

Anterior composite restorations: survival rate and main reason for failure.

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Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

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Ao meu Pai Jalel,

Por tudo o que lhe devo,

Que esta tese seja um testemunho da minha profunda gratidão.

À minha mãe Nadia,

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À Lolo e Lolo,

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para as suas amigas

RESUMO

Introdução: Desde a sua introdução, as resinas compostas tornaram-se na primeira escolha para restaurações diretas anteriores. A procura crescente de conhecimento relativamente aos potenciais fatores preponderantes para o fracasso a longo prazo deste tipo de abordagem terapêutica, poderá facilitar as decisões dos Médicos dentistas, e consequentemente reduzir os custos e aumentar a longevidade das restaurações.

Objetivos: O objetivo deste estudo é avaliar a taxa de sobrevivência das restaurações diretas anteriores, à base de resinas compostas (RBC), e as principais razões para o seu insucesso.

Materiais e Métodos: Pesquisa na base de dados *PubMed* e seleção dos artigos científicos em inglês, com limitação temporal dos últimos 10 anos, recorrendo às seguintes palavras-chave: "*Direct Restoration*", "*Composite Resin*", "*Failure OR Survival Evaluation*", "*Clinical Evaluation OR Clinical Performance*". Dos 930 artigos encontrados, foram selecionados 10 estudos para fazer parte deste estudo.

Discussão: As restaurações compostas diretas anteriores mostraram uma taxa de sobrevivência global variável de 38% a 96,3% AFR, variando de 1,1% a 5%. Para as restaurações *Build-up*, a taxa de sobrevivência variou de 82,4% a 96,3%, e a taxa de AFR variou de 1,1% a 9,2%. Para restaurações de classe III e IV de 64% com 2,9% de AFR. Para as facetas em compósito, de 38,0% a 80,1%, e a AFR variou de 6,0% a 9,2%. As fraturas foram a principal razão de fracasso, variando entre 62,0% e 73,3%.

Conclusão: Para RBC, a presente revisão indica geralmente um bom desempenho clínico a longo prazo, com taxas anuais de insucesso de 1,1% a 5%. A causa mais relatada de falha foi a fratura. Alguns fatores, como o tempo necessário para a restauração e a vitalidade clínica do dente, foram apontados como possíveis falhas em restaurações compostas anteriores.

ABSTRACT

Introduction: Since their introduction, composite resins have become the first choice for direct anterior restorations. The increasing demand for knowledge regarding the potential factors preponderant for the long-term failure of this type of therapeutic approach may facilitate dentists' decisions, and consequently reduce costs and increase the longevity of restorations.

Objectives: The aim of this study is to evaluate the survival rate of anterior direct resin based composite (RBC), and the main reasons for their failure.

Materials and Methods: Search in the PubMed database and selection of scientific articles in English, with a time limitation of the last 10 years, using the following keywords: *"Direct Restoration", "Composite Resin", "Failure OR Survival Evaluation", "Clinical Evaluation OR Clinical Performance"*. From the 930 articles found, 10 studies were selected to be part of this study.

Discussion: Anterior direct composite restorations showed an overall survival rate varying from 38% to 96.3% AFR, ranging from 1.1% to 5%. For Build-up restorations, the survival rate ranged from 82.4% to 96.3%, and the AFR ranged from 1.1% to 9.2%. For class III and IV restorations of 64% with 2.9% AFR. For composite veneers from 38.0% to 80.1%, and AFR ranged from 6.0% to 9.2%. Fractures were the main reason for failure, ranging from 62.0% to 73.3%.

Conclusion: For RBC, the present review generally indicates good long-term clinical performance, with annual failure rates of 1.1% to 5%. The most reported cause of failure was fracture. Some factors, such as the time required for restoration and the clinical vitality of the tooth, were pointed out as possible failures in anterior composite restorations.

