

Risk Factors for Failure of direct Restorations in General Dental Practices

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Short title: Management of direct Restorations

Keywords: longevity, dental restoration failure, preventive dentistry, clinical study, retrospective studies, private practice

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supplementary discussion

Several previous studies analyzed if the risk level of caries influences the longevity of dental treatments (Opdam et al. 2010; Opdam et al. 2007; van de Sande et al. 2013; van Dijken and Pallesen 2013; Wierichs et al. 2018). In a previous meta-analysis on the longevity of posterior direct composite restorations risk level of caries was found to significantly influence failure rates (Opdam et al. 2014). For high caries risk patients a significantly higher failure rate was observed compared to medium or low caries risk patients. However, different methods to calculate the risk levels were used. Previous studies used the history of occurrence of new lesions over the study period (Opdam et al. 2010; van de Sande et al. 2013), the age and the DMFT at the beginning of the study (Wierichs et al. 2017; 2018) or plaque and gingival indices (van Dijken and Pallesen 2013). Thus, the definition of the term 'risk level of caries' varied widely. In the present study for risk of caries the DMFT at a respective age was taken into account (Bratthall and Hansel Petersson 2005; Paris et al. 2013). The other six parameters (systemic diseases, medication, nutrition (sugar), nutrition (frequency), oral hygiene, fluoride sources, salivary flow) proposed by the cited studies could not be taken into account. However, the information that in younger patients the DMFT is related more to caries and in older patient more to the number of restorations present is included. By including age, DMFT and caries risk in the multivariate analysis the statistical program highlighted that there is a correlation between the three factors. Since caries risk was a quotient, but age and DMFT direct variables, we decided to only include direct variables. Interpretation of direct variables is more intuitive than the interpretation of quotients. Therefore, in the present study age and DMFT instead of the 'risk level of caries' (being the quotient of age and DMFT) were included in the multivariate analysis. Regardless if anterior and posterior teeth were analyzed separately or not, an up to 1.7 times higher failure for patients with a DMFT score >20 could be observed when compared to patients with a DMFT score ≤ 10 . Thus, the results of the present study seem to be in agreement with the previous ones. However, it remains unclear if the influence of the DMFT is based on the caries experience or on other risk factors (e.g. parafunctional habits (Laske et al. 2019)).

Previous studies on longevity used the position of the dental schedule of fees to identify restorations and to classify the number of restored surfaces (Rädel et al. 2015). In contrast, in the present study the positions of the dental schedule of fees were only used for the initial screening of a direct restoration (Wierichs et al. 2019). After detection, relevant information (e.g. restorative material) were extracted by searching the dental history of the patient and not by searching the positions of the dental schedule of fees. Even the size of the restoration was determined by using the information of the odontogram and the database entry of the date of insertion. However, no information was extractable whether e.g. a two-surface restoration is a

rather small or a rather large one. Thus, the sizes of restorations within one Black (sub-)classification may vary. This, of course, may cause difficulties to control bias and confounders. Nonetheless, the sizes of restorations within one Black (sub-)classification also vary in other retrospective practice-based studies (Laske et al. 2016a; Laske et al. 2016b; Opdam et al. 2010; van de Sande et al. 2013) as well as other studies on data of National Health Services (Burke and Lucarotti 2009; Burke et al. 2005a; Kopperud et al. 2012; Pallesen et al. 2013; Rädcl et al. 2015). Even in some prospective studies the sizes of restorations within one Black (sub-)classification may vary (Beck et al. 2015; Pallesen et al. 2013).

In a previous study on dental implants it could be observed that the results of the dependent and independent model were similar (Chuang et al. 2001). Only when very high failure rates were observed the estimated survival rates differed. However, in that study patient related factors were identical when more than one implant and thus, more than one data set per patient was analyzed.. In contrast, in the present study, the used program extracted all data on the tooth level and not on the patient level. When a direct restoration was inserted all patient related factors of the respective date (patient's age, DMFT, number of check-ups per year etc.) were recorded. If the same patient got a second (or a third) direct restoration (e.g. 4 years later) patient's age, DMFT, etc. differed compared to the first(/second) restoration. In some cases even the number of check-ups per year differed. Thus, for some patients all patient related factors differed in data sets if they got more than one restoration. Therefore, the independent model was chosen for the multivariate analysis although the mean number of restorations per patient was 4.5 (SD: 2.8).

