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Longevity of Anterior Composite Restorations in a General Dental Practice-Based Network

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Abstract

This practice-based study investigated the performance of a large set of anterior composite restorations placed by a group of 24 general practices. Based on data from electronic patient files, the longevity of 72,196 composite restorations was analyzed, as placed in 29,855 patients by 47 general dental practitioners between 1996 and 2011. Annual failure rates (AFRs) were calculated, and variables associated with failure were assessed by multivariate Cox regression analysis with shared frailty for 2 age groups (5 to 24 y and ≥25 y). The observation time of restorations varied from 2 wk to 13 y, with a mean of 4.8 y, resulting in a mean AFR of 4.6% (95% confidence interval [95% CI], 4.5% to 4.6%) at 5 y. Among dentists, a relevant variation in clinical performance of restorations was observed, with an AFR between 2% and 11%. The risk for restoration failure increased in individuals up to 12 y old, having a 17% higher risk for failure when compared with the age group of 18 to 25 y (hazard ratio, 1.17; 95% CI, 1.03 to 1.34), and for the age group >65 y, having a 81% higher risk for failure when compared with 25 to 35 y (hazard ratio, 1.81; 95% CI, 1.66 to 1.98). In both multivariate models, there was a difference in longevity of restorations for different teeth in the arch, with fillings in central incisors being the most prone to failure and replacement. It was concluded that anterior composite restorations placed by general dental practitioners showed an adequate clinical performance, with a relevant difference in outcome among operators.

Keywords: clinical study, retrospective studies, composite resins, survival analysis, dental veneers, restorative dentistry

Introduction

The main workload for general dental practitioners (GDP) is placement and replacement of dental restorations (Mjor et al. 2002). The first restorative intervention in a tooth may be due to caries, tooth wear, or fracture of the tooth, but many interventions are replacements of older restorations, attributed to secondary caries, fracture of the restoration or tooth, aesthetic reasons, and endodontic complications, among several other reasons (Demarco et al. 2012). Most restorations placed by GDPs are directly applied with composite resin, amalgam, or glass ionomer cement. Nowadays, composite resin, placed with an adhesive technique, is the preferred material among most GDPs (Lynch et al. 2014; Kopperud et al. 2016).

The main focus of clinical studies is the performance of posterior restorations, with data published on observation times up to 30 y (Da Rosa Rodolpho et al. 2011; Pallesen and van Dijken 2015a, 2015b) showing good survival, with annual failure rates (AFRs) ranging from 1% to 4% (Heintze and Rousson 2012; Opdam et al. 2014). However, the number of clinical studies on anterior restorations is limited, probably because the posterior environment is more challenging for testing dental materials and composites are promoted as a replacement for dental amalgam (Opdam et al. 2007; Opdam et al. 2010; Moraschini et al. 2015). Recently, systematic reviews on anterior restorations have been published (Demarco et al. 2015; Heintze et al. 2015; Schwendicke et al. 2015) showing that anterior restorations have a different failure behavior when compared with posterior restorations. Caries is less prominent in front teeth than posterior teeth, and consequently, secondary caries is likely to be less present too. However, front teeth may be exposed to other challenges, such as traumatic injuries and wear of the incisal edge caused by parafunctions (e.g., nail biting, grinding). Due to their increased visibility and important role in a patient's appearance, anterior restorations may be more prone to repair and replacement (i.e., the aesthetic demands of the patient). Moreover, the shape of anterior defects, especially for class IV and V preparations, is less retentive, and this may lead to increased restoration loss.