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List of acronyms and abbreviations

AFRs - Annual failure rates

RBC - Resin based composite

1 INTRODUCTION

Since their introduction, Composite resins have become the first choice for direct anterior restorations. Their great popularity is related to their aesthetic appearance and reduced need for healthy tissue removal. ⁽¹⁾

Their ability to be bonded to tooth tissues, to matching the natural tooth color, and the lower cost compared to indirect materials are some of the additional reasons for their increasing usage among professionals. ⁽²⁾

Direct composite veneers technique may also be an interesting option to recover the esthetic appearance of damaged teeth, especially because indirect techniques require more tissue removal of sound structure and have a higher cost, due to the laboratory procedures. ⁽³⁾

Nowadays, minimally invasive direct resin composite restorations are substantially increasing as state- of-the-art technique in restorative dentistry for the restoration of anterior. Especially for the restorative treatment of adolescents and young adults with intact enamel surfaces, this option offers minimally invasive or even noninvasive treatment approaches. ⁽⁴⁾

Adhesive systems, restorative techniques and composite resins technology were in continuous evolution in the last decades, which contributed to a significant improvement of restorative and esthetic dentistry. ^(5,6)

In anterior teeth, the increasing quest for aesthetics, suggests that composite based restorative needs, and reasons for restoration failure, other than caries, might occur in a larger extent. Placement or replacement of restorations is one of the most common dental procedures still observed. In clinical dentistry large demand for restorative procedures is accounting for a significant part of the dentists' working time. ⁽⁷⁾

At the end of the last century, replaced dental restorations were estimated at £173 millions of annual cost of England's national health care. ⁽¹⁾

Over the years, literature has evaluated the clinical survival and performance of posterior and anterior composite restorations, showing that these restoratives might have low annual failure rates (AFRs) and long survival rates in posterior teeth. ^(8,9)

However, demand for knowledge still exists regarding the potential influencing factors for failure in the long-term. In posterior teeth, the main reported reasons for failure are secondary caries and fracture, with a survival rate between 70–98% after 8 and 22 years. While caries do not represent a major cause for failure of anterior restorations. ⁽¹⁰⁾

Long-term performance of posterior composite restorations could be affected by patients' factors, and operator characteristics ⁽²⁾; the same could be true for anterior restorations.

Even if, determining the patient's effect and their related variables is not easy in clinical studies. Age, socioeconomic status, and missing teeth, are simple variables that can be easily collected, caries risk or parafunctional habits, those are complex processes involving several signs and symptoms, which increases the challenge of choosing the best collection method and criteria to apply. ⁽¹⁾

Identifying risk factors and main reason for common failure, might facilitate dentist's decisions, and consequently reduce costs and increase restorative longevity.

Another factor of interest is to determine if other characteristics of composites such as filler size could influence the clinical performance of anterior restorations.

2 OBJECTIVE

2.1 MAIN OBJECTIVE

The objective of this systematic review was to gather information on the long-term survival and main reason for failure of resin composite-based restorations, placed in anterior teeth.

Clinical studies investigating the survival of anterior composite restorations with follow-up periods of at least two years were searched to find out the overall survival rate and the main reasons for restoration failure.

2.2 SPECIFIC OBJECTIVES

Investigate the variables related to patient, operator, or materials that would impact the clinical longevity or performance of the direct anterior restorations.

3 MATERIAL AND METHOD

This work is characterized as an integrative systematic review study, based on a literature search in the *PubMed* database.

The aim was to collect as much information as possible on the subject, using the following strategy, in isolation and combined using the Boolean operators AND and OR, so that the largest possible number of articles is obtained.

Manual Search: performed with the aim of further investigation, indexed journals were manually consulted to identify studies that could meet the search criteria.

The search criteria were the terminology in the medical index "Dental journals" with the following strategy:

#1 Search: (direct) AND (anterior restoration) AND (failure OR last OR survival evaluation).

#2 Search: (clinical evaluation OR clinical performance) AND (direct anterior restoration).

#3 Search: (clinical performance) AND (direct restoration) AND (composite resin).

This resulted in 930 articles that, after applying the inclusion and exclusion criteria, remained 10 relevant studies, the oldest article is from 2013 and the most recent article is from 2018.