Appendix table 1

Frequency, number of failures of anterior teeth included in study and bivariate Cox proportional hazard regression analyses of time until failure by categories of each baseline characteristic

category	Frequency [n (%)]	Failures [n (%)]	p-value	Teeth		Estimated Median Survival time	95% CI	AFR [%]
				HR	95% CI			
restored surfaces according to the classification of Black								
Class I	990 (12%)	220 (22%)		1.0	Reference	137.4	129.2 - 145.6	5.0
class II	-	-	-	-	-	-	-	-
class III	4491 (53%)	1054 (23%)	0.276	0.9	0.8 - 1.1	145.5	142 - 149	4.6
class IV	2325 (27%)	567 (24%)	0.818	1.0	0.8 - 1.1	146.1	141.1 - 151	4.9
class V	712 (8%)	105 (15%)	0.023	0.8	0.6 - 1	151.5	138.2 - 164.7	3.7
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
age [years]								
0-20	574 (7%)	112 (20%)		1.0	Reference	148.7	138.9 - 158.4	4.6
21-40	2782 (33%)	540 (19%)	0.015	0.8	0.6 - 1	161.0	156.6 - 165.4	3.7
41-60	3250 (38%)	736 (23%)	0.631	1.0	0.8 - 1.2	147.5	143.2 - 151.7	4.5
>60	1912 (22%)	558 (29%)	<0.001	1.5	1.2 - 1.9	117.8	111.7 - 123.8	7.0
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
sex								
female	3378 (40%)	718 (21%)		1.0	Reference	135.2	129.6 - 140.7	5.2
male	5140 (60%)	1228 (24%)	<0.001	0.8	0.8 - 0.9	150.6	147.4 - 153.8	4.4
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
tooth type								
incisor	5695 (67%)	1281 (22%)		1.0	Reference	147.7	144.5 - 151	4.6
canine	2823 (33%)	665 (24%)	0.301	1.1	1 - 1.2	144.1	139.3 - 148.8	4.8
premolar	-	-	-	-	-	-	-	-
molar	-	-	-	-	-	-	-	-
Wisdom	-	-	-	-	-	-	-	-
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
dentist								
1	1247 (15%)	312 (25%)		1.0	Reference	106.8	102.9 - 110.8	5.6
2	563 (7%)	93 (17%)	<0.001	1.6	1.2 - 2	46.6	45 - 48.3	7.7
3	3021 (35%)	705 (23%)	<0.001	0.6	0.6 - 0.7	158.5	154.8 - 162.3	3.9
4	2069 (24%)	583 (28%)	0.148	1.1	1 - 1.3	104.8	101.6 - 108	6.3
5	1618 (19%)	253 (16%)	<0.001	0.6	0.5 - 0.7	141.8	136.5 - 147.1	3.3
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
number of check-ups per year								
<2	6324 (74%)	1474 (23%)		1.0	Reference	149.9	147 - 152.9	4.3
2	1932 (23%)	415 (21%)	<0.001	1.5	1.3 - 1.6	138.4	130.9 - 145.9	5.9
>2	262 (3%)	57 (22%)	<0.001	5.0	3.8 - 6.5	101.0	65.2 - 136.7	15.8
overall	8518 (100%)	1946 (23%)				147	144.3 - 149.7	4.7
number of restorative treatments per patient								
1	291 (3%)	48 (16%)		1.0	Reference	108.8	99.9 - 117.8	5.0
2	443 (5%)	85 (19%)	0.763	1.1	0.7 - 1.5	137.2	125.1 - 149.2	5.4
3	524 (6%)	109 (21%)	0.434	1.1	0.8 - 1.6	124.4	110.8 - 137.9	5.8
4	606 (7%)	119 (20%)	0.848	1.0	0.7 - 1.4	145.5	136.2 - 154.9	5.0
≥5	6654 (78%)	1585 (24%)	0.293	0.9	0.6 - 1.1	148.0	145.1 - 151	4.5

overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7
DMFT								
>20	2141 (25%)	558 (26%)		1.0	Reference	120.7	115.4 - 125.9	5.9
20	3006 (35%)	606 (20%)	<0.001	0.6	0.6 - 0.7	151.5	147.3 - 155.8	3.9
≤10	1066 (13%)	218 (20%)	<0.001	0.5	0.4 - 0.6	170.0	164.2 - 175.7	3.0
n/a	2305 (27%)	564 (24%)	0.820	1.0	0.9 - 1.1	132.6	126.5 - 138.8	5.8
overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7
risk level of caries								
low	1890 (22%)	434 (23%)		1.0	Reference	159.4	154.7 - 164.1	3.7
moderate	943 (11%)	195 (21%)	0.154	1.1	1 - 1.3	146.8	139.1 - 154.6	4.1
high	3380 (40%)	753 (22%)	<0.001	1.3	1.2 - 1.5	137.3	132.8 - 141.8	4.8
n/a	2305 (27%)	564 (24%)	<0.001	1.6	1.4 - 1.8	132.6	126.5 - 138.8	5.8
overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7
restorativ material								
GIC	333 (4%)	107 (32%)		1.0	Reference	94.7	86.8 - 102.7	7.8
composite (hybrid-filler)	1688 (20%)	251 (15%)	<0.001	0.5	0.4 - 0.6	110.3	107.2 - 113.4	3.9
composite (micro-hybrid)	728 (9%)	169 (23%)	0.008	0.7	0.6 - 0.9	98.1	94 - 102.3	5.6
composite (nano-hybrid)	834 (10%)	125 (15%)	0.001	0.7	0.5 - 0.9	104.5	99.3 - 109.8	4.9
composite	526 (6%)	179 (34%)	0.059	0.8	0.6 - 1	115.5	108.5 - 122.4	6.4
AOB or n/a	4409 (52%)	1115 (25%)	<0.001	0.5	0.4 - 0.7	151.1	147.8 - 154.3	4.4
overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7
insurance								
private	6941 (81%)	1590 (23%)		1.0	Reference	146.3	143.3 - 149.3	4.7
statutory	1577 (19%)	356 (23%)	0.092	0.9	0.8 - 1	149.2	143 - 155.3	4.3
overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7
jaw								
upper	6414 (75%)	1462 (23%)		1.0	Reference	147.0	143.9 - 150.1	4.6
lower	2104 (25%)	484 (23%)	0.375	1.0	0.9 - 1.2	145.5	140.2 - 150.9	4.8
overall	8518 (100%)	1946 (23%)				147	144.3 – 149.7	4.7

Factors associated with time until failure ($p < 0.25$; bold) in the separate models were entered in the multivariate Cox regression model (Appendix table 2).

Appendix table 2

Multivariate Cox proportional hazard regression analyses of time until failure as function of baseline characteristics identified for anterior teeth

category	p-value	HR	95% CI
number of surfaces	<0.001		
class I		1.0	Reference
class II		-	-
class III	0.785	0.980	0.8 - 1.1
class IV	0.069	1.159	1 - 1.4
class V	<0.001	0.652	0.5 - 0.8
age [years]	<0.001		
0-20		1.0	Reference
21-40	0.007	0.750	0.6 - 0.9
41-60	0.089	0.835	0.7 - 1
>60	0.083	1.209	1 - 1.5
sex			
female		1.0	Reference
male	0.918	0.995	0.9 - 1.1
dentist	<0.001		
1		1.0	Reference
2	<0.001	1.881	1.4 - 2.5
3	0.100	0.810	0.6 - 1
4	0.174	1.188	0.9 - 1.5
5	0.009	0.702	0.5 - 0.9
number of check-ups per year	<0.001		
<2		1.0	Reference
2	<0.001	1.433	1.3 - 1.6
>2	<0.001	5.237	4 - 6.9
DMFT	<0.001		
>20		1.0	Reference
20-10	<0.001	0.739	0.7 - 0.8
≤10	<0.001	0.579	0.5 - 0.7
n/a	0.431	0.929	0.8 - 1.1
restorative material	0.002		
GIC		1.0	Reference
composite (hybrid-filler)	0.010	0.706	0.5 - 0.9
composite (micro-hybrid)	0.043	0.726	0.5 - 1
composite (nano-hybrid)	<0.001	0.526	0.4 - 0.7
composite	0.242	0.865	0.7 - 1.1
AOB or n/a	0.045	0.801	0.6 - 1
insurance			
private		1.0	Reference
statutory	0.103	0.905	0.8 - 1

Bold p values (p<0.05) indicate factors strongly associated with a de- or increased failure rate.

