The Relationship of Caries Risk and Oral Hygiene Level with Placement and Replacement of Dental Restorations

Bushra Rashid Noaman[1, *], Lezan Dawood Fattah[2]

[1]Department of Paedodontics, Faculty of Dentistry, Tishk International University, Erbil, Iraq, [2]Department of Conservative, Faculty of Dentistry, Tishk International University, Erbil, Iraq

Correspondence: *Bushra.rashid@tiu.edu.iq*; Tel.: + 964 751 0207481

Abstract
Objectives. To assess the caries risk and oral hygiene level that affect the placement and replacement of restorations. **Materials and Methods.** A practice-based study performed in private clinics. A total of 76 dentists participated. The sample consisted of 10,076 restorations of >14-year old patients collected by volunteer dentists over a period of two months. Clinicians were asked to record the details of their patients and also the state of oral hygiene and caries risk of each patient. The data were analysed using Microsoft Excel and SPSS 20.00 software. It was considered that a P value less than 0.05 was significant. **Results.** 50.9% restorations replaced were due to secondary caries with moderate oral hygiene, with no significant differences. Of Class II type, 75% were replaced in moderate oral hygiene with a significant difference. There was a significant difference between the use of amalgam and composite according to the state of oral hygiene. 47.7% of the individuals who had their restorations replaced due to secondary caries had high caries risk. According to CI II cavity type, it was shown that 70.5% of the patients had moderate and 23% of the patients had high caries risk. **Conclusion.** Most restorations were replaced due to secondary caries. There is a synergetic relationship between oral hygiene level and caries risk in patients and the possibility of secondary caries development and restoration replacement.

Key Words: Amalgam ▪ Caries Risk ▪ Composite ▪ Dental Restoration ▪ Oral Hygiene.

Introduction

One of the most common and significant features of dental practice is caries treatment. Over all, caries is taken to be a progressive disease that finally damages the tooth unless a dentist intervenes, and the trend in intervention is minimal, either by prevention, fissure sealant or resin infiltration rather than surgical intervention. Understanding of caries has altered significantly, and this alteration needs to be seen in dental practice. The significance of caries risk assessment as a precondition for suitable preventive and treatment interventions needs to be understood, and e practical information provided on how general practitioners can include caries risk assessment in their management of caries (1).

In the meantime, many risk factors remain undefined. Insufficient salivary flow and structure, high amounts of cariogenic bacteria, insufficient fluoride exposure, gingival recession, and immunological components are the physical and biological risk factors for enamel or root caries which need special health care. Behavioral factors under a person's control are directly related to caries incidence in that person. These factors include: poor oral hygiene, improper dietary habits, frequent consumption of oral medications containing sugar, incorrect methods of feeding infants, and genetic factors (2). Other factors related to caries risk include poverty, deprivation or social status; education level; dental insurance availability; dental sealant application; the presence of orthodontic appliances; and poorly designed partial dentures (3).

*ORCID: http://orcid.org/0000-0003-3500-9729

According to many studies, it is said that the restoration replacement rate due to secondary caries is higher for composite restorations compared to amalgams and that it is related to the oral hygiene of the individual and increases when caries risk increases (4-6). The risk of restoration failure because of secondary caries increases when the patient has high caries risk. Amalgam replacement due to secondary caries is less frequent than composite, which has been explained in the literature by various factors: I. the metallic structure of amalgam: It has been reported that the antibacterial effect of metal ions released from dental materials may have an effect on secondary caries (7). II. the microbial ecosystem adjacent to the restoration: Svanberg et al. reported that the amount of *Steptococcus mutans* detected in composite restoration margins was significantly higher than in amalgam restorations (8). III. plaque accumulation: In a study by Friedl et al., plaque accumulation between composite restorations and the tooth surface was reported to be higher than between amalgam restorations and tooth structure interface (9).

The aim of this study is to assess the caries risk and oral hygiene level that affect the placement and replacement of restoration

Materials and Methods

This research was conducted after receiving permission from the authorities of Tishk International University (Decree No. 14 on September 4/2020).

Study Design

The study group was formed by dentists working in private dental clinics. The clinicians were general dentists and their experience ranged from one year to 10 years. They were selected by personal contact, which was the first appointment with them. Dentists who specialized in any form of dental specialty were not included in the study. The university from which the dentists graduated was not taken into account. Dentists working in private dental clinics in the city center of Erbil were included in the study in order to be able to represent the entire northern Iraqi region, as well as to maintain contact with the dentists from the beginning to the end of the study. A total of 100 dentists were contacted, but only 80 responded. The number then fell to 76 because two dentists had a lack of data and two withdrew because they did not have time. Information was provided about the aims, method and requirements of the study. After providing the information, volunteer dentists who were open to participate in the study were included.