3.1 Inclusion Criteria:

The inclusion criteria involved studies in English, in the last ten years, between 2011 and 2021, that evaluate the clinical survival and reason for failure of direct Composite based restorations in anterior permanent teeth. Including Class III and IV cavities, direct veneers, and full-coverage build-ups. With at least 2 years follow-up time.

3.2 Exclusion Criteria:

Exclusion criteria are those that did not meet the defined inclusion criteria, that is, studies that were not written in English, published with more than ten years, that did not report follow up time, did not concern direct composite restorations or treating posterior dentition.

3.3 Article Selection:

In total, 23 studies were selected for full-text reading, 10 were finally selected to be part of the study. The included studies evaluated the direct Build-up clinical performance (8 studies), which were placed in worn teeth, due to caries or fracture or aesthetic reasons. Composite veneers and class III or IV restorations, placed for aesthetic reasons (2 studies).

In addition, 8 articles from *PubMed* database, have been included for the introduction interest.

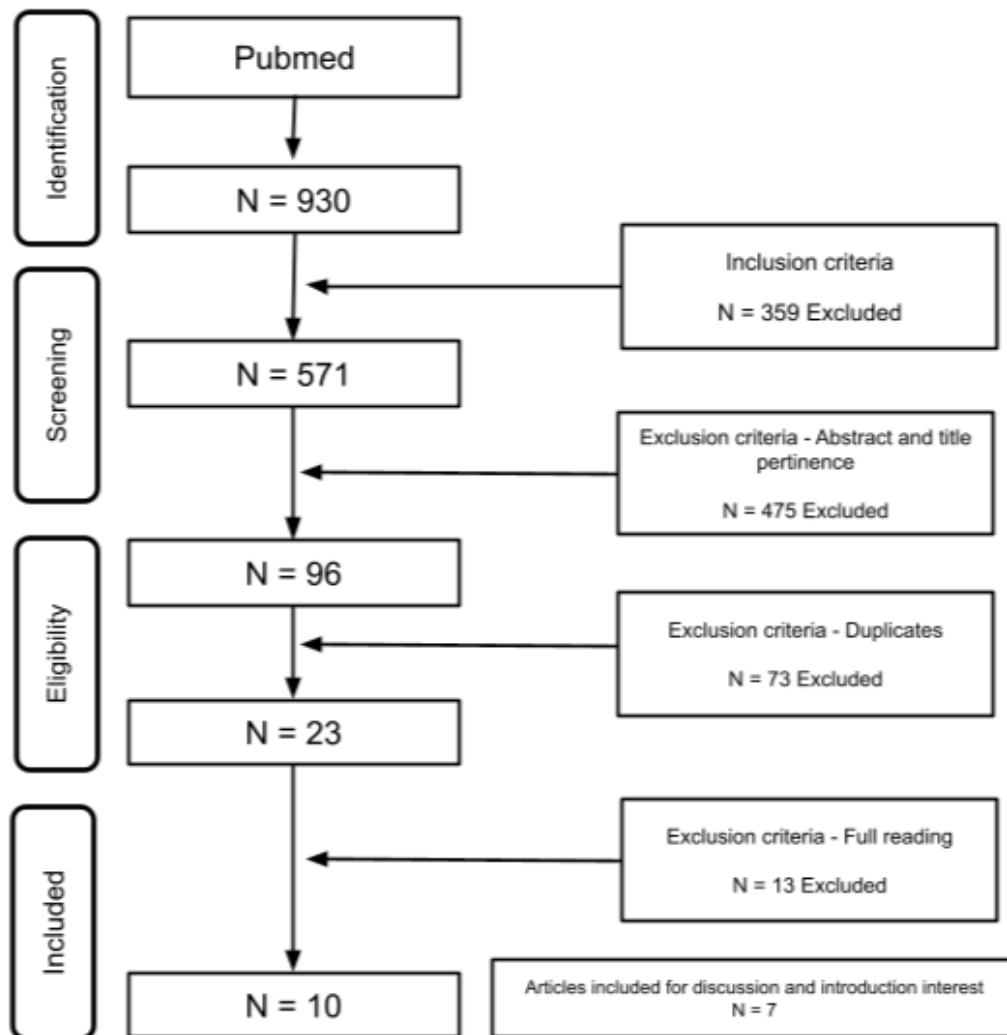


Figure 1: PRISMA scheme for bibliographic research.

