regarding the longevity, the surface texture showed an increase in the frequency of failures from the second time interval (3.1 to 6 years). Higher prevalence of failure was found in class II and III restorations, with secondary caries being the main reason. No significant differences were found for anatomic form, marginal adaptation, and color matching. Class V restorations showed a higher fracture rate with total displacement of the restoration, with no increase in the frequency of fracture over time. **Conclusion:** High rate of restoration failure was observed, possibly due to the lack of experience and skills of the students. This outcome highlight the need for continuous revision and improvements of teaching practice regarding the development of clinical competences and skills by dental students.

**Keywords:** Dental restoration permanent. Dental restoration failure. Composite resins.



## Introduction

Resin composite (RC) is the choice material for direct restoration of teeth with caries lesion, fracture, and/or unsatisfactory restoration due to its aesthetic and physical properties, adhesion to dental tissues, reinforcement of the remnant tissue, low-cost and conservative approach compared to indirect restorations<sup>1-3</sup>. Although good clinical survival with an annual failure rate ranging from 0.3 to 4.1%<sup>2,4-6</sup>, the number of RC restorations has increased<sup>7,8</sup> and dental clinicians (DC) have been replaced RC restorations more often<sup>6</sup>.

RC restorations can fail due to several reasons. The number of surfaces affected, tooth position in the arch, and cavity size are tooth-related conditions impacting the longevity of restorations<sup>1,4-6,9,10</sup>. Concomitantly, oral hygiene, deleterious habits<sup>4,6,11</sup>, and socioeconomic factors<sup>5,12</sup> of patients directly affect the clinical performance of RC restorations. Besides, DC can also interfere in survival rates of RC restorations since expertise and clinical skills are crucial to correctly develop the restorative technique<sup>6</sup>. In this way, RC restorations may be compromised when placed by dental students since their skills and knowledge are under progress through the course<sup>13,14</sup>.

Several studies clinically evaluating RC restorations performed by qualified and calibrated DC have been reported<sup>2,3-5,9,10</sup>. However, there is a lack of studies<sup>14-17</sup> reporting clinical outcomes of RC restorations placed by dental students. These studies will certainly be useful to assess the quality of restorative techniques and guide some improvements in dental teaching and qualification.

This retrospective, cross-sectional, and observational study aimed to clinically evaluate the performance of RC restorations placed by dental students from the College of Dentistry of the State University of Londrina (UEL) based on Ryge's criteria (modified USPHS)<sup>16</sup>.

## Material and Methods

### Experimental design and ethical aspects

In this retrospective, cross-sectional, and observational study, RC restorations (anterior and posterior) placed by dental students from the State University of Londrina were clinically evaluated. The restorations were classified according to Black's classification in I, II, III, IV, and V. This study received ethical approval by the Research Ethics Committee Involving Human Beings from the State University of Londrina (CEP/UEL 1.607.965/2016). All the volunteers were properly informed of the objective of this study. Those who agreed to participate, a Consent Form was signed. None invasive procedure was performed in the participants.

### Patients' recruitment

The patients were selected based on dental charts of the Screening Section of University Dental Clinic from the State University of Londrina. We evaluated only RC restorations performed by dental students from the third, fourth, and fifth grades of

the dentistry course. These restorations were placed during curricular dental practice activities under the supervision of qualified professors in patients older than 18 years. For inclusion in this study, RC restorations should be correctly recorded in the dental chart, which must contain: grade of the student, date of the procedure, cavity type, restorative material used, and finishing and polishing procedures. Only RC restorations with a minimum of 12 months and a maximum of 15 years were included. Restorations performed in private practice or any other dental care, by formed dental clinicians, and in patients with special needs were excluded.

## Data acquisition

Clinical evaluation for data acquisition was uninterruptedly performed for 24 months by four dental clinicians from the Residency Program in Restorative Dentistry. The operators were calibrated in two time points with an interval of 30 days between them. The Intraclass Correlation Coefficient (ICC) obtained was 0.87.

During the clinical evaluation, teeth were cleaned, dried with air spray, and a clinical probe (Nº 5, Golgran, São Caetano do Sul, Brazil) was used to evaluate the surfaces. Artificial spotlights directly illuminated the operatory field, and it was considered adequate by the operators.

RC restorations were classified according to Ryge's criteria (modified USPHS) in: Alpha (A) – satisfactory; Bravo (B) – regular, and Charlie (C) – unsatisfactory (Table 1)<sup>8</sup>. Regarding the time of placement, the restorations were allocated in five intervals: 1º interval = 1 to 3 years; 2º interval = 3.1 to 6 years; 3º interval = 6.1 to 9 years; 4º interval = 9.1 to 12 years, and 5º interval = 12.1 to 15 years.