Collection of Data

A second appointment was made with the dentists who had volunteered to participate in the study so that the details of the study could be explained. The researcher completed a presentation for the dentists who attended, for work in their private practice. The presentation included information, for example, on the criteria for patient selection, the number of restorations to be collected for each dentist, and how to use the data collection form. Each group included two or three dentists for the presentation. The participants asked questions and the researchers clearly answered all their questions. The researchers asked the participant dentists to collect the data within two months, but additional time was given for clinicians who could not achieve a sufficient number of restorations within the time given.

Standardization and Calibration

The clinicians were asked to choose the patients aged over 14 years so that they had complete permanent dentition. Clinical photographs and radiographs of some restorations that needed to be replaced for various reasons were discussed with each clinician. These photographs, used for calibration by clinicians, were taken from books and websites. The criteria of secondary caries detection used in this study included visual, tactile and radiograph methods. Visual detection involved the valuation of discoloration, staining or other

visual alterations. Tactile detection concentrated on evaluation of the presence of any ditching. Radiographic recognition was used either alone or in combination with visual assessment (10). We requested the clinicians to collect data on secondary caries from vital teeth, anterior and posterior, with neither cracked nor broken restorations, and did not specify the tooth location as posterior or anterior. Oral hygiene levels or caries risk status of patients used by general dental practitioners in practice-based studies (11, 12) were used instead of detailed indices. Parameters such as the current active and cavitated carious lesions, the number of restorations present in the mouth, and the frequency of tooth brushing were used when determining caries risk. Patients were classified as low, moderate and high risk according to the parameters indicated above. Plaque accumulation in the mouths of patients was taken into account when oral hygiene level was determined.

Sample

The sample consisted of 14 and >14 year-old patients who had complete permanent dentition. Patients were grouped as: 15-19, 20-29, 30-39, 40-49, 50-59, and >60 years of age. Clinicians were asked to record the following data: the patient's gender, age, the number of restored teeth, cavity type, and material used, restoration placement, and the reasons for replacement of each restoration. Clinicians were asked to collect data such as the number of teeth to be restored, the type of cavity (according to Black's classification), the type of material used and replaced, the age of the restoration being replaced (based on the patients'

statements), in addition to oral hygiene and caries risk assessment of the patients. Furthermore, the clinicians' gender and professional experience was also recorded. Forms were designed for each visit, not for each patient. More than one form was completed for patients for whom numerous restorations were placed.

Statistical Analysis

The data were collected in Microsoft Excel, and SPSS 20.00 software for Windows was used to evaluate the findings. The Pearson Chi-Square test was used. It was considered that a P value less than 0.05 was significant.

Results

Sample Distribution

The data were collected from a total of 4,771 patients. Of those patients, 53% (2,528) were male and 47% (2,243) were female. The difference between male and female patients was non-significant (Table 1).

Cavity Type

Operative procedures were predominantly performed in class II cavities (Pearson Chi-Square test P=0.000 for both males and females) in male and female patients (40.2% in males and 40.9% in females). Class I cavities were the second most common type of cavities where operative procedures were performed, after class II in both males and females (Table 2).

Table 1. The Number of Patients According to Age Group

Age groups (years)								
Gender	15-19	20-29	30-39	40-49	50-59	>60	Total	P-value*
Male	239	974	751	375	120	69	2528	0.643
Female	263	742	715	354	121	48	2243	
Total	502	1716	1466	729	241	117	4771	-

*At P<0.05. Pearson Chi-Square test.

Table 2. The Distribution of Classes of Restorations According to Patient Gender

Gender	Restoration class					Total N (%)
	Class I N (%)	Class II N (%)	Class III N (%)	Class IV N (%)	Class V N (%)	
Male	1726 (33)	2101 (40.2)	558 (10.7)	341 (6.5)	498 (9.5)	5224 (100)
Female	1547 (32.2)	1964 (40.9)	517 (10.8)	338 (7)	439 (9.1)	4805 (100)
Total	3273 (32.6)	4065 (40.5)	1075 (10.7)	679 (6.8)	937 (9.3)	10029 (100)

Oral Hygiene

Only 8.2% of all restorations investigated in this study were placed in patients with good oral hygiene (Table 3). Of the individuals who had restorations replaced, 6% had good, 67.2% had moderate, and 26.8% had bad oral hygiene, with significant a difference (P=0.001).