4 RESULTS

Table 1 shows all studies included in the systematic review and the data collected. Included studies were published between 2013 and 2018, and the follow-up times varied from 2 to 15 years.

Most studies were carried out in university dental hospitals or dental school clinic ^(3,4,10-14). Two studies indicates an experienced dentist as operator. ^(12,15)

The number of restorations in each study varied from 73 to 72,196, with most studies including less than 300 restorations. Only 6 studies were restricted to the evaluation of anterior direct restorations. ^(3,10,15-17)

The United States Public Health Service (USPHS) criteria was the criteria most often used to evaluate restorations; the two most recently published studies used the FDI World Dental Federation criteria. ^(11,16)

Most studies treat build-up restoration type ^(4,10-14,16,17), only two studies treat composite veneer performance ^(3,15). In 4 studies, no AFR was reported, while in one study no overall survival rate was calculated (16). Apart from that study, without taking into consideration the follow-up times, anterior direct composite restoration showed an overall survival rate varied from 38% to 96.3%, and AFR varied from 1.1% to 5%. For build-up, the overall survival rate varied from 82,4% to 96.3%, and AFR varied from 1.1% to 9.2%. ^(4,10-14)

Class III and IV restorations showed an overall survival rate of 64% with 2.9% AFR (15). For composite veneer restorations, overall survival rate varied from 38.0% to

80.1%, and AFR varied from 6.0% to 9.2%. Composite veneer restorations generally had a lower survival rate and the highest AFR. ^(3,15)

Considering the restorative materials, five studies use at least 2 different composites ^(3,4,10,11,15), four studies only 1, and one study did not indicate the used composite. ⁽¹⁶⁾

Author, Year	Country	Service type	Follow-up time (years)	Patients/ Number of restorations	Restoration type	Composite	Survival rate/ AFR	Follow-up criteria
Restorations in worn teeth								
Milosevic & Burnside, 2016	UK	University Hospital Dental	2.8	164/903	Build-up	Spectrum® (DentsplyDeTrey)	92.6% / 5%	USPHS
A.S Al-Khayatt et al, 2013	UK	Dental Hospital	7	15/85	Build-up	Herculite XRV	85% / *	Modified USPHS
A. Aljawad et al, 2016	UK	University Hospital Dental	2.1	41/296	Build-up	CeramX Duo	95.6% / *	USPHS
Loomans et al, 2018	Netherlands	University Center Medical	3.5	* / 687	Build-up	Clearfil AP-X, IPS Empress Direct, Ivoclar Vivadent	96.3% / 1.1%	FDI
Restorations for aesthetic reasons								
F.H Coelho de souza et al, 2015	Brazil	Dental School Clinic	3.5	86/196	Composite veneers	Durafil, Charisma, 4Seasons, Filtek Z350XT, Opallis	80.1% / 6.0% (microfilled veneers) 6.2% (universal veneers)	FDI
C. Frese et al, 2013	Germany	Departement of conservative dentistry, University Hospital	5	58/176	Build-up	Enamel Plus HFO, Artemis, Herculite XRV, EsthetX	84.6% / *	Modified USPHS/FDI
E. Lempel et al, 2017	Hungary	Operative dentistry departement, Pécs University	7.2	65/163	Build-up (Fracture Diastema closure) &	Filtek Supreme XT, Enamel Plus HFO	88.3% / 1.43%	USPHS