Controlled and sometimes randomized clinical studies on dental restoration performance include, most of the time,

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a limited number of restorations placed according to a fixed protocol by calibrated dentists. This study design permits a comparison of materials and restorations in detail and an evaluation of restorations according to specified criteria (Ryge and FDI; Hickel et al. 2007). A disadvantage of the design is that it is not possible to evaluate restorations placed by GDPs in their routine practice. As in routine care, many variables are not under control; as such, a survival analysis of these restorations should include all available risk factors to control for confounding, resulting in a sufficient number of restorations, with a high variability of characteristics. In populations where patients are loyal to their dental practice and where restorations are periodically checked by the dentist, it is now possible to collect data from electronic patient files (EPFs), and these data can be used to have an impression of the performance of restorations routinely placed by GDPs. A recent study in the Netherlands reported on the performance of >400,000 restorations placed in anterior and posterior teeth (Laske et al. 2016). For a proper analysis, due to the different behaviors of anterior and posterior restorations, the data set was divided, and the specific performance of >200,000 class II restorations was reported elsewhere (Laske et al. 2016). As data on performance of anterior restorations are relatively scarce, especially practice-based data, the present study was designed. It aimed to analyze the performance of a large set of anterior composite restorations placed by a group of general practitioners, based on data from the electronic files.

Materials and Methods

This study is reported in accordance with the RECORD statement (Reporting of Studies Conducted Using Observational Routinely Collected Health Data; Benchimol et al. 2015)

Study Design and Setting

This was a retrospective longitudinal study, carried out by secondary data collection in a practice-based research network in the Netherlands. From January 1996 to December 2011, 82 dentists placed direct and indirect restorations on anterior and posterior teeth. The 24 dental practices in which the dentists worked joined the practice-based research network on invitation, especially to gain insight on the longevity and quality of their restorative work. All practices used 1 of 2 software systems (Exquise, Vertimart; Novadent, Complan), and during the observation period, all dental treatments were recorded by the software in the EPF. EPFs were also used for financial purposes, as the software program regulated reimbursement of the treatment to patients or insurance companies. The software firms volunteered in the study by designing an application that enabled dentists to produce a raw data file including all their restorative work during the observation period. This raw data file was send to the researchers for further analysis. Data were collected anonymously, and the study design was approved by the local ethics committee (METC; CMO file 2013/483).

Sample and Variables

For the present study, only data related to direct anterior restorations were included. Inclusion criteria were as follows:

- Restorations were placed with composite resin in non-endodontically treated teeth, excluding restorations placed only with flowable composites.
- Restorations were placed in anterior permanent teeth (teeth 11, 12, 13, 21, 22, 23, 31, 32, 33, 41, 42, 43); restorations in deciduous teeth were excluded.
- Dentists were included only if their work included at least 250 restorations placed in the observation period.
- Full information for all variables was available for a restoration, except for brand of composite.
- Restorations had a minimum observation time of 2 wk, except in case of premature failures.
- Patients visited practices at least once every year for checkup, to be sure that EPFs provided the complete history.
- For each restoration, a set of variables was available from the EPF as collected by the dentists during their regular practice hours: information on the patient's age and sex, type of tooth restored, surfaces included on restoration, and the name and brand of composite used (when available). Patient's age was categorized in 7 groups, with the youngest group being 5 to 12 y old and the oldest ≥65 y. Composite resins were divided by their indication into 1) materials developed especially for aesthetic indications (having different color opacities for dentin, enamel, and incisal shades) and 2) universal materials for posterior and anterior restoration use (with universal shades). Other patient-related variables included the number of dentists who treated each patient during the observation period, the number of restorations placed per year on each patient (including anterior and posterior restorations), and the presence of more anterior than posterior restorations placed during the observation period. This variable was obtained by dividing number of anterior restorations by the number of posterior restorations. When the result was >1.0, the patient was considered as having more anterior than posterior restorations. Data on posterior restorations are published in another paper (Laske et al. 2016).

For each restoration, 3 dates were recorded: the date of placement of the restoration, the date of an intervention on the restoration (if present), and the date of the last checkup (considered the censoring date). Reasons for placement and failure of restorations could not be retrieved from the EPFs by the software, as these data were inserted as a text line or were absent.

Interventions were the following treatments in the observation period: a new restoration in the same tooth including at least 1 surface of the first restoration, extraction of the tooth, and endodontic treatment. All interventions were considered a failure.

