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Restoration in primary molars placed by undergraduate dental students: reasons for failures

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Abstract

Dental caries is one of the most common chronic childhood diseases and highly prevalent in the world. The commonest treatment procedure for dental caries is a dental restoration which aims to retain the tooth. The survival of restoration depends on the factors associated with restorative materials, patients or operators. Thus, this study aimed to determine the reasons for the failure of restoration in posterior primary teeth performed by undergraduate dental students. A total number of 32 patients aged from 5 to 12 years old were included in this study. Overall, 115 primary molar restorations were assessed clinically using the modified United States Public Health Service Ryge criteria. The O'Leary plaque score was used to evaluate the oral hygiene status of all patients. Then, the data was analysed using the Kaplan-Meier survival curves with log-rank test and Cox regression analysis. 43 (37.4 %) restorations failed with 62.1 % for glass ionomer cement and 36.4 % for composite restorations. Marginal adaptation (62.8 %) is the commonest cause of failure. 76.7% of failure restoration was in patients with poor oral hygiene, and it showed a significant difference compared to patients with moderate and good oral hygiene (p = 0.014). Thus, it was concluded that the type of restorative material and oral hygiene status contributed to the failure of restoration placed in primary molar restorations with failure restoration may occur 2.6 times more in poor oral hygiene patients.

Keywords: *primary molar restorations, longevity, oral hygiene, failure rate*

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Introduction

Dental caries is one of the most common chronic childhood diseases affecting 621 million children and a highly prevalent disease worldwide (Kassebaum *et al.,* 2015). Caries in children requires careful intervention whereby, if untreated, premature extraction of primary teeth may occur and lead to malocclusion in permanent dentition due to space changes since primary teeth act as a space maintainer (Tunison *et al.,* 2008, Lin *et al*., 2011).

In order to retain the tooth, dental restorations are the most expected dental intervention performed by dentists. A long survival rate of restoration depends on the factors associated with restorative materials, patients or operators (Demarco *et al.*, 2012). Several restorative materials could be used to restore carious primary molar teeth, including amalgam, stainless steel crowns, composites, glass ionomer cements, resin modified glass ionomer cements and polyacid-modified composite resins. These materials appeared to have acceptable properties; however, many failures have been reported mainly due to secondary caries, fractured restoration and marginal gaps (Damarco *et al.,* 2012; Franzon *et al*., 2015). Type of material influence on the longevity of primary tooth restoration and composite restorations have shown favourable success rates in posterior teeth (Pinto Gdos *et al.,* 2014; Chisini *et al.,* 2018). Conversely, a study by Casagrande *et al.* (2013) found that longevity of restoration was not influenced by the type of restorative material and the technique used for caries removal (Casagrande *et al.,* 2013).

Microleakage is a clinically undetectable passage between tooth surfaces and the restorative or filling material, which allow bacteria, fluids, molecules or ions to infiltrate, and if left untreated, will lead to secondary caries formation and marginal gap of restoration and cause failures of restoration (Kemoli & Van Amerongen, 2011). In primary teeth, composite resins can be used for restorations of class III, IV and V, and I and II cavities; however, they are time-consuming and more technique-sensitive procedures. Glass ionomer cements which can be placed in only one increment are occasionally a better option favouring clinical management, especially in less cooperative children because they are less technique sensitive. Patient cooperation is required to achieve optimum isolation during composite resin placement for a higher success rate, although cooperation in children can sometimes be challenging (Fayle *et al.*, 2003).

Caries risk assessment is essential prior to restorative treatment. High-risk caries patients tend to lower the success rate of the restorations two times as compared to low-risk caries patients (Opdam *et al.,* 2010). Furthermore, the failure rate increases as the DMFT value increases (Melgar *et al*., 2017). Oral hygiene and plaque occurrence also contributed to the failure of restoration in which patients with a higher amount of visible plaque experienced more failure of restorations (Kemoli & Van Amerongen, 2011; Casagrande *et al*., 2013; Melgar *et al*., 2017).

Operator skills and experience are factors that may influence the longevity of the restorations. Inexperienced dental students are often unable to do proper restorations as compared to the experienced ones; however, a study of clinical performance of posterior resin composite restorations performed by undergraduate dental students showed that the survival rate is still acceptable, but less experienced students placed restorations with a shorter lifetime compared with more experienced students. The reasons for failure were secondary caries, restoration fractures, endodontic treatments, defective margins and lack of proximal contact (Opdam *et al*., 2004). Therefore, the knowledge and experience of the operator determine the longevity in terms of the techniques used. More experienced operators showed a higher survival rate of restorations than the less experienced (Da Rosa Rodolpho *et al*. 2011; Al-Samhan *et al.,* 2010).

