Exploration of Risk Factors for Failure of Dental Restorations at Kuwait University Dental Center

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Abstract

The aim of this study is to evaluate the risk factors for failures of direct class II restorations performed at Kuwait University Dental Center (KUDC).

This study retrospectively analyzed 103 dental records of patients who received Class II direct restorations of at least 2 surfaces at the Kuwait University comprehensive dental care clinic. Electronic data collection was done using Microsoft Forms software. Success or failure of a procedure was assessed by accessing the progress notes from digital dental files. Restorations were considered as failed restorations when a new restoration was placed in the same tooth number, including ≥1 surfaces of the previous restoration.

The data was analyzed using Statistical Package for Social Sciences (SPSS) software. To investigate the impact of factors on restoration survival, a multivariate Cox regression analysis was performed. Significant differences between selected groups were determined with Kaplan-Meier statistics and log-rank tests where P value < 0.05 is considered statistically significant.

Factors such as endodontically treated teeth and the type of restorative material used were found to be significant predictors for restoration failures. Factors such as caries risk and periodontal status including oral hygiene were found to be non-statistically significant. Emphasis on the knowledge in modern tendencies in restorative procedures is useful to guide dental schools to improve their teaching methodology. In addition, documentation of the reasons for the placement and replacement of direct restorations is important to prevent potential failures and facilitate future clinical studies.

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Introduction

Dental caries remains the most widespread noncommunicable disease[1]. It is also the most prevailing disease reported in the 2015 Global Burden of Disease Study[2], although its prevalence in industrialized countries has declined. Dental practitioners along with dental educators and dental students spend considerable amount of time restoring decayed dentition and replacing failed restorations[3]. Replacement of a restoration may lead to less desired results such as increase in cavity preparation size, tooth destruction and possible need for endodontic treatment or extractions. This cycle is very well known as the "death spiral"[4].

Multiple studies assessed the longevity of direct restorations and the reasons for failure in permanent teeth[4, 5, 6, 7]. Risk factors that could be attributed to the failure of direct restorations placed on posterior permanent teeth were assessed individually by multiple studies[7, 8]. These risk factors included the patients' age, gender, oral hygiene, and the presence of parafunctional habits. Other risk factors that studies have explored included the type of restorative material used, tooth type, and preparation size and type. Studies with controversial results were available in the literature with regards to the restorative material[4, 9, 10]. Direct restorations using amalgam or resin-based composite, have shown to be acceptable replacements materials for the lost tooth

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structure[9]. According to Kopperud and colleagues, the mean annual failure rate detected was 2.9% for resin-composite restorations and 1.6% for amalgams[4]. On the other hand, Opdam and colleagues stated that composite resin has shown a survival of 91.7% at 5 years and 82.2% at 10 years, whereas the survival of amalgam restorations was 89.6% at 5 years and 79.2% at 10 years[10]. Another controversial topic is the preparation size and tooth type. A study by Brunthaler reported that class II restorations done on molars with large cavity preparations had higher failure rates[11]. However, Nordbo found no significant differences with regards to location, class, and size of restorations after a 10-year follow-up period[12]. To this day, there is a lack of long-term studies on factors influencing class II direct restorations failure.

One of the most critical complications of restorative dentistry to this day is the failure of complete bonding of restorative materials to tooth structure leading to microleakage[13]. Marginal discoloration and recurrent caries have been reported to be a result of microleakage[13]. Mjor and colleagues concluded that almost 60% of all restorative work performed is related to replacement of previously restored teeth[14]. With respect to resin-composite restorations, secondary caries was the most common reason for replacement (73.9%), followed by loss of restoration (8.0%), fracture (5.3%), and last finding for restoration replacement was marginal defects (2.4%)[4]. Other reasons for failure included insufficient proximal contact, color-shade mismatch, marginal discoloration, loss of the anatomic form, and lack of marginal adaptation[15]. Reducing the failure rate of restorations is an important goal in dentistry, as exploring the reasons for restoration replacement can be utilized in avoiding the potential loss of tooth structure and saving the time and expenses on both dentist/patient ends[16].