Statistical Methods

Statistical analyses were performed with STATA 12 software package (StataCorp LP) and R version (Foundation for Statistical Computing). Descriptive statistics were used to report frequency distributions of restorations by independent variables. Kaplan-Meier survival graphs were constructed to show survival of restorative groups, and AFRs were calculated from life tables according to the formula $(1 - y)^z = (1 - x)$, in which y expresses the mean AFR and x, the total failure rate at z years. The proportional hazards test was assessed for each variable. Variables associated with failure were assessed by multivariate Cox regression analysis with shared frailty, considering restorations clustered in patients. As the proportional hazards test showed that analysis of all groups of patients together was not possible, Cox regression analyses were stratified by age groups (5 to 24 y and ≥25 y). Hazard ratios (HRs) with 95% confidence intervals (CIs) were determined. The dentist variable was included in both models for adjustment purposes, but the effect was not presented. A significance level of 5% was used for all analyses.

Results

From the database, a total of 72,196 anterior composite restorations were included. These restorations were placed in 29,855 patients, 5 to 93 y old (mean, 42.4 y), by 47 dentists in 24 clinical practices. The number of restorations per dentist varied from 253 to 4,995. The observation time of the restorations varied from 2 wk to 13 y, with a mean observation time of 4.8 y. The mean AFR at 3, 5, and 10 y was 4.4% (95% CI, 4.4 to 4.5), 4.6% (95% CI, 4.5 to 4.6), and 4.6% (95% CI, 4.5 to 4.7), respectively. A total of 5,373 restorations that did not match inclusion criteria were excluded from the analysis.

Table 1 shows the main descriptive data for the study. It is remarkable that 75% of anterior restorations were placed in patients between 35 and 65 y old. Moreover, 75% of the restorations were placed in the upper front teeth and 27% in central incisors. In that respect, it is notable that only 14% of front restorations were placed in lower incisors.

Two Cox regression analyses were performed. Table 2 shows the results of the younger age group. Restorations placed at a younger age (5 to 12 y) showed a higher risk for failure when compared with those restorations placed in patients 13 to 24 y old. A 17% higher risk for failure was observed when >1 dentist performed restorative treatments on the same patient. There was a significant difference in longevity performance among restorations for different teeth, with fillings in central incisors being more prone to failure and replacement (HR, 2.46; vs. lower incisors). Larger restorations including more surfaces had a higher failure risk, with 3-surface restorations having a 64% higher risk for failure.

Table 3 shows the result of the Cox regression for the older patient group from 25 y onward. Within this age group, the risk for failure increases especially after 50 y old, with patients >65 y having a 81% higher risk for failure versus the age group of 25 to 34 y. When people received a mean of >1 restoration per year (vs. <1), the risk for failure increased 31%, as well as for patients who had more anterior than posterior restorations during the observation time, which resulted in a 52% higher risk for failure. For the younger age group, an increasing number of surfaces also increased the risk for failure. No differences could be detected among the types of composites.

An analysis of AFRs showed a relevant difference among dentists on restorative longevity, with a range of 2% to 11% between the dentists who presented the best and worst clinical performance. The most interesting survival graphs are shown in Figure A–D, expressing the survival among the different age groups and the differences in survival among the different tooth types.

Discussion

The present study is based on a large data set of restorations placed by general practitioners in the Netherlands (Laske et al. 2016), and it is the first to retrospectively assess the longevity of anterior composite restorations placed by several practitioners. The only comparable study would that be of Lucarotti et al. (2005), which is based on insurance data from the British NHS (National Health Service). As, within the NHS at that time, no posterior composite restorations were allowed to be placed, data on composite survival are merely based on anterior composite resin survival, showing a 10-y survival of 43%. The calculated AFR for composites in anterior teeth in the present study was approximately 4.5%, which would resemble a median survival time of about 12 y—better than the data from the NHS study. Until now, limited prospective clinical studies have evaluated the performance of anterior restorations (van Dijken and Pallesen 2010; Gresnigt et al. 2012), showing AFRs of 0% to 4.1% (Demarco et al. 2015). Within that perspective, the results of the Dutch group of GDPs are quite acceptable.