**Table 1.** Ryge's criteria - Modified United States Public Health Service (USPHS).

Ryge Criteria	Alpha (A)	Bravo (B)	Charlie (C)
Color matching	Restoration matches with the color and translucence of the adjacent dental tissues.	Restoration does not match with the color and translucency of the adjacent dental tissues. However, the unmatched is clinically acceptable, i.e., less changed.	Restoration does not match the shade and translucency of the adjacent dental tissues. The unmatched is outside the normal range of tooth shade and translucency, i.e., very altered.
Marginal discoloration	No visual evidence of marginal discoloration different from the restorative material shade and the adjacent dental tissue shade.	There is visual evidence of marginal discoloration at the interface tooth/restoration. But the discoloration has not penetrated along the restoration in a pulpal direction. Staining at the cavosurface angle <1mm.	There is visual evidence of marginal discoloration at the tooth structure junction and the restoration that has penetrated along the restoration in a pulpal direction. Staining along the restoration interface.
Secondary caries	The restoration is a continuation of the existing anatomical shape adjacent to the restoration or is slightly flattened (absence of secondary caries).	There is visual evidence of discoloration remaining dark next to the restoration (presence of secondary caries).	

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Anatomic form	The restoration is a continuation of the existing anatomical shape or is slightly flattened. It can be bypassed and when the exploratory probe side is placed tangentially through the restoration, it must touch both sides, i.e. the tooth surface and the restoration at the same time.	The surface concavity is evident. When the exploratory probe side is placed tangentially on the entire restoration, it does not touch two opposite sides of the cavus angle at the same time, but the dentin or base is not exposed. Poor contact point, cervical excess.	There is a loss of restorative substance such that a concavity is evident and the base or dentin is exposed
Marginal adaptation	The probe does not grip when drawn over the restoration surface toward the tooth, there is no visible slit, or that threads the exploratory probe, along the restoration periphery.	There is visible evidence of a slit, which penetrates the exploratory probe, indicating that the restoration edge does not closely adapt to the tooth structure. The dentin and base are not exposed and the restoration is not movable.	The probe penetrates an extended gap to the dentin-enamel junction.
Surface texture	The surface texture similar to the polish enamel.	Surface with a sandy texture or similar to a white stone surface or similar to a macroparticulated resin composite.	Surface is thick enough to inhibit the continuous circulation of an exploratory probe over the entire surface. Probe does not slide.
Fracture	Restoration is intact and fully placed.	Restoration is partially placed with some portion of the restoration still intact.	Restoration completely absent.

## Statistical analysis

Data normality was verified by Shapiro-Wilk test. Frequency of failure in different classes of restorations and different time intervals were expressed in absolute numbers and relative frequencies. The frequency differences were determined by Chi-square test with Yates's correction or Fisher exact test at a significance level of 5%. GraphPad Prism statistical software was used.

## Results

498 RC direct restorations (anterior and posterior) were evaluated in 120 patients with mean age of 54 ( $\pm 13.6$ ) years-old, being 81 (67.5%) females and 39 (32.5%) males. Class IV restorations was the more prevalent type, representing 137 of the 498 restorations (27.5%) (Table 2).