Due to the high prevalence of dental caries globally, the State of Kuwait have shared the same findings of high dental caries rate among adults and adolescents[17, 18].

The Faculty of Dentistry was founded at the Kuwait University in 1996. The Faculty of Dentistry aims to provide high quality dental treatments to all admitted patients as a part of the faculty's vision to help in the community's dental health. The Dental Faculty curriculum is stretched over seven years where dental students start their foundation education at the faculty of medicine for four years; a bachelor degree of medical sciences awarded to students. Students officially enrolled in the dental curriculum on their fifth year of their education till the seventh year[19]. Students start seeing patients in the fifth year, where they start by making a comprehensive treatment plan, followed by preventive and periodontal treatment before initiating the restorative treatment. Decisions regarding the material used are usually a combination of an evidence-based decision and patient preference.

KUDC is the sole dental educational institution in Kuwait that provides dental care for the general public at no charges for basic treatment and discounted rates for advanced dental services. The patients come to the university clinic mainly for emergency dental care, general checkups, or esthetic concerns. Following admission, students start by making a comprehensive treatment plan, followed by preventive and periodontal treatment before attending to the patient's restorative and esthetic needs. Therefore, the patient has the opportunity to do all the necessary dental treatment for free, or at a minimum cost.

The Faculty of Dentistry generates numerous published articles that explored the dental status of the Kuwaiti population. After meticulous literature review, this is the first study that discuss the risk factors of failed restorations. The aim of this study is to evaluate the risk factors for failures of direct class II restorations performed at Kuwait University Dental Center (KUDC).

Materials and methods

This study was conducted in full accordance with the World Medical Association Declaration of Helsinki and was approved by the Ethics Committee of the Health Sciences Center at Kuwait University, (Ref.No.VDR: 280). All previously enrolled patients at KUDC have signed consent forms that stated the possibility of using patient's information for scientific projects with assurance of anonymity and privacy. Patients' dental records were retrieved using Titanium dental software (Titanium Software, Inc. USA).

This study retrospectively analyzed 103 dental records of patients who received Class II

direct restorations of at least 2 surfaces at the Kuwait University comprehensive dental care clinic. The restorative procedures were performed under either local anesthesia alone, mostly 2% lidocaine with 1:100 000 epinephrine, or combined with nitrous oxide inhalation sedation from the period of January 1st, 2014, to January 1st, 2021.

Student variable was sub grouped into senior and junior levels. Patients' variables included: age (categorized into three groups, <20, 20-40 and >40), gender, socioeconomic status (categorized into low, medium, high), general health status (based on the classification of the American Society of Anesthesiologists (ASA)[20]) (sub grouped into ASA I, II, and III), periodontal status (based on the Dutch Periodontal Screening Index[21]), oral hygiene (categorized into good, average, and poor), caries risk assessment (categorized into low, medium, and high), DMFT (sub grouped into <10, 11-20, >20), checkups per year, the existence of parafunctional habits, and use of removable dentures. Teeth variables included: tooth type, arch, number of restored surfaces (2 and 3 surfaces), endodontic treatment, used restorative materials (sub grouped into composite resins, amalgam, resin-modified glass ionomer (RMGI), and glass ionomer cement (GIC)), and diagnosis for replacing restorations (categorized into caries, fracture/wear, and defective margins). Other explored variables included number of restorative treatments per patient and number of failed restorations per patient.

Exclusion criteria were as follows:

- Patients with uncontrolled medical conditions
- Mentally challenged patients
- Patients with incomplete follow up records after the completion of the treatment
- Restorations placed on primary teeth
- Patients <10 years of age
- Restorations with insufficient data

Data extraction

Electronic data collection forms were developed by two senior dental students and validated by the research supervisor using Microsoft Forms software (Microsoft 365 ©, USA).