Appendix table 3

Frequency, number of failures of posterior teeth included in study and bivariate Cox proportional hazard regression analyses of time until failure by categories of each baseline characteristic

category	Frequency [n (%)]	Failures [n (%)]	p-value	Teeth		Estimated Median Survival time	95% CI	AFR [%]
				HR	95% CI			
restored surfaces according to the classification of Black								
Class I	5539 (29%)	990 (18%)		1.0	Reference	186.8	167 - 206.6	3.6
class II	12374 (66%)	2404 (19%)	0.003	1.1	1 - 1.2	214.0	201.4 - 226.6	4.0
class III	-	-	-	-	-	-	-	-
class IV	-	-	-	-	-	-	-	-
class V	976 (5%)	153 (16%)	0.088	1.2	1 - 1.4	146.4	134.4 - 158.3	4.1
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
age [years]								
0-20	2786 (15%)	536 (19%)		1.0	Reference	153.0	148.3 - 157.8	4.0
21-40	9155 (48%)	1583 (17%)	0.017	0.9	0.8 - 1	221.3	210.7 - 231.9	3.5
41-60	5193 (27%)	1011 (19%)	0.293	1.1	1 - 1.2	153.2	149.3 - 157	4.2
>60	1755 (9%)	417 (24%)	<0.001	1.4	1.2 - 1.6	134.1	128.1 - 140.2	5.5
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
sex								
female	7584 (40%)	1293 (17%)		1.0	Reference	213.6	201.7 - 225.5	4.1
male	11305 (60%)	2254 (20%)	0.017	0.9	0.9 - 1	157.2	154.9 - 159.5	3.8
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
tooth type								
incisor	-	-	-	-	-	-	-	-
canine	-	-	-	-	-	-	-	-
premolar	7762 (41%)	1303 (17%)		1.0	Reference	163.5	160.5 - 166.5	3.5
molar	9937 (53%)	2008 (20%)	<0.001	1.2	1.1 - 1.3	199.8	185 - 214.6	4.3
Wisdom	1190 (6%)	236 (20%)	0.076	1.1	1 - 1.3	149.9	142.7 - 157	4.0
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
dentist								
1	2537 (13%)	462 (18%)		1.0	Reference	118.1	115.5 - 120.7	3.9
2	1180 (6%)	169 (14%)	<0.001	2.0	1.7 - 2.4	48.0	46.9 - 49.1	6.6
3	6928 (37%)	1317 (19%)	0.004	0.9	0.8 - 1	163.1	160.4 - 165.8	3.4
4	5043 (27%)	1227 (24%)	<0.001	1.4	1.3 - 1.6	112.2	110 - 114.4	5.5
5	3201 (17%)	372 (12%)	<0.001	0.6	0.5 - 0.7	242.9	224.1 - 261.7	2.4
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
number of check-ups per year								
<2	14358 (76%)	2754 (19%)		1.0	Reference	210.8	197 - 224.6	3.7
2	4020 (21%)	702 (17%)	<0.001	1.4	1.3 - 1.5	148.3	142.7 - 153.8	4.8
>2	511 (3%)	91 (18%)	<0.001	5.2	4.2 - 6.5	67.0	53.9 - 80.1	13.8
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
number of restorative treatments per patient								
1	659 (3%)	69 (10%)		1.0	Reference	157.9	138.9 - 176.9	3.1
2	1058 (6%)	106 (10%)	0.569	0.9	0.7 - 1.2	178.3	169.8 - 186.7	2.9
3	1313 (7%)	127 (10%)	0.173	0.8	0.6 - 1.1	275.7	258.6 - 292.8	2.6
4	1465 (8%)	190 (13%)	0.998	1.0	0.8 - 1.3	161.7	153.4 - 170	3.2