It was determined that more than half (50.9%) the individuals who had restorations replaced due to secondary caries had moderate oral hygiene and about 46% had poor oral hygiene levels (P=0.001). Three-quarters (75%) of Class II type cavity restorations were placed in individuals with moderate oral hygiene levels, with a significant difference (P=0.001) (Table 4).

The effect of oral hygiene level on the choice of restorative material: Amalgam was the preferred material in more than half of the patients with poor oral hygiene, and composite restorations were preferred in patients with good oral hygiene (79%). There were very highly significant differences in the choice of restorative materials between all oral hygiene levels (P=0.000) (Table 5).

Table 3. Number and Percentage Distribution of Placed and Replaced Restorations According to Oral Hygiene Level

Oral hygiene state	Placed restorations	Replaced restorations	P-value*
	N (%)	N (%)	
Good	823 (8.2)	80 (6.0)	
Moderate	7329 (73.1)	899 (67.2)	0.001
Bad	1877 (18.7)	359 (26.8)	
Total	10029 (100.0)	1338 (100.0)	

*At P<0.05; Pearson Chi-Square test.

Table 4. Oral Hygiene Levels in Patients with Replaced Restorations in Class II Cavities

Oral hygiene state	Restorations replaced due to secondary caries	P-value	Restoration replaced in class II cavities	P -value*
	N (%)		N (%)	
Good	11 (2.5)		214 (5.3)	
Moderate	223 (50.9)	0.001	3050 (75.0)	0.001
Bad	204 (46.6)		801 (19.7)	
Total	438 (100.0)		4065 (100.0)	

*At P<0.05; Pearson Chi-Square test.

Table 5. Choice of Restorative Material and Oral Hygiene Level

Material	Oral hygiene level			Total	P-value*
	Good N (%)	Moderate N (%)	Bad N (%)		
Amalgam	54 (5.3)	515 (50.7)	446 (43.9)	1015	0.000
Composite	561 (7.9)	56037 (79)	933 (13.1)	7097	0.000
GIC	20 (28.6)	41 (58.6)	9 (12.9)	70	0.000
Other	108 (21.2)	271 (53.2)	130 (25.5)	509	0.000
Total	743 (100)	6430 (100)	1518 (100)	8691	-

*At P<0.05; Pearson Chi-Square test.

Table 6. Number and Percentage Distribution of Caries Risk in the Studied İndividuals

Caries risk	With restoratio	P-value	With replaced restoration	P-value*
	N (%)		N (%)	
High	2300 (22.9)		434 (32.4)	
Moderate	6883 (68.6)	0.121	826 (61.7)	0.521
Low	846 (8.4)		78 (5.8)	
Total	10029 (100.0)		1338 (100.0)	

*At P<0.05; Pearson Chi-Square test.

Table 7. The Distribution of Class II Cavities According to Caries Risk

Caries risk	Class II restorations were placed		P-value*	With replaced restorations due to secondary caries		P-value*
High	948	23.3		209	47.7	
Moderate	2866	70.5	0.071	214	48.9	0.062
Low	251	6.2		15	3.4	
Total	4065	100.0		438	100.0	

*At P<0.05; Pearson Chi-Square test.

Caries Risk

Table 6 shows the number and percentage distribution of caries risk of the studied individuals. In this study, 68.7% of all restorations were performed in patients with moderate caries risk, and 22.9% in patients with high caries risk. There were no significant difference between the three levels of caries risk in initial restorations (P=0.121). Of the restoration replacements, 60% were performed in patients with moderate caries risk, and 32% in those at high risk for caries, with no significance difference (P=0.521).

The distribution of Class II cavities according to caries risk is shown in Table 7. Of the patients, 70.5% had moderate and 23% of the patients had high caries risk, with no significant difference (P=0.07). Only 47.7% of the individuals who had their restorations replaced due to secondary caries had high caries risk, and 48.9% of them had moderate caries risk (P=0.062).

Discussion

A research design defined in international medical literature as practice-based was used in this study. This type of research depends on data analysis as the clinicians are in daily routine dental work (13). The data reported by clinicians are essential in the estimation and evaluation of new materials and techniques in the biomedical field, including medicine and dentistry. Long-term controlled clinical trials are ideally used to test materials and techniques in dentistry with a small number of patients and clinicians. In addition, long-term controlled clinical trials need to choose a group of patients and expert clinicians to carry out the survey without time limits and under controlled conditions, which is very difficult to apply in day-to-day practice. Thus, controlled clinical trials are more accurate than practice-based studies. (14). The disadvantages of practice-based research have been pointed out as follows (13, 14): differences in clinicians' treatment decisions and assessment of quality, the criteria are not standardized for making treatment decisions in restoration replacement, and there is a possibility of misunderstanding the instructions in the research procedure.