Procedure protocols

All restorations were placed by dental students under the supervision of a staff member under a strict aseptic sterile technique consistent with standard practice in the dental clinic. Standard protocol was used by all students. Topical oral anesthetic gel was applied (20% Benzocaine, Beutlich© Pharmacuticals, Bunnell, Fl, USA). Lidocaine Hydrochloride 2% with Epinephrine 1:100,000 (Novocol Pharmaceutical, Inc,Ontario, Canada) was mainly used as local anesthetic solution.

The protocol included the following steps in sequence

1. Local anesthesia and rubber dam isolation/Isolite mouthpiece (Henry Schein, Zyris, USA)
2. Cavity preparation following a conservative design
3. In case of deep cavities, placement of light-cured glass ionomer cement (VitrebondTM Liner/Base, 3M-ESPE, St Paul, MN, USA) as a liner under the restoration
4. Metal/clear plastic matrix band and wooden wedge application
5. Acid etching with 37% phosphoric acid (Ultra-Etch) for 15 seconds, rinsing and drying while leaving the dentin moist
6. Application of a dentin bonding agent (Single Bond Universal Adhesive, 3M-ESPE, St Paul, MN, USA) and light curing for 20 seconds
7. Incrementally restoring the cavity with resin composite (Filtek Z350 XT, 3M-ESPE) and light curing each increment for 40 seconds
8. Finishing and polishing of the restoration
9. Checking occlusion and proximal contacts

Outcome assessment

Success or failure of a procedure was assessed by accessing the progress notes from digital dental files. Dates of class II restoration placement and reintervention were recorded. Restorations were considered as failed restorations when a new restoration was placed in the same tooth number, including ≥1 surfaces of the previous restoration.

Statistical analysis

The Statistical Package for Social Sciences, version 22.0 software (SPSS Inc., Chicago, IL) was used for data analysis. The frequency distributions among different variables were obtained to investigate the impact of factors on restoration survival, a multivariate Cox regression

analysis was performed. Significant differences between selected groups were determined with Kaplan-Meier statistics and log-rank tests where P value < 0.05 is considered statistically significant.

Results

Between 2014 and 2021, 103 failed direct class II restorations in 81 patients were documented in Titanium digital dental software at KUDC. Of these restorations, 38% (*n* = 40) were excluded due to insufficient documentation. Consequently, total number of patients was 55 where 28 (44%) were males and 35 (56%) were females. The mean age of the patients was 33 years (SD=13.7). The final data set included 63 direct class II restorations, 68% (n=43) of which were placed by junior students and 32% (n=20) by seniors. The distribution of the failed restorations according to patient factors such as age, gender and socioeconomic status are presented in table 1. The same table also shows the distribution of the restorations according to tooth type and location, and the level of the student who performed the procedure. The data collected from the patients' files was regarded appropriate for multivariate regression analysis.

Table 2 describes the results of the multivariate logistic regression analysis. Failure of direct class II restorations was found to be higher in endodontically treated teeth. Non-endodontically treated teeth had significantly (p=0.005) better success rates as compared with endodontically treated teeth (OR: 0.073; 95% CI: 0.012-0.463). Similar results were noticed with the type of used restorative material. Composite restorations had significantly better (p=0.03) success rates as compared with amalgam or GIC (OR: 0.5; 95% CI: 0.2-0.9). On the other hand, there was no statistically significant difference in the failure rate among different tooth types, upper and lower teeth, and student level (P >0.05).

The survival curves of restorations according to endodontic treatment are shown in Figure 1. Kaplan-Meier survival graphs for restorations according to type of restorative material are presented in Figure 2. Figure 3 shows the failures according to the student level.

Discussion

Ordinarily, an evidence-based approach is becoming more anticipated of dentists. Well controlled long-term clinical studies of resin composite restorations are limited in number as the evidence-based approach is highly used[8]. Moreover, randomization of patient-, dentist-, and tooth-related factors is important for generalization of the outcome, which appears to be burdensome to accomplish. Hence, a retrospective study on clinical performance of resin composite restorations together with multivariate analysis may be advantageous to evaluate longevity retrospectively. The current study retrospectively evaluates the failure of direct class II restorations related to multiple potential risk factors in a university dental clinic setting. The results confirmed that endodontically treated teeth and the type of restorative material used can influence direct restoration survival rate.