Data on the failure of primary tooth dental restorations placed by undergraduate

students in dental schools are still scarce. The failure in dental restorations may be because the students are less experienced or other factors involved such as oral hygiene or type of restorative material used. Thus, this study aims to determine the reasons for failure restorations placed by undergraduate dental students with a different type of restorative materials in primary molar teeth and an association with oral hygiene.

Materials and Methods

Ethical approval was obtained from IIUM Research Ethics Committee (IREC) (Project number IREC 273), and the parents/guardian provided written informed consent for their children participation before data collection.

This retrospective study was conducted at the Student Polyclinic, Kulliyyah of Dentistry, International Islamic University Malaysia. The targeted population consisted of healthy children aged between 5 to 12 years old with dental restorations placed at their posterior primary teeth by fourth-year undergraduate dental students. The procedures performed are closely supervised by Paediatric Dentistry specialist lecturers. All restorations were placed under cotton rolls isolation and saliva aspirator. All information was obtained from the patient's dental records and were used in this study after consented by parents or guardians.

Cavities were prepared with a slow-speed dental handpiece, and dentinal caries was excavated using an excavator aiming for total caries removal whenever necessary. The area close to the pulp was covered with calcium hydroxide cement in a very deep cavity. Composite restorations were placed using the acid etch and rinse adhesive system. Glass ionomer cement restorations were restored following the manufacturer's recommendations. Restorations were finished and polished before the patient was discharged. Patients were given oral hygiene instructions by the students prior to the commencement of any dental treatment. Only consented participants were called for a review visit at the polyclinic during the data collection period. Patients should have at least one review visit after the placement of restorations to be included in this study. The prefabricated stainless steel crown (SSC), self-cure glass ionomer cement (GIC), dental amalgam (AR) and light-cure resin-based composite (CR) restorations for posterior tooth were evaluated during the visit after 6 to 36 months of restoration placement using the modified United States Public Health Service (USPHS) Ryge criteria (Table 1) (Sartori *et al.*, 2013).

The restorations were evaluated according to a four-grade scale for marginal adaptation, anatomical form, and signs of secondary caries criteria. The scale of 1 and 2 are considered acceptable; likewise, 3 and 4 are considered as a failure for marginal adaptation and anatomical form criteria. As for secondary caries, scale 1 is considered acceptable, while scale 2 is considered as failure. The restoration is considered a failure if it failed one or more criteria. The date of restoration placement and review visits were recorded, and the time between the placement of restoration and review visit, either a failed or accepted restoration, was counted in weeks.

The O'Leary plaque index was used to assess the oral hygiene status (Rafatjou *et al*., 2016). Patients were asked to chew a disclosing tablet during the review visit. The dental plaque on tooth surfaces was stained, and the plaque occurrence was recorded. The index score is calculated by dividing the number of plaque-containing surfaces by the total number of available surfaces and then multiplied by 100 (percentage). The percentage of the disclosed plaque was then calculated for each patient. The percentage below 25 % is indicated as good oral hygiene, 25 to 35 % as moderate and above 35 % is poor. The association between oral hygiene status and the failure of the restorations were then compared and analysed.

Table 1. The modified United States of Public Health Services Ryge criteria

Ryge criteria	Scale			
	1	2	3	4
Marginal adaptation	Restoration adapts closely to the tooth along margins	The clinically insignificant gap between restoration and cavity margins	Poor marginal adaptation with an obvious gap with or without caries. Restoration needs replacement.	Loss of restoration
Anatomical form	Good anatomic form with optimal approximal	Clinically acceptable shape with acceptable approximal contact	Insufficient approximal contact resulting in food impaction	No approximal contact
Secondary caries	Not observed (acceptable)	Present clinically and/or radiographically (not acceptable)		

Clinical examinations and evaluations were performed by three trained and calibrated examiners. The examiners were calibrated before data collection, showed satisfactory intra-examiner and inter-examiner reliability ($\kappa > 0.8$).

Data Analysis

SPSS version 24.0 was used in this analysis. The survival rate analysis was used to analyse the data collected with the life table, Kaplan Meier and Cox regression.

The Kaplan Meier procedure is used to estimate time-to-event variables in the presence of censored cases. The assumption was made that paediatric patients who begin treatments at different times should behave similarly. To analyse the survival time for the restorative materials, the time variable used was in weeks; the status variable used was the results, which meant the failure status of the materials over time.