**Table 2.** Frequency of failure according to the Ryge criteria in different types of cavities of RC restorations.

Criteria	Score	Class I (n=52)		Class II (n=109)		Class III (n=104)		Class IV (n= 137)		Class V (n=96)		TOTAL (n=498)	
		N (%)	N (%)	p*	N (%)	p*	N (%)	p*	N (%)	p*	N (%)	p*	N (%)
Color match	A	42 (80.7)	68 (68.0)		72 (73.5)		96 (79.3)		46 (67.6)		324 (73.8)		
	B	09 (17.3)	28 (28.0)	>0.05	22 (22.4)	>0.05	22 (18.2)	>0.05	20 (29.4)	>0.05	101 (23.0)		
	C	01 (01.9)	04 (4.0)		04 (04.1)		03 (02.5)		02 (02.9)		14 (03.2)		
Marginal discoloration	A	25 (48.1)	33 (33.0)		42 (42.9)		67 (55.3)		45 (65.2)		212 (48.2)		
	B	24 (46.1)	63 (63.0)	>0.05	48 (48.9)	>0.05	51 (42.1)	>0.05	20 (28.9)	>0.05	206 (46.8)		
	C	03 (5.7)	04 (4.0)		08 (08.2)		03 (02.5)		04 (05.8)		22 (05.0)		
Secondary caries	A	44 (84.6)	53 (53.0)		66 (66.7)	<0.02 <sup>*</sup>	100 (82.6)	>0.05 <sup>i</sup>	57 (82.6)	>0.05 <sup>i</sup>	320 (72.6)		
	B	08 (15.3)	47 (47.0)	<0.0001 <sup>*</sup>	33 (33.3)	>0.05 <sup>ii</sup>	21 (17.4)	<0.0001 <sup>iii</sup>	12 (17.4)	<0.0001 <sup>iii</sup>	121 (27.4)		
Anatomic form	A	27 (51.9)	35 (35.3)		55 (56.1)		60 (49.6)		32 (46.4)		209 (47.6)		
	B	24 (46.1)	55 (55.6)	>0.05 <sup>i</sup>	43 (43.9)	>0.05 <sup>i</sup>	58 (47.9)	<0.02 <sup>ii</sup>	32 (46.4)	>0.05 <sup>ii</sup>	212 (48.3)		
	C	01 (01.9)	09 (09.1)		-		03 (02.5)	>0.05 <sup>iii</sup>	05 (07.2)	>0.05 <sup>iii</sup>	18 (04.1)		
Marginal adaptation	A	28 (53.8)	32 (32.0)		51 (52.0)		73 (60.3)		40 (57.9)		224 (50.9)		
	B	22 (42.3)	58 (58.0)	<0.02 <sup>*</sup>	38 (38.8)	>0.05 <sup>i</sup>	40 (33.1)	<0.0001 <sup>iii</sup>	26 (37.7)	<0.003 <sup>iii</sup>	184 (41.8)		
	C	02 (03.8)	10 (10.0)		09 (09.2)	<0.01 <sup>ii</sup>	08 (6.6)	>0.05 <sup>iii</sup>	03 (04.3)	>0.05 <sup>iii</sup>	32 (07.3)		
Surface texture	A	23 (44.2)	29 (29.0)		34 (34.7)		45 (37.2)		27 (39.1)		158 (35.9)		
	B	24 (46.1)	53 (53.0)	>0.05	53 (54.1)	>0.05	59 (48.8)	>0.05	33 (47.8)	>0.05	222 (50.4)		
	C	05 (09.6)	18 (18.0)		11 (11.2)		17 (14.0)		09 (13.0)		60 (13.6)		
Fracture	A	43 (82.7)	87 (79.8)		92 (88.5)		98 (71.5)	<0.03 <sup>*</sup>	61 (64.2)	<0.0001 <sup>*</sup>	381 (76.6)		
	B	09 (17.3)	13 (11.9)	>0.05 <sup>i</sup>	06 (5.8)	>0.05 <sup>ii</sup>	23 (16.8)	>0.05 <sup>ii</sup>	07 (07.4)	<0.0007 <sup>iii</sup>	58 (11.7)		
	C	-	09 (08.0)		06 (05.8)		16 (11.7)	>0.05 <sup>iii</sup>	27 (28.4)	0.001 <sup>iv</sup>	58 (11.7)		
TOTAL	52 (10.5)	109 (21.9)		104 (20.8)		137 (27.5)		96 (19.3)		498 (100)			

Chi-square test. Differences were significant when P < 0.05 (\*): <sup>i</sup> class I; <sup>ii</sup> class II; <sup>iii</sup> class III; <sup>iv</sup> class IV; <sup>v</sup> class V.

Secondary caries was the main reason for failure in Class II (47%) and III (33.3%) restorations. The same RC restorations (Class II and III) exhibited marginal adaptation failure (10 and 9.2% respectively). Regarding anatomic form, Class II failed more frequently (9.1%), while Class III did not exhibit any failure. Color matching, marginal discoloration, and surface texture were the less affected criteria without differences between the cavity types ( $P > 0.05$ ) (Table 2). Class V restorations showed the highest fracture rate (28.4%) (Table 1), but without increase between the time intervals (Table 3).

**Table 3.** Frequency of failure of RC restorations according to the Ryge criteria in relation to the time of placement.