The key finding of this study is that endodontically treated teeth and type of restorative material used had a statistically significant association with direct class II restoration failure. This finding is in line with that of a previous study by Laske and colleagues, where endodontic treatment is significantly associated with restoration failure rates[22]. A systematic review by van de Sande and others stated that no association is present between endodontically treated teeth and restoration failure[23]. With regards to the type of restorative material used, unlike the results of the current study, Mjör and colleagues found that even when statistically significant differences were found, they are probably not clinically relevant[24]. It was hypothesized that most factors evaluated in the present study would have an influence on restoration survival, however the results of this study exhibited otherwise. For instance, patient's age was not found to be associated with restoration failure in this study as well as in few other studies[8, 25, 26]. In contrast, multiple studies did find a significant association between age and restoration failure[27, 28, 29]. More controversial factors are the patient's caries risk and oral hygiene, both of which were not associated with restoration survival in the current study. With regards to caries risk, our finding is supported by a study by Laegreid *et al*[26]. On the contrary, an association was found in studies in the Scandinavian region, in the Netherlands[10], Sweden[30, 31] and Norway[4]. The above conflicting findings could be attributed to the fact that in studies on restoration survival, the use of cumulative scores as a single indicator may

overestimate the caries risk, therefore the association value was overestimated. For oral hygiene factor, its effect was not significant in this study, similar results were reported by Kopperud and colleagues[4] and Smales[32]. Only one study, however; concluded that oral hygiene was associated with restoration survival[33].

Our investigation of parafunctional habits indicated that there wasn't a significant association with failed restorations, and as stated by van de Sande, until now, no study has reported bruxism and other parafunctional habits as factors influencing restoration survival[23].

In the State of Kuwait, the Kuwaiti government provides access to dental care to all residents regardless of their socioeconomic status. This can be attributed to our finding where there was no significant relationship between socioeconomic status and restoration survival, as opposed to the findings of Correa and colleagues[34]. In a review by van de Sande, it was stated that no longitudinal evaluation studies investigated the effect of low socioeconomic status were found[23]. Another investigated variable is tooth type, which had no significant effect based on the current study findings, which agreed with Kubo and colleagues' outcomes[8]. Kubo *et al* also concur with the current study with respect to insignificant association of the number of restorations per patient, Pallesen and colleagues complied with this finding as well[6]. Alternatively, some studies found that individuals with more restorations experienced more failures[10, 25]. Furthermore, some studies have recognized an association between restoration failure and factors such as general health and periodontal status[35]. This may differ from our finding, where no association was found between restoration failure and these factors, due to the fact that KUDC follows strict periodontal and health management protocols before proceeding to the restorative phase of the treatment plan. For instance, patients who are not compliant with oral hygiene and controlled periodontal status would be placed in a holding phase until they get cleared to proceed to the next phase of the treatment plan.

An interesting aspect of evaluating failures at a university setting is that patients are treated by students with limited clinical experience under mentor's supervision. A study by Opdam and colleagues showed that junior dental students placed restorations with a shorter lifetime compared with senior students[36]. In this study, although the student level variable was not statistically significant, juniors showed to have higher failure rates than seniors. This implies that dental students go through a learning curve with consequential higher longevity for restorations placed by more experienced operators.

Limitations of the current study can be linked to the small sample size which could be attributed to several factors. One of which is that KUDC had switched to using electronic files fairly recently, thus, collecting data regarding restoration failures that took place prior to January 2014, which were paper-documented, was not feasible. Furthermore, there is an underreporting of failed restorations with patients who missed their recall visits, restoration failures cannot be documented. Additionally, KUDC doesn't accept patients during official holidays and school vacations; we hypothesize that patients may seek dental treatment elsewhere while KUDC is closed. This may justify the low number of failed Class II direct restorations. Last, another limitation in this study, numerous electronic patient files were incomplete leading to missing data set, therefore; files with incomplete data were excluded from the study. Conducting analyses on complete cases only would likely result in exclusion bias and loss of power.