F.H van de Sande et al, 2018	Brazil	Private Dental Practice, Experienced dentist specialized in esthetic dentistry	15 ----- 10	144/634 (n=226) ----- (n=408)	Class III / IV ----- Composite veneers	Renamel Microfill, Durafill VS, Four Seasons, Tetric Ceram, Charisma	64% / 2.9% ----- 38% / 9.2%	*
Restorations due to non carious lesions, fracture and other								
Vural et al, 2017	Turkey	Restorative Dental Clinic, Dental School / Experienced clinicians	2	51/73	Build-up	Spectrum TPH	82,4% / *	USPHS
K. Collares et al, 2017	Netherlands	Clinical Practices / Dentists (n=47)	3 5 10	29,855/72,196	Build-up	*	* / 4.4% * / 4.6% * / 4.6%	FDI

* Data not informed in the study.

Table 1 – Longitudinal clinical studies with at least two years of follow-up evaluating anterior composite restorations: the systematic review results.

Table 2 presents the main reason for failure of anterior composite restorations reported in the included studies. Four studies did not report specific reasons for failure, thus were not included in Table 2. ^(12,13,15,16)

Fracture was the most common main reason for failure, varying between 62.0% and 73.3% of all failures, in those studies that reported fractures.

Author, Year	Reason for failure of anterior composite restorations reported in the included studies (% of total failure).
A.S Al-Khayatt et al, 2013	Marginal breakdown (*)
Loomans et al, 2018	Fracture (62%)
F.H.Coelho-de-Souza et al, 2015	Fracture (*)
C. Frese et al, 2013	Fracture/Chipping (63.3%)
E. Lempel et al, 2017	Fracture (73.7%)
A.Aljawad et al, 2016	Bulk fracture (*)

Studies that did not report specific reasons for failure were not included in the table.
* Data not informed in the study.

Table 2 – Main Reasons for failure of anterior composite restorations reported in the included studies.

5 DISCUSSION

5.1 Method used to evaluate the restorations

In the included studies, the clinical performance of the restorations was evaluated by the use of standardized criteria.

The evaluations can be measured with some factors, as the USPHS (United States Public Health Service) criteria and the FDI (Fédération Dentaries Internationale/World Dental Federation), divided into functional, biological, and aesthetic parameters.

In USPHS criteria, the restorations can be classified with three scores: Alpha, Bravo and Charlie. ⁽¹⁵⁾

In the FDI criteria, restorations can be classified with five scores: 1 = clinically very good; 2 = clinically good; 3 = clinically sufficient/satisfactory; 4 = clinically unsatisfactory; and 5 = clinically bad. ⁽⁴⁾

Most studies included in our study used the USPHS method ^(4,10,12-14,17), 5 studies that used the USPHS method reported that a "modified" version of the criteria was used. ^(4,10,13,14,17)

5.2 Restorative material and technique

5.2.1 The restoration types

This systematic review includes two studies treating 604 composite veneer restorations ^(3,15). It seems that, without retreatment, the survival rate of this type of composite restoration varies between 80.1% at 3.5 years of follow-up and 38% after 10 years, composite veneers showed satisfying clinical performance with an AFR varied from 6.0% to 9.2%. Direct veneer restorations seem to require more repairs than other anterior restorations, and have a greater chance of replacement at 10 years ⁽¹⁵⁾.

Our systematic review also includes seven studies treating direct composite build-up, which were found to have an overall survival rate between 82,4% and 96.3% and AFR varied from 1.1% to 5%. ^(4,10-14,17)

Direct build-up restorations provide an excellent treatment alternative for the aesthetic correction, anterior teeth reshaping and an excellent treatment option for fractured teeth and for closing diastemas. ⁽¹⁰⁾

Even under such extreme conditions, direct composite build-ups seem to provide enough strength to endure and survive heavy forces. ⁽¹⁶⁾

In larger restorations, a higher risk for failure was found, reflecting the higher risk of class IV restorations versus class III. ⁽³⁾

5.2.2 The composite resins

According to F.H. van de Sande *et al.*, the effect of resin composite type on survival was only significant for veneer restorations when repair was not considered as failure, reducing the failure risk of veneers presenting a surface layer of microfilled composites. ⁽¹⁵⁾