Criteria	Score	Time intervals									
		(1–3 years)		(3.1–6 years)		(6.1–9 years)		(9.1–12 years)		(12.1–15 years)	
		N (%)	p*	N (%)	p*	N (%)	p*	N (%)	p*	N (%)	p*
Color match	A	106 (67.0)		151 (76.2)		35 (87.5)		16 (64.0)		10 (83.3)	
	B	45 (28.4)	0.05	41 (20.7)	>0.05	03 (7.5)	>0.05	09 (36.0)	>0.05	02 (16.6)	>0.05
	C	07 (04.4)		06 (03.0)		02 (5.0)		-		-	
	Total	158 (100)		198 (100)		40 (100)		25 (100)		12 (100)	
Marginal discoloration	A	78 (49.3)		93 (46.90)		20 (50.00)		07 (28.0)		10 (83.3)	
	B	70 (44.3)	>0.05	96 (48.4)	>0.05	18 (45.0)	>0.05	18 (72.0)	>0.05	02 (16.6)	>0.05
	C	10 (06.3)		09 (04.5)		02 (05.0)		-		-	
	Total	158 (100)		198 (100)		40 (100)		25 (100)		12 (100)	
Secondary caries	A	122 (77.2)		131 (66.1)		30 (75.0)		20 (80.0)		12 (100)	>0.05 <sup>a</sup>
	B	36 (22.7)		67 (33.8)	<0.02 <sup>a*</sup>	10 (25.0)	>0.05 <sup>a</sup>	05 (20.0)	>0.05 <sup>b</sup>	-	<0.01 <sup>b*</sup>
	Total	158 (100)		198 (100)		40 (100)	>0.05 <sup>b</sup>	25 (100)	>0.05 <sup>c</sup>	12 (100)	>0.05 <sup>d</sup>
Anatomic form	A	80 (50.6)		92 (46.4)		18 (45.0)		09 (36.0)		09 (75.0)	
	B	69 (43.6)	>0.05	97 (48.9)	>0.05	20 (50.0)	>0.05	16 (64.0)	>0.05	03 (25.0)	>0.05
	C	09 (05.7)		09 (04.5)		02 (05.0)		-		-	
	Total	158 (100)		198 (100)		40 (100)		25 (100)		12 (100)	
Marginal adaptation	A	81 (51.2)		96 (48.4)		24 (60.0)		11 (44.0)		09 (75.0)	
	B	62 (39.2)	>0.05	89 (44.9)	>0.05	13 (32.5)	>0.05	12 (48.0)	>0.05	03 (25.0)	>0.05
	C	15 (09.4)		13 (06.5)		03 (07.5)		02 (08.0)		-	
	Total	158 (100)		198 (100)		40 (100)		25 (100)		12 (100)	

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	A	38 (24.0)	84 (42.4)	19 (47.5)	8 (32.0)	08 (66.6)	
Surface texture	B	96 (60.7)	90 (45.4)	17 (42.5)	13 (52.0)	03 (25.0)	<0.005 <sup>a*</sup> >0.05 <sup>b</sup>
	C	24 (15.1)	24 (12.1)	04 (10.0)	04 (16.0)	01 (08.3)	>0.05 <sup>b</sup> >0.05 <sup>c</sup> >0.05 <sup>d</sup>
	Total	158 (100)	198 (100)	40 (100)	25 (100)	12 (100)	
	A	141 (78.7)	167 (75.5)	33 (67.3)	21 (77.7)	12 (85.7)	
Fracture	B	16 (8.9)	31 (14.0)	07 (14.2)	04 (14.8)	-	>0.05 >0.05 >0.05
	C	22 (12.2)	23 (10.4)	09 (18.3)	02 (07.4)	02 (14.2)	
	Total	179 (100)	221 (100)	49 (100)	27 (100)	14 (100)	

Chi-square test. Differences were significant when  $P < 0.05$  (\*). <sup>a</sup> time interval of 1-3 years; <sup>b</sup> time interval of 3.1-6 years; <sup>c</sup> time interval of 6.1-9 years; <sup>d</sup> time interval of 9.1-12 years; <sup>e</sup> time interval of 12.1-15 years.

Color matching and marginal discoloration criteria did not show significant changes on frequency over time. However, the surface texture experienced more failures after the second time interval (3.1 to 6 years) (Table 3).

Higher occurrence of secondary caries was observed in the second time interval regardless of the cavity type ( $P < 0.02$ ). For surface texture, more failures were observed in the second, third- and fifth-time intervals ( $P < 0.01$ ). No differences between the interval times were verified for color matching, marginal discoloration, anatomic form, marginal adaptation, and fracture (Table 3).

## Discussion

To evaluate the clinical performance of RC restorations placed by dental students, retrospective studies can display the clinical reality more accurately than prospective cross-sectional studies conducted by calibrated operators with selected patients<sup>6,18</sup>.