For future studies, a more accurate clinical evaluation of restorations can be done using Ryge or United State Public Health Service (USPHS) or modified USPHS criteria[36]. Additionally, factors such as the type of isolation used and the use of liners/bases can be considered to further assess the determinants of restoration failure. In addition, prospective studies on cohort of patients are needed to further evaluate the factors contributing to failed restorations.

Conclusion

It was established by previous studies that the longevity of dental restorations is dependent upon many different factors, including patient-, dentist-, and tooth-related factors. The current study findings concluded that factors such as endodontically treated teeth and the type of restorative material used are particularly significant predictors for restoration failure. Emphasis on the knowledge in modern tendencies in restorative procedures is useful to

guide dental schools to improve their teaching methodology and clinical protocols. In addition, documentation of the reasons for the placement and replacement of direct restorations is important to prevent potential failures and facilitate future clinical studies.

	Number	Percentage
Student level		
Junior	43	68.3%
Senior	20	31.7%
Age		
<20	11	17.5%
20-40	35	55.6%
>40	17	27%
Gender		
Male	28	44.4%
Female	35	55.6%
Socioeconomic status		
Low	46	73%
Medium	7	11.1%
High	10	15.9%
ASA*		
ASA I	39	61.9%
ASA II	20	31.7%
ASA III	4	6.3%
Periodontal status		
BOP†/Calculus	30	47.6%
Pockets 4 mm, no recession	23	36.5%
Pockets 4-5 with recession or >6 mm	10	15.9%
Oral hygiene		
Good	1	1.6%
Average	17	27%
Poor	45	71.4%
Caries risk assessment		
Low	1	1.6%
Moderate	8	12.7%
High	54	85.7%
DMFT‡		
<10	15	23.8%
11-20	32	50.8%
>20	16	25.4%

	Number	Percentage
Checkups per year		
<2	61	96.8%
2	2	3.2%
Parafunctional habits		
Yes	0	
No	63	100%
Removable dentures		
Yes	4	6.3%
No	59	93.7%
Tooth type		
Premolar	39	61.9%
Molar	23	36.5%
Third molar	1	1.6%
Arch		
Maxilla	28	44.4%
Mandible	35	55.6%
Number of restored surfaces		
2	61	96.8%
3	2	3.2%
Endodontic treatment		
Yes	3	4.8%
No	60	95.2%
Used restorative material		
Composite	52	82.5%
Amalgam	8	12.7%
RMGI§	1	1.6%
GIC**	2	3.2%
Diagnosis for placing restoration		
Caries	57	90.5%
Fracture/wear	2	3.2%
Defective margin	4	6.3%
Number of restorative treatments per patient		
1-2	1	1.6%
3-4	2	3.2%
≥5	60	95.2%
Number of failures per patient		
1	47	74.6%
2	14	22.2%
3	2	3.2%

Table 1. Distribution of the direct class II restorations based on doctor, patient, and tooth-related factors.

*ASA: American Society of Anesthesiology. †BOP: Bleeding on probing. ‡DMFT: Decayed, missing, filled teeth. §RMGI: Resin-modified glass ionomer. **GIC: Glass ionomer cement.