Coelho-de-Souza *et al.*, found no differences in the survival of veneers performed with universal or microfilled composites, both presenting satisfying performance, with no significant differences in relation to the survival rates. Even if they reported better aesthetic properties for microfilled composites, statistically better anatomic form and marginal adaptation, better surface lustre, lower marginal and surface staining and better colour match. ⁽³⁾

Lempel *et al.*, evaluated two composites placed in anterior teeth, one microhybrid and one nanofilled; after 7 years of evaluation, they did not find significant survival differences. They also reported that nanofill restorations had a risk of failure because of colour mismatch 8.3 times higher than those made from microhybrid

Composite, while micro-hybrids more frequently failed due to fracture of restoration, 3.7 times higher. In that study, the teeth were bevelled prior to conditioning the enamel, in order to reduce the number of restorations with marginal staining. The other benefit expected of the long bevel may be the higher fracture resistance of the resin based composite restoration at the tooth-restoration interface. It was also noticed in that

clinical trial that none of the restorations had failed due to bulk fracture or due to loss of retention. ⁽¹⁰⁾

This opens the question whether the advances in filler composites technology for anterior teeth in the last decade could improve the longevity and restorations performances; with a deeper analysis into the influence of composite material.

5.2.3 Aspects influencing longevity

A number of factors that could be associated with restoration failures in anterior composite restorations have been detected by the literature on clinical longevity.

The paper by Al-khayatt *et al.*, about the performance and patient satisfaction of direct composite restorations bonded to worn anterior mandibular dentition, showed that, Pre-operative preparation did not influence restoration survival or clinical performance (restoration staining, marginal discolouration, shade match, surface roughness and marginal adaptation). ⁽¹⁷⁾

While the time required for the initial build-up of the restorations was statistically significant, a longer procedure time means less chance of the restoration being present in 7 years. These conclusions agree with B.A.C. Loomans *et al.*, remarked that the restoration of anterior restorations in two different sessions increased the risk of failure by 4 times. ⁽¹¹⁾

Coelho-de-Souza *et al.*, investigated the performance of direct veneers using different composites in vital or non-vital anterior teeth, in a retrospective longitudinal clinical study. It appears that the AFR for non-vital teeth (9.8%) was two times higher than AFR for vital teeth (4.9%). The lack of tooth vitality was considered as a possible risk factor for composite restorations. Furthermore, in the qualitative evaluation, vital teeth showed a better performance on the criteria of fracture and retention, colour match, while a borderline significance was found for surface lustre. ⁽³⁾

The author explains that, when the pulp is removed and endodontic therapy is carried out, there is a significant removal of tooth structure and as a consequence lower

resistance to fracture in these teeth exists. Endodontically treated front teeth often show discolorations that may result in the patient's wish for replacing a veneer restoration. ⁽³⁾

In the Van de Sande *et al.* study, restorations placed in the maxilla showed an increased risk for failure compared to the lower arch. More specifically, restorations in central incisors show increased risk of failure compared with other anterior teeth. No significant differences were found for incisors compared to canines. Regarding veneers restorations, a higher risk of failure was observed for the upper jaw and central incisors compared to canines. ⁽¹⁵⁾

The influence of tooth type on failure risk was present when repair was considered as failure. When repair was not seen as failure, the higher failure risk for central incisors compared to canines was also maintained, showing the influence of the type of composite on the survival rates. Restorations with a top layer of microfilled composite should be favoured over the other composite types. ⁽¹⁵⁾

5.3 Patients related factors

5.3.1 Age and Gender

K. Collares *et al.* study is based on 72,196 sets of restorations placed by general practitioners in the Netherlands. The calculated AFR was approximately 4.5%, with a median survival time of about 12 years. The study found that the significant effect of older age on restoration survival, expresses the higher risk of failure observed for older groups due to lesions by carie, because of a declined oral health maintenance. ⁽¹⁶⁾