Both clinical experience and scientific research have the possibility of reinforcing the evidence-based groundwork of dental practices (15). Henceforth, creating links between practicing clinicians and academics can initiate some developments in increasing the effectiveness of dental services in daily practice (16).

The effects of oral hygiene and caries risk on individuals' restorative treatments have been addressed in only two studies. In these studies, published by Burke et al. (11) and Tyas (12), the dentists' evaluations were taken into consideration instead of detailed indices to determine patients' oral hygiene levels and caries risk. A similar methodology was used in this study. It is therefore advisable to approach the data obtained in this part of the study cautiously. However, the primary goal of practice-based research is the scientific dissemination of the routine practice of clinicians. Perhaps the most important reason for the willingness of dentists to take part in such studies is that they were not required to spend any extra time doing the work, apart from the time spent to record the data. Therefore, it is not possible to obtain detailed indices of the degree of caries risk or oral hygiene levels from clinicians in such studies. In a study conducted by Burke et al. (2001) (11) with 32 dentists, it was found that 37% of the patients had good oral hygiene, 44% of them had moderate oral hygiene, and 19% had bad oral hygiene. Regarding caries risk, 26% had high and 40% had low caries risk. In this study the results were similar. In this study, restoration placement was present in 8% of those with good oral hygiene, and there was an increase in the possibility of needing restoration with moderate oral hygiene (73%) and in bad oral hygiene (19%), where this low percentage with bad oral hygiene may be related to neglecting regular dental visits. Tyas (12) found these rates as 13.9% and 7.4% for amalgam and composite, respectively. In the current study, composite restorations were found in only 7.9% of the individuals with good oral hygiene. On the other hand, motivating the patient to practice good oral hygiene is also of great importance. Another important point that should be noted in routine patient visits is the control of secondary caries.

Studies conducted to date have shown that secondary caries plays an important role in restoration replacement. As previously stated, secondary caries does not differ histopathologically from primary caries, and similar factors play a role in both types of caries. Studies in the literature have shown

that there is a relationship between oral hygiene level and the development of caries (17, 18). In this study, restorations were replaced in only 5.8% of the individuals with low caries risk, and in about half of those with poor oral hygiene. The causes of replacing restorations may be attributed to three major categories (19): clinician factors, material properties, and patient factors. Studies have found a positive correlation between good oral hygiene and restoration lifespan. Especially after inadequate polishing, the environment required for growth of *Steptococcus mutans* in composite materials is improved. This, combined with poor oral hygiene, may increase the formation of secondary caries, creating synergistic effects (20). Occasionally a mixture of factors may be the cause of the failure, even though clinicians seldom register more than one cause for replacement of restorations. The majority of failures happen gradually, but rapid failures can also happen, e.g., restoration fracture. The presence of defects may not be to an extent that it necessities instant restoration replacement (19). Since defects occur gradually there is a chance for repair by minimally invasive dentistry rather than entire restoration removal and replacement. By minimally invasive dentistry the dentist can repair the restoration and refurbish a defect (10).

It is known that oral hygiene practices affect the development of interproximal caries. Particularly in individuals who did not use dental floss, class II type cavities were encountered more frequently (21). In our study, 23.3% of class II type cavities were found in individuals with high caries risk and 19% of them in those with bad oral hygiene. However, in the current study, amalgam and composite restorations were replaced due to secondary caries at similar rates. This may have been affected by the differences in the educational backgrounds of the clinicians, as well as the diagnostic instruments used by the clinicians when deciding to replace the restorations.

Limitations of the Study

Limitations of the study include: differences in the clinicians' treatment decisions and assessment of

quality, in their restoration replacement, criteria that are not standardized for making treatment decisions, and the possibility exists of clinicians misunderstanding the instructions in the research procedure. The involvement of dentists who may have not undertaken any training or continuing education courses in diagnosing restoration failures may be regarded as a limitation of this study. The study did not specify anterior and posterior teeth but included all teeth generally.

Conclusion

There is synergetic relationship between oral hygiene and caries risk in patients with the possibility of development of secondary caries, and restoration replacement, especially in CI II cavity types. This information is important for communicating the experience of clinicians to scientists. Henceforth, establishment of links between experienced clinicians and academics can improve dental services in everyday practice.

What Is Already Known on this Topic:
Physical and biological risk factors for enamel or root caries consist of insufficient salivary flow and structure, high numbers of cariogenic bacteria, insufficient fluoride exposure, gingival recession, immunological components, and the need for special health care. Other factors related to caries risk include poverty, deprivation, or social status; the number of years in education; dental insurance coverage; use of dental sealants; use of orthodontic appliances; and poorly designed or ill-fitting partial dentures. Behavioral factors under a person's control are directly related to caries incidence in that person. These factors include poor oral hygiene; poor dietary habits, frequent use of oral medications that contain sugar; inappropriate methods of feeding infants, and genetic factors.