Cox regression procedure is used for modelling the time to a specified event, based upon the values of given covariates. The covariates used was the oral hygiene status. The central statistical output is the hazard ratio. The status variable used was the type of restorative materials, time-variable used was weeks, and covariates or the categorical variable used was oral hygiene status.

Results

In total, 115 posterior primary teeth restorations in 32 children were evaluated. CR was the restorative material most frequently used (47.8 %), whereas 25.2 % of restorations were performed using GIC, 13.9 % using SSC and 13.6 % using AR. There were 43 (37.4%) restorations that were considered as failure, and GIC showed the highest percentage of failure (62.1 %), followed by CR (36.4 %), AR (20 %) and SSC (12.5 %). The number of failures according to the type of restoration is shown in Table 2.

Table 3 summarises the cause of failures in different types of restorations. All types of restorations showed that poor marginal

adaptability (62.8 %) is the commonest cause, followed by the presence of secondary caries (23.3 %) and poor anatomical form (13.9 %). Nevertheless, poor marginal adaptability causes failures the most in composite restorations (70 %) compared to glass ionomer cement and amalgam.

Table 4, 5 and 6 summarise the data for the relationship between oral hygiene status and clinical performance of overall restorations. There were significant differences noted as the *p*-value is 0.014, which means that oral hygiene status affects the clinical performance of restorations, with the restoration failure increasing with poor oral hygiene, as illustrated in Table 7.

Figure 1 shows the survival plot for restorations in weeks. Poor oral hygiene showed the steepest decrement when compared to good and moderate oral hygiene.

Table 2. Failure restoration according to the type of restorative materials

Materials	Total number of restorations N (%)	Failure n	Percentage of failure (%)
SSC	16 (13.9)	2	12.5
GIC	29 (25.2)	18	62.1
CR	55 (47.8)	20	36.4
AR	15 (13.6)	3	20
OVERALL	115	43	37.4

Table 3. Causes of restoration failure

Materials	Failure	Percentage of failure causes		
		Margin n (%)	Anatomic n (%)	Caries n (%)
SSC	2	2 (100.0)	0	0
GIC	18	11 (61.1)	2 (11.1)	5 (27.8)
CR	20	14 (70.0)	2 (10.0)	4 (20.0)
AR	3	0	2 (66.7)	1 (33.3)
OVERALL	43	27 (62.8)	6 (13.9)	10 (23.3)

Table 4. Failure or success of restorations according to oral hygiene status

Failure/success	Percentage N (%)	Good OH n (%)	Moderate OH n (%)	Poor OH n (%)
Failure	43 (37.4)	10 (23.3)	13	20 (76.7)
Success	72 (62.6)	14 (19.4)	33	25

Table 5. Categorical Variable Codings [b]

		Frequency	(1)	(2)
OH[a]	1=Poor	45	1	0
	2=Moderate	46	0	1
	3=Good	24	0	0

a. Indicator Parameter Coding, b. Category variable: OH

Table 6. Omnibus Tests of Model Coefficients [a, b]

-2 Log Likelihood	Overall (score)			Change from Previous Step			Change from Previous Block		
	Chi-square	*df*	Sig.	Chi-square	*df*	Sig.	Chi-square	*df*	Sig.
231.459	8.499	2	.014	7.791	2	.020	7.791	2	.020

a. Beginning Block Number 0, initial Log Likelihood function: -2 Log likelihood: 239.251

Table 7. Variables in the Equation

	B	SE	Wald	*df*	Sig.	Exp(B)
OH (poor)			8.005	2	.018	
OH (moderate)	.895	.411	4.745	1	.029	2.448
OH (good)	-.053	.459	.014	1	.907	.948