In the higher age group, having more anterior than posterior restorations during the observation time was also identified as a possible risk marker for survival. Children (5 to 12 y) showed a higher risk of restoration failure when compared with the young adult group (18 to 25 y). Younger patients and elderly people had relatively lower survival, and upper anterior restorations resulted in more failure than lower anterior ones. ⁽¹⁶⁾

Frequency of dental trauma was higher in males than in females, but it was not statistically significant. No statistically significant difference between the cause of trauma

and gender was detected; only a male predominance in restoration debonding failures was observed. ⁽¹²⁾

This result may be attributed to the age and gender of the participants included in the study. In this age group, males have a tendency of being more energetic and more active and choosing to play dangerous games. Falling, collision, or sports accidents due to higher physical activity could lead to fracture or debonding. ⁽¹²⁾

Also because they temporized at a more advanced stage of the disorder before seeking treatment, the males were significantly older than the females. This could explain a higher proportion of failures in males, due to less tooth substance available for bonding purposes. ⁽¹³⁾

5.3.2 Bruxism

It was suggested that bruxism was a potential cause for early restoration of fractures, but studies by Milosevic *et al.* and Edina Lempel *et al.* could not demonstrate such a relation. In Loomans *et al.* study also no significant relationship between the presence of bruxers risk profiles and restoration survival was found. ^(10,11,13)

In other types of restorative material such as amalgam and partial-crown ceramic restorations, the negative effect of bruxism or parafunctional habits on posterior restoration survival was observed. ⁽¹⁴⁾

5.4 Main reason for failure

In our systematic review, six studies indicated specific reasons for failure; the most reported cause of restoration failure was fracture of the tooth or restoration, varying from 62% to 73,3% of the total of all reported failures. ^(3,4,10,11,14,17)

In A.Aljawad *et al.* review showed that Major failure in the form of bulk fracture occurred relatively early following placement, between 12 to 22 months post-placement.

The data showed that the number of restorations failing with major failures, declined with time after placement; the median survival time of all restorations when considering major failure only, was 4.2 years. ⁽¹⁴⁾

Large restorations have a high prevalence of failures. Also, class IV restorations fail due to high masticatory loads. Besides, the lack of mechanical retention may lead to debonding in most restorations. ⁽¹²⁾

Frese C. *et al.* noticed that under extreme conditions, direct composite build-ups seem to provide enough heavy force resistance. Even if the study reported that the most complications were also due to fracture/chipping (63.3%). ⁽⁴⁾

Restorations debonding was mostly observed between 12 and 18 months. Bad marginal adaptation rates with time, were significant. Debonding was mostly observed in fractured teeth (type Ellis II). Although changes in colour matching were significant over time, changes in marginal discoloration were not significant. ⁽¹²⁾

Minor failures in the form of chipping of the incisal edges, occurred between 18 and 32 months after the placement of the restorations, with a mean time of 24.4 months. Happening more frequently on upper central and lateral incisors, compared to canines. ⁽¹⁴⁾

5.5 Operator

Operator factor had significant influence on the survival time. Even if patient's factors and operator characteristics remain to be determined, especially in long-term clinical trials. ⁽¹⁰⁾

It was noticed that, as patients tend to have regular check-ups and remain loyal to the dentist, might be advantageous for the success rate. Also, it was reported that changing dentists, represents a risk factor for restoration survival. Young patient, who were treated by >1 dentist, had a higher risk for failure. ⁽¹⁶⁾

A challenge for future clinical studies treating anterior composite based restorations longevity, is to reveal the relationship between these factors related to dentists and patients.

6 CONCLUSION

For anterior composite resin restorations, the present review generally indicates a good clinical performance in the long-term (follow-up 2+ years), with annual failure rates varying from 1.1% to 5%. The most reported cause of restoration failure was fracture, varying from 62% to 73,3% of the total of all reported failures.

A number of factors that could be associated with restoration failures in anterior composite restorations have been detected as the time required for the initial build up and clinical tooth vitality.

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