The present study has several limitations to be addressed. As it is based on EPFs, all mistakes that might have been made by dentists, such as including the wrong tooth number, are also in the data set. Because the treating dentist decided whether a restoration should be replaced, there is a considerable bias in the information on restoration failure, as it is likely that decision making varies considerably among dentists and that patient demands also influence this process. However, this is a reflection of all-in-1-day dentistry, and outcomes should be more interpreted within that perspective. In the same way, evaluation of a restoration by the same dentist who has placed it can also lead to biased information on restoration failures. Because data of the EPF were also used for declaration, it is not likely that many interventions on the restorations have been lost. Diagnosis for placing restorations and reasons for failure were not reported in this retrospective analysis. Also, patient-related factors (except sex and age) relevant for restoration survival (van de Sande et al. 2013; Opdam et al. 2014; van de Sande et al. 2016) were not recorded, as they are not denoted in a specific spot in the file. The absence of such relevant risk factors and the

Table 1. Distribution of Anterior Composite Restorations (n = 72,196) by Patient- and Tooth-Related Variables.

	Group, 5 to 24 y		Group, ≥25 y	
	n	%	*n*	%
	Patient-related variables			
Age, y				
5 to 12	1,729	13.4	—	—
13 to 18	5,128	39.7	—	—
19 to 24	6,070	47.0	—	—
25 to 34	—	—	9,962	16.8
35 to 49	—	—	25,175	42.5
50 to 64	—	—	18,104	30.6
≥65	—	—	6,028	10.2
Sex				
Male	6,858	53.0	29,049	49.0
Female	6,069	47.0	30,220	51.0
No. of dentists who treated the patient				
1	9,253	71.6	41,631	70.2
≥2	3,674	28.4	17,638	29.8
Restorations per year				
≤1	6,843	52.9	34,064	57.5
>1	6,084	47.1	25,205	42.5
Patient has more anterior than posterior restorations				
No	8,575	66.3	40,809	68.8
Yes	4,352	33.7	18,460	31.2
	Tooth-related variables			
Tooth type				
Upper central incisor	5,551	42.9	15,909	26.8
Upper lateral	3,314	25.6	13,591	22.9
Upper canine	2,091	16.2	14,722	24.8
Lower central incisor	732	5.7	4,331	7.3
Lower lateral incisor	536	4.2	3,875	6.5
Lower canine	703	5.4	6,841	11.5
No. of surfaces				
1	5,731	44.3	23,551	39.7
2	3,686	28.5	20,249	34.2
≥3	3,510	27.2	15,469	26.1
Composite				
Aesthetic	1,462	11.3	5,295	8.9
Universal	1,952	15.1	7,498	12.7
Unknown	9,513	73.6	46,476	78.4
Total	12,927	100.0	59,269	100.0

presence of other, still-unknown confounding factors in this large data set urge caution in drawing too-detailed conclusions. However, the size of the data set permitted inclusion of different characteristics of anterior restorations to identify possible risk factors. The large size of the data set can be considered a strength of the study, although it incorporates the risk that even small differences will show statistical significance with limited clinical relevance. Therefore, it is important to look at not only the *P* values but also the value of the HRs, focusing mainly on larger differences.

Significant variation in longevity of anterior restorations among operators was found, with AFRs between 2% and 11%. Although the dentist variable was used only as a control variable in the multivariable analysis and HRs were not presented, the significant difference of the AFR among dentists suggests operators as a risk factor for failure of restorations. This is in accordance with the findings on class II amalgam and composite restorations placed by the same dentist group showing an AFR of 4.9% and a comparable variation in AFRs among operators between 2.6% and 7% (Laske et al. 2016). The accuracy and skills of practitioners may be due to these differences, but the threshold for repairing or replacing a restoration may also vary widely among dentists. The decision for replacing a restoration is based on the clinical expertise of the practitioner during checkup, rather than on strict criteria (e.g., FDI; Hickel et al. 2007), and it has been shown that dentists decide differently on repair and replacement when cases of defective restorations are presented to them (Heaven et al. 2013). We hypothesize that clinical decision making by dentists may be influenced by different "dentist profiles" that can be described as either proactive (more eager to replace in an attempt to prevent complications) or reactive (postponing interventions until

Table 2. Cox Regression Analyses on Factors Related to Failure of Anterior Composite Restorations for Younger People (5 to 24 y).