Herein, the main outcome was that Class II was the most failed restoration, due to the number of restored surfaces<sup>1,4,10</sup>. Furthermore, secondary caries was the most prevalent reason for failure, as Opdam et al.<sup>5</sup> (2014) reported. However, Moura et al.<sup>15</sup> (2011) evaluated RC restorations placed by dental students for no longer than 3 years and have found that marginal adaptation was the main reason for failure due to negligence during adhesive procedures.

In clinical short-term evaluations with a limited number of RC restorations placed in patients with low risk of caries, it is quite difficult to observe differences in the type of restorative materials used<sup>6</sup>. However, our study showed a higher failure rate by secondary caries occurring after 3 years of placement.

Especially in Class II restorations, the lack of clinical skills by dental students can be highlighted in: the use of RC in extensive cavities with unfavorable cervical limit; the isolation of the operatory field; the application of adhesive systems to dentin; the use

of matrix band systems and wood wedges; and the correct insertion and light-curing of RC increments. Failures during these clinical steps may result in reduced marginal adaptation and gap formation on the cervical interproximal region<sup>14,19</sup>.

In this study, for anterior RC restorations, Class III and IV showed high rates of secondary caries, differently than Heintze et al.<sup>2</sup> (2015) has found. Secondary caries occurs by the invasion of cariogenic microorganisms within the tooth/restoration interface due to adhesive failure<sup>20</sup>. Taking into account that we evaluated RC restorations placed by dental students in different levels of knowledge and clinical skills, some factors may be attributed to the high prevalence of secondary caries, such as inadequate use of RC in extensive cavities with high occlusal loads and little or any enamel in the cervical cavo-superficial angle; negligence in adhesive system application, resulting in material's degradation; inefficient light-curing by inadequate irradiance and time of light exposure; and the inherent polymerization shrinkage and stress<sup>15,21</sup>.

Adhesive failure can compromise the marginal adaptation and lead to total or partial fracture of the restoration without the occurrence of secondary caries<sup>15</sup>. The prevalence of restoration displacement was higher in Class V cavities, followed by Class IV. These results corroborate with previous studies<sup>2,5</sup> and show similar failure rates compared to other RC restorations placed by dental students<sup>14,15</sup>.

Cervical lesions are normally non-carious and showed hypermineralized, less-permeable, and acid-resistant dentin<sup>22</sup>. These features associated with the cavity type, polymerization shrinkage, quality and amount of enamel in the cervical cavo-superficial angle, difficulty in achieving adequate isolation of the operatory field may be contributed to high rates of adhesive failure and displacement of Class V restorations<sup>22</sup>. However, the fracture of Class IV restorations can be mainly associated with failure or absence of occlusal adjustment since the incisal angle region suffers from tensions not observed in any other type of cavities<sup>15</sup>.

Color matching was the criteria that showed the less failure rate, followed by surface texture, which is in accordance with previous studies<sup>23,24</sup>. These results highlighted that in this clinical step of the restorative technique, the dental students perform the finishing and polishing procedures satisfactorily. Clinically, adequate finishing and polishing procedures may reduce biofilm accumulation on the resin surface, ensure the maintenance of marginal adaptation, the control of marginal discoloration, and may reduce the occurrence of secondary caries consequently<sup>23</sup>.

From the second interval time, there is an increase of failure due to surface texture. In this context, the oral environment provides critical and challenging conditions to resin-based materials, such as humidity and pH changes<sup>24</sup>. This scenario may result in degradation of the polymeric matrix<sup>25</sup>, which alters the surface texture of the RC and contributes to surface wear, plaque accumulation, and less survival rates of the restoration<sup>25</sup>.

We emphasize that dental students are constantly improving their competencies and skills over the dentistry course<sup>6,10,14</sup>. Thus, the relative lack of clinical skills and the subjectivity of diagnosis may be contributed to the results obtained. In this way, periodical evaluation of the teaching practice is crucial to discuss and establish novel

improvement strategies. Additionally, further clinical studies evaluating the performance of RC restorations placed by dental students are needed.

## Conclusion

Within the limitations of this study, a high rate of failure in RC restorations placed by dental students was verified. This outcome can be attributed to their lack of expertise and clinical skills. We encourage the constant revision and updating of the teaching process in order to enhance the development of clinical skills by dental students.

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## Conflict of interest

None.

## Data availability

Datasets related to this article will be available upon request to the corresponding author.

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