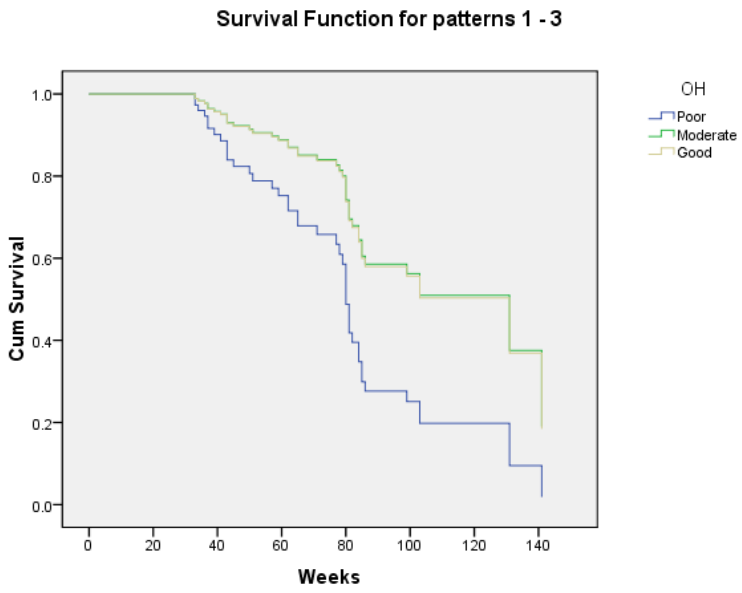

Figure 1. Survival Plot for Comparison of Oral Hygiene Status

Discussion

In this study, the failure percentage of restorations performed by undergraduate dental students was evaluated. The result showed that 37.4 % of restorations failed, and GIC showed the highest percentage of failure. The percentage of failure is considered high when compared to the reported global failure rate (12.5 %) without taking the follow-up times into consideration (Chisini *et al*., 2018). The high percentage of failure might be due to the student's lack of clinical experience. They only started treating patients in the clinical years, with all of them having only one to two years of clinical experience. Furthermore, they had a limited number of paediatric patients to perform dental restorations. Thus, dental schools must play an important role in providing adequate training to the student to develop their clinical skills throughout the course.

The longevity of restorations placed by more experienced operators is greater compared to less experienced operators (Opdam *et al.,* 2004; Ortiz-Ruiz *et al*., 2020). However, another study of undergraduate student's experience based on the years of clinical practice revealed that the operator's ability influenced the survival of restoration more than the operator's experience (McAndrew *et al*., 2011). Thus, proper training and full supervision are required to increase the student's capability in performing restorations as it will improve the reliability of the restorations (McAndrew *et al*., 2011).
The main reason for failures observed in this study for all types of restoration materials was poor marginal adaptability (62.8 %). Poor marginal adaptability causes the most failures in composite restorations (70 %) compared to other types of restorations. Good marginal adaptation is crucial for the success of restorations. If the restoration margins are not completely sealed, there will be accumulation of plaque and bacterial invasion between the restorative material and tooth surface, which will lead to secondary caries, and therefore the restoration needs to be replaced (Ferracane & Hilton, 2016). The cause of inadequate marginal adaption is closely related to polymerisation shrinkage of the material used, which is one of the disadvantages of direct composite restoration (Kaisarly & Gezawi, 2016; Han *et al*., 2017).

Isolation during the restoration procedure is necessary to reduce the amount of saliva at the treatment site and avoid contamination of microbes, which is an important factor for a successful restoration. Isolation with cotton rolls and aspiration by saliva ejector is a common practice in dental procedures to facilitate the bonding between restorative materials to the tooth surfaces for an optimum marginal adaptation. However, this technique requires frequent replacement of sodden cotton rolls. Rubber dam isolation had been introduced with numerous advantages and claimed to be optimum in preventing saliva contamination compared to cotton roll isolation; thus, the use may lower the failure rate of restorations (Heintze & Rousson, 2012; Keys & Carson, 2017). However, rubber dam placement in children can be a significant challenge because the patient needs to cooperate throughout the procedure.

Therefore, in cases where moisture control is required and in non-cooperative children, the isolation procedure can be jeopardised, and failure of restoration can be expected. In this study, all restoration procedures were performed under cotton roll isolation due to this reason. It could be one of the reasons for a higher percentage of failure and poor marginal adaptability. On the other hand, previous studies concluded that there was no solid evidence to suggest rubber dam usage will improve the survival rate of restorations compared to cotton roll isolation, and type of isolation had no influence on the success rate of restorations (Wang *et al*., 2016; Ortiz-Ruiz *et al.,* 2020).

The success of restoration is influenced by the patient risk factors, type of restorative materials, the severity of the tooth affected, and the experience and ability of the operator (van de Sande *et al*., 2013; Chisini *et al.*, 2018). Previous studies concluded that a higher risk of restoration failure is presented in patients with higher caries risk

(Opdam *et al.,* 2010; Damarco *et al.,* 2012; van de Sande *et al.,* 2013). In our study, patients with poor oral hygiene demonstrated the highest number of primary teeth restoration failures significantly, which can be concluded that oral hygiene is one factor contributing to the failure rate of primary molar restorations. This result corresponds with the previous report that poor oral hygiene status may have resulted in a lower survival rate of the restorations (Kemoli & Amerongen, 2011). It is crucial to lowering the caries risk status of patients by improving oral hygiene as caries risk play a significant role in restoration survival (Opdam *et al*., 2014).

In conclusion, our results show a high percentage of failure of restorations placed in primary molar teeth, with poor marginal adaptation as the commonest cause of the failure, and oral hygiene could also influence the failure percentage.

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