	Group, 5 to 24 y	
Variables	HR (95% CI)	*P* Value
Patient-related variables		
Age, y (ref = 18 to 25 y)		
5 to 12	1.17 (1.03 to 1.34)	0.017
13 to 18	1.05 (0.95 to 1.17)	0.327
Sex (ref = female): male	1.05 (0.96 to 1.15)	0.305
No. of dentists who treated the patient (ref = 1): ≥2	1.15 (1.01 to 1.29)	0.028
Patient with more anterior restorations than posterior (ref = no): yes	1.11 (0.99 to 1.24)	0.073
Tooth-related variables		
Tooth type (ref = lower lateral incisor)		
Upper central incisor	2.46 (1.84 to 3.27)	<0.001
Upper lateral	1.77 (1.31 to 3.37)	<0.001
Upper canine	1.92 (1.42 to 2.61)	<0.001
Lower central incisor	1.26 (0.90 to 1.75)	0.175
Lower canine	1.21 (0.87 to 1.69)	0.255
No. of surfaces (ref = 1)		
2	1.32 (1.17 to 1.48)	<0.001
≥3	1.64 (1.46 to 1.85)	<0.001
Composite (ref = aesthetic)		
Universal	1.13 (0.90 to 1.43)	0.300
Unknown	1.03 (0.81 to 1.30)	0.813

Cox regression was performed with clustering for patients. The dentist variable was included in the model but is not presented here. The variable "restorations placed per year" was not included in the model, due to violation on the condition of proportional hazards.
95% CI, 95% confidence interval; HR, hazard ratio; ref, reference.

Table 3. Cox Regression Analyses on Factors Related to Failure of Anterior Composite Restorations for Older People (≥25 y).

	Group, ≥25 y	
Variables	HR (95% CI)	*P* Value
Patient-related variables		
Age, y (ref = 25 to 34)		
35 to 49	1.14 (1.07 to 1.21)	<0.001
50 to 64	1.40 (1.31 to 1.51)	<0.001
≥65	1.81 (1.66 to 1.98)	<0.001
Sex: male (ref = female)	1.09 (1.04 to 1.14)	<0.001
No. of dentists who treated the patient: ≥2 (ref = 1)	1.04 (0.98 to 1.10)	0.241
Restorations placed per year: >1 (ref = ≤1)	1.31 (1.24 to 1.38)	<0.001
Patient has more anterior than posterior restorations: yes (ref = no)	1.52 (1.44 to 1.60)	<0.001
Tooth-related variables		
Tooth type (ref = lower lateral incisor)		
Upper central incisor	1.34 (1.24 to 1.46)	<0.001
Upper lateral	1.14 (1.05 to 1.24)	0.002
Upper canine	1.12 (1.03 to 1.22)	0.010
Lower central incisor	1.02 (0.93 to 1.11)	0.703
Lower canine	1.04 (0.96 to 1.14)	0.349
No. of surfaces (ref = 1)		
2	1.17 (1.12 to 1.23)	<0.001
≥3	1.35 (1.28 to 1.42)	<0.001
Composite (ref = aesthetic)		
Universal	1.04 (0.93 to 1.18)	0.480
Unknown	1.07 (0.95 to 1.21)	0.242

The Cox regression was performed with clustering for patients, and the dentist variable was included in the model but not presented.
95% CI, 95% confidence interval; HR, hazard ratio; ref, reference.

a complication occurs and patients ask for help; Kopperud et al. 2016). Such profiles may be useful to investigate the influence of decision making on restoration survival.