What this Study Adds:
This study proved that there is a relationship between oral hygiene and caries risk in individuals and the need for restoration, and secondary caries and restoration replacement.

Authors' Contributions: Conception and design: LDF; Acquisition, analysis and interpretation of data: LDF and BRN; Drafting the article: BRN; Revising it critically for important intellectual content: BRN and LDF; Approved final version of the manuscript: BRN and LDF.

Conflict of Interest: The authors declare that they have no conflict of interest.

References

1. Fontana M, Zero DT. Assessing patients' caries risk. J Am Dent Assoc. 2006;137(9):1231-9.

2. Kidd EAM, Fejerskov O. Dental caries: The disease and its clinical management. Oxford: Blackwell Munksgaard; 2003. p. 245-250.

3. Curzon ME, Preston AJ. Risk groups: nursing bottle caries/caries in the elderly. Caries research. 2004;38(Suppl 1):24-33.

4. Bernardo M, Luis H, Martin MD, Leroux BG, Rue T, Leitão J, et al. Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial. J Am Dent Assoc. 2007;138(6):775-83.

5. Nedeljkovic I, De Munck J, Vanloy A, Declerck D, Lambrechts P, Peumans M, et al. Secondary caries: prevalence, characteristics, and approach. Clinical oral investigations. 2020;24(2):683-91.

6. Askar H, Krois J, Göstemeyer G, Bottenberg P, Zero D, Banerjee A, et al. Secondary caries: what is it, and how it can be controlled, detected, and managed? Clin Oral Investig. 2020;24(5):1869-76.

7. Menon T, Kumar CP, Dinesh K. Correspondence-Antibacterial activity of glass-ionomer restorative cements and polyacid modified composite resin against Cariogenic bacteria. Indian J Med Microbiol. 2006;24(2):150-1.

8. Svanberg M, Mjör IA, Ørstavik D. Mutans streptococci in plaque from margins of amalgam, composite, and glass-ionomer restorations. J Den Res. 1990;69(3):861-4.

9. Friedl KH, Hiller KA, Schmalz G. Placement and replacement of composite restorations in Germany. Oper Dent. 1995;20(1):34-8.

10. Gordan VV, Riley JL 3rd, Carvalho RM, Snyder J, Sanderson JL, Anderson M, et al. Methods used by Dental Practice-based Research Network (DPBRN) dentists to diagnose dental caries. Oper Dent. 2011;36(1):2-11.

11. Burke FJ, McHugh S, Hall AC, Randall RC, Widstrom E, Forss H. Amalgam and composite use in UK general dental practice in 2001. Br Dent J. 2003;194(11):613-8; discussion 609.

12. Tyas MJ. Placement and replacement of restorations by selected practitioners. Aust Dent J. 2005;50(2):81-9.

13. Mjör IA. Practice-based dental research. J Oral Rehabil. 2007;34(12):913-20.

14. Mjör IA, Gordan VV, Abu-Hanna A, Gilbert GH. Research in general dental practice. Acta Odontol Scand. 2005;63(1):1-9.

15. Mungia R, Oates TW. Bridging community dental practitioners to research: the South Texas Oral Health Network (STOHN). Tex Dent J. 2011;128(10):1031-8.

16. Curro FA, Grill AC, Thompson VP, Craig RG, Vena D, Keenan AV, et al. Advantages of the dental practice-based research network initiative and its role in dental education. J Dent Educ. 2011;75(8):1053-60.

17. Andlaw RJ. Oral hygiene and dental caries--a review. Int Dent J. 1978;28(1):1-6.

18. Prasai Dixit L, Shakya A, Shrestha M, Shrestha A. Dental caries prevalence, oral health knowledge and practice among indigenous Chepang school children of Nepal. BMC Oral Health. 2013;13:20.

19. Hickel R, Manhart J. Longevity of restorations in posterior teeth and reasons for failure. J Adhes Dent. 2001;3(1):45-64.

20. Mo SS, Bao W, Lai GY, Wang J, Li MY. The microfloral analysis of secondary caries biofilm around Class I and Class II composite and amalgam fillings. BMC Infect Dis. 2010;10:241.

21. Ogaard B, Seppa L, Rolla G. Relationship between oral hygiene and approximal caries in 15-year-old Norwegians. Caries Res. 1994;28(4):297-300.