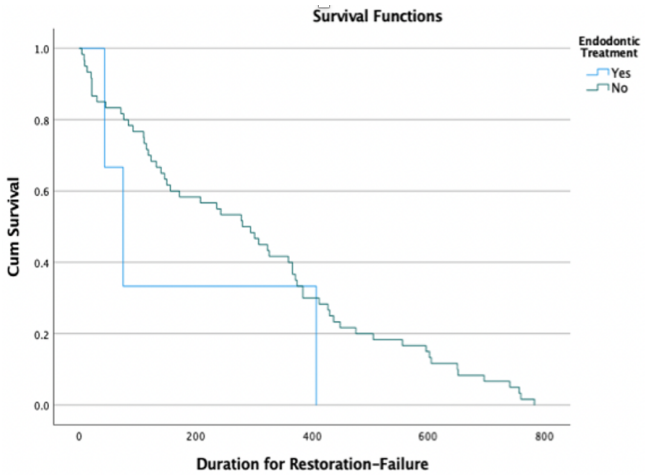

Figure 1. Kaplan-Meier survival graphs for direct restorations according to endodontic treatment. (P 0.27).

			95.0% CI for Exp(B)	
	Sig.	Exp(B)	Lower	Upper
Student Level	0.938	0.971	0.466	2.026
Gender	0.671	0.851	0.404	1.793
Age	0.785	1.004	0.975	1.034
Socioeconomic Status	0.667	1.117	0.676	1.844
General Health Score (ASA)	0.067	0.520	0.258	1.048
Periodontal Status	0.160	1.531	0.846	2.774
Oral Hygiene	0.390	0.667	0.266	1.676
Caries Risk	0.519	0.719	0.263	1.963
DMFT	0.073	0.647	0.402	1.041
Number of Checkups Per Year	0.862	0.859	0.155	4.762
Presence of a Removable Denture	0.706	1.283	0.352	4.674
Tooth Type	0.878	0.949	0.486	1.852
Arch	0.330	0.727	0.382	1.382
Number of Restored Surfaces	0.271	0.615	0.258	1.463
Endodontic Treatment	0.005	0.073	0.012	0.463
Used Restorative Material	0.033	0.500	0.264	0.946
Diagnosis for Placing Restorations	0.332	1.350	0.736	2.479
Number of Restorative Treatments per Patient	0.975	1.015	0.409	2.518

Table 2. Multivariate Cox-regression analyses on factors related to failure of direct class II restorations.

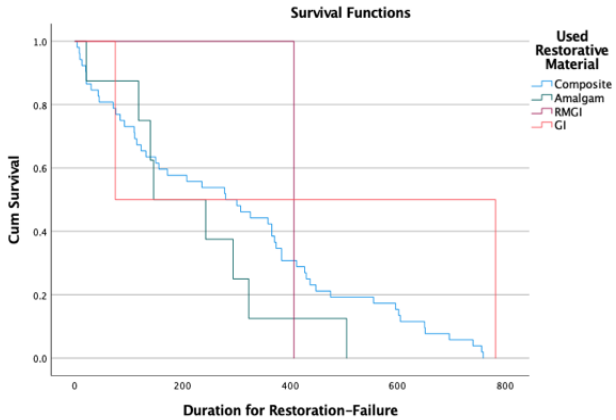

Figure 2. Kaplan-Meier survival graphs for direct restorations according to type of restorative material. (*P* 0.261).

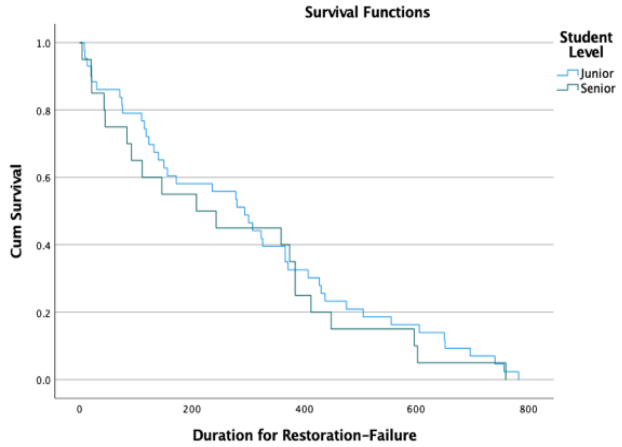

Figure 3. Kaplan-Meier survival graphs for direct restorations according to student level. (*P* 0.566).

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Declaration of Interest

The authors report no conflict of interest.

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