≥5	14394 (76%)	3055 (21%)	0.047	1.3	1 - 1.6	152.7	150.6 - 154.9	4.1
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
DMFT								
>20	2103 (11%)	501 (24%)		1.0	Reference	126.8	121.4 - 132.2	5.3
20	6834 (36%)	1205 (18%)	<0.001	0.7	0.6 - 0.8	155.1	151.7 - 158.5	3.8
≤10	5300 (28%)	939 (18%)	<0.001	0.6	0.5 - 0.6	221.4	200.9 - 241.8	3.2
n/a	4652 (25%)	902 (19%)	0.021	0.9	0.8 - 1	145.4	140.8 - 150	4.7
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
risk level of caries								
low	4870 (26%)	929 (19%)		1.0	Reference	161.3	158.1 - 164.6	3.5
moderate	2471 (13%)	419 (17%)	0.901	1.0	0.9 - 1.1	194.3	159.7 - 228.8	3.5
high	6896 (37%)	1297 (19%)	0.004	1.1	1 - 1.2	212.3	201.6 - 222.9	4.0
n/a	4652 (25%)	902 (19%)	<0.001	1.3	1.2 - 1.5	145.4	140.8 - 150	4.7
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
restorativ material								
GIC	1944 (10%)	545 (28%)		1.0	Reference	102.3	98.7 - 105.9	3.9
composite (hybrid-filler)	2557 (14%)	286 (11%)	<0.001	0.4	0.3 - 0.4	112.4	110.7 - 114.1	2.0
composite (micro-hybrid)	826 (4%)	129 (16%)	<0.001	0.6	0.5 - 0.7	109.5	105.6 - 113.4	3.9
composite (nano-hybrid)	2354 (12%)	209 (9%)	<0.001	0.5	0.4 - 0.5	110.3	107.2 - 113.4	3.1
composite	750 (4%)	150 (20%)	<0.001	0.6	0.5 - 0.7	138.4	131.5 - 145.2	4.3
AOB or n/a	10458 (55%)	2228 (21%)	<0.001	0.5	0.5 - 0.6	209.6	196 - 223.2	3.9
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
insurance								
private	15765 (83%)	2994 (19%)		1.0	Reference	204.1	189 - 219.3	4.0
statutory	3124 (17%)	553 (18%)	0.013	0.9	0.8 - 1	161.3	156.6 - 165.9	3.6
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9
jaw								
upper	9713 (51%)	1824 (19%)		1.0	Reference	209.3	184.8 - 233.9	3.9
lower	9176 (49%)	1723 (19%)	0.915	1.0	0.9 - 1.1	154.5	151.7 - 157.2	3.9
overall	18889 (100%)	3547 (19%)				207.8	194.4 - 221.1	3.9

Factors associated with time until failure ($p < 0.25$; bold) in the separate models were entered in the multivariate Cox regression model (Appendix table 4).

Appendix table 4

Multivariate Cox proportional hazard regression analyses of time until failure as function of baseline characteristics identified for posterior teeth

category	p-value	HR	95% CI
number of surfaces	0.053		
class I		1.0	Reference
class II	0.021	1.104	1 - 1.2
class III	-	-	-
class IV	-	-	-
class V	0.835	1.019	0.9 - 1.2
age [years]	<0.001		
0-20		1.0	Reference
21-40	0.001	0.836	0.8 - 0.9
41-60	0.061	0.891	0.8 - 1
>60	0.400	1.065	0.9 - 1.2
sex			
female		1.0	Reference
male	0.134	1.062	1 - 1.1
tooth type	<0.001		
incisor	-	-	-
canine	-	-	-
premolar		1.0	Reference
molar	<0.001	1.326	1.2 - 1.4
wisdom	0.061	1.147	1 - 1.3
dentist	<0.001		
1		1.0	Reference
2	<0.001	2.148	1.8 - 2.6
3	0.061	1.185	1 - 1.4
4	<0.001	1.542	1.3 - 1.8
5	0.006	0.767	0.6 - 0.9
number of check-ups per year	<0.001		
<2		1.0	Reference
2	<0.001	1.491	1.4 - 1.6
>2	<0.001	5.697	4.6 - 7.1
number of restorative treatments per patient	<0.001		
1		1.0	Reference
2	0.699	0.942	0.7 - 1.3
3	0.489	0.902	0.7 - 1.2
4	0.598	1.077	0.8 - 1.4
≥5	0.007	1.395	1.1 - 1.8
DMFT	<0.001		
>20		1.0	Reference
20-10	0.016	0.872	0.8 - 1
≤10	<0.001	0.728	0.6 - 0.8
n/a	0.030	1.191	1 - 1.4

restorative material	<0.001		
GIC		1.0	Reference
composite (hybrid-filler)	<0.001	0.490	0.4 - 0.6
composite (micro-hybrid)	<0.001	0.655	0.5 - 0.8
composite (nano-hybrid)	<0.001	0.446	0.4 - 0.5
composite		0.099	0.852 0.7 - 1
AOB or n/a	<0.001	0.784	0.7 - 0.9
insurance			
private		1.0	Reference
statutory		0.178	0.937 0.9 - 1

Bold p values ($p < 0.05$) indicate factors strongly associated with a de- or increased failure rate.

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