For posterior restorations, the patient's age has been identified as a risk factor for failure of restorations (Al-Samhan et al. 2010; Kopperud et al. 2012; Pallesen et al. 2013; van de Sande

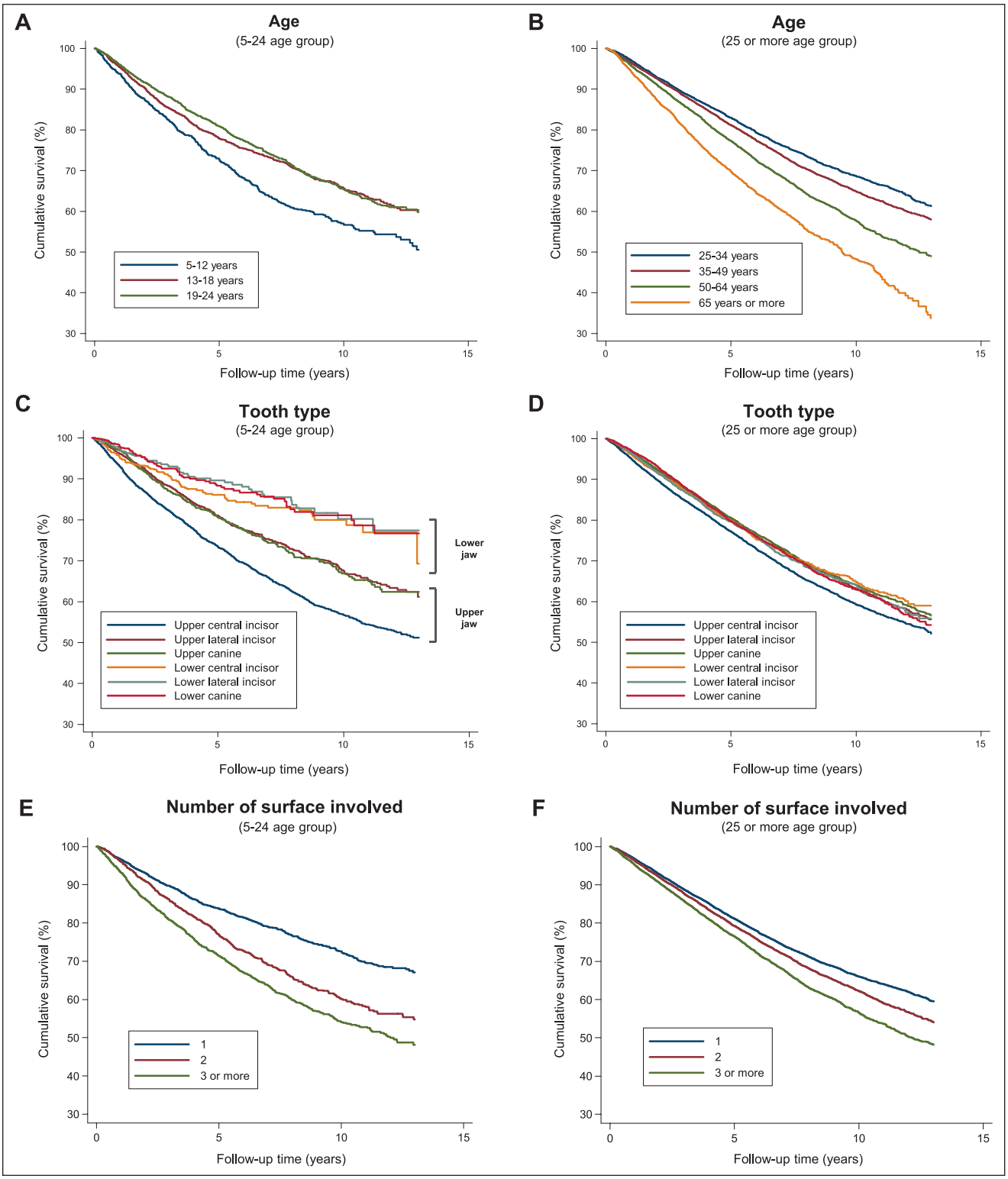

Figure. Kaplan-Meier graphs. (**A**, **B**) Survival of anterior restorations placed in 7 age groups. (**C**, **D**) Survival curves for types of front teeth between younger and older groups. (**E**, **F**) Survival curves for number of restored surfaces between younger and older groups.

et al. 2013). A recent systematic review assessed the influence of patient-related factors on posterior restoration survival and showed that age may have a significant effect, with higher failure rates for the very young and more mature patients (van de Sande et al. 2016). A study on class II restorations based on the same data set as the present study also found this effect,

which might be explained by children having more class II restorations due to primary caries and the elderly having more root caries and active caries attributed to medicine use, decreasing oral health maintenance, and dry mouth (Laske et al. 2016). Also, the analysis of the present study showed a considerable age affect, and even the data set had to be divided into younger and older age groups to enable a multivariate Cox regression. For example, in the present study, children (5 to 12 y) showed a higher risk of restoration failure when compared with the young adult group (18 to 25 y). In the age group until 12 y, restorations in permanent anterior teeth due to caries are placed in limited cases and often as treatment for dental trauma. For trauma, the prevalence in front teeth is known to be higher in children (Glendor 2009), and direct composite restorations are common for treating these injuries. Traumatized teeth have a high risk for endodontic complications and reinterventions due to premature restoration failure. Moreover, prevalence of primary caries in front teeth is not common and may be limited to very high-risk patients, which in itself will result in a higher AFR of restorations (van de Sande 2016). However, the significant effect of older age on restoration survival, as shown in the Figure, expresses the higher risk of failure observed for older groups due to caries and declined levels of oral health maintenance.

Upper front teeth restorations showed a higher risk for failure when compared with lower front teeth for both age groups, with a higher effect size for younger patients. A likely explanation is the higher visibility and the importance of the smile's appearance, resulting in more critical evaluation and more interventions. Generally, older patients present a high resilience to deal with dental problems (Slade and Sanders 2011), accepting small defects better. This can explain why the effect of tooth type (or jaw) was higher for younger patients. Moreover, children with dental trauma often have upper front teeth exposed to high risk for trauma due to an overjet, which also may result in new fractures and reinterventions.

The present study reflects the situation in a group of Dutch dental practices and, as such, is related to the dental care provided in the Netherlands. As patients tend to visit for regular checkups and remain loyal to the dentist, this might be advantageous for the failure rate, as it is reported that changing dentists is a risk factor for restoration survival (Bogacki et al. 2002; Burke et al. 2005). This finding appears to be valid for the present study, as young people who were treated by >1 dentist had a higher risk for failure; however, an emergency treatment in case of a failed restoration could be a confounder, since another operator is likely to provide the service.

In larger restorations, a higher risk for failure was found, reflecting the higher risk of class IV restorations (≥3 surfaces) versus class III restorations. This relation between restoration size and risk for failure is also found in studies on posterior restorations (Opdam et al. 2014).

In the present study, having more anterior than posterior restorations during the observation time was identified as a possible risk marker for survival in the higher age group (HR, 1.52). This may be due to the importance of aesthetics and patients requesting restoration replacements more often for anterior teeth, but at the same time it may reflect a part of the population with shortened arches and limited posterior teeth remaining to be restored. However, this is highly speculative and needs more research. Therefore, we do not want to call this variable a risk factor for survival, but we indicate it as a possible risk marker.

Conclusion

Anterior composite restorations placed by GDPs showed an AFR of 4.9%, with relevant differences among practitioners. Younger patients and elderly people had relatively lower survival, while upper anterior restorations resulted in more failure than lower anterior ones.

Author Contributions

K. Collares, contributed to conception, design, data acquisition, analysis, and interpretation, drafted the manuscript; N.J.M. Opdam, M. Laske, contributed to data acquisition, analysis, and interpretation, critically revised the manuscript; E.M. Bronkhorst, F.F. Demarco, M.B. Correa, M.C.D.N.J.M. Huysmans, contributed to conception and design, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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