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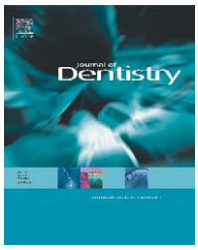

Age of failed restorations: A deceptive longevity parameter

Niek J.M. Opdam [a,*], *Ewald M. Bronkhorst* [a], *Max S. Cenci* [b], *Marie-Charlotte D.N.J.M. Huysmans* [a], *Nairn H.F. Wilson* [c]

[a] *College of Dental Science, Department of Preventive and Restorative Dentistry, Radboud University Nijmegen Medical Centre, The Netherlands*

[b] *Department of Dentistry and Cariology, School of Dentistry, Federal University of Pelotas, Pelotas, RS, Brazil*

[c] *King's College London Dental Institute Central Office, London, UK*

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ABSTRACT

There is pressing need to enhance evidence base in respect of longevity of restorations. Currently, there is lack of appreciation of differences between survival data based on the age of failed restorations as compared to gold standard Kaplan–Meier statistics.

Objectives: This study was undertaken to compare and contrast longevity data for a number of data sets. It investigated if restoration longevity, as calculated by the Kaplan–Meier method, is different from longevity according to the median survival time of failed restorations.

Methods: Existing clinical datasets of dental restorations and an artificial dataset were used to calculate longevity according to Kaplan–Meier statistics and by means of calculation of median age of failed restorations.

Results: The findings indicate that median age of failed restorations may be considered as a deceptive measure of restoration longevity. Specially extending the duration of longitudinal studies of restorations apparently leads to higher values for median age of failed restorations. Restorations of materials that tend to exhibit early failures may have lower values for median age of failed restorations, compared to restorations of different materials which tend to exhibit failures later in clinical service, and thereby not giving a true measure of overall restoration longevity.

Conclusion: In absence of all dates of placement and failure for a series of restorations a reliable measure of restoration longevity is not yet available. Kaplan–Meier statistics remains the preferred method of calculating longevity of a group of dental restorations.

1. Introduction

Evidence-based practice is increasingly considered to be critical to successful clinical outcomes. Given that the restoration of diseased and otherwise damaged teeth constitutes a large element of, in particular, primary dental care, there is a pressing need to enhance the evidence base in respect of the longevity of restorations, with an emphasis on the restorative material used and the type of restoration—traditional or minimally interventive. Dental restorations may be found to exhibit wide variation in longevity, sometimes extending to the lifetime of the patient—permanent restorations. To deal with such variations, survival analyses are conducted on data obtained in respect of populations of restorations that include both failed restorations and restorations remaining in clinical service. In longitudinal studies,

* Corresponding author at: Department of Preventive and Restorative dentistry, Radboud University Nijmegen Medical Centre-The Netherlands, P.O. Box 9101, NL 6500 HB Nijmegen, The Netherlands. Tel.: +31 24 361 6410; fax: +31 24 354 0265.
E-mail address: n.opdam@dent.umcn.nl (Niek J.M. Opdam).

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longevity can be accurately assessed give dates of placement and failure, together with data on the performance of restorations which remain in clinical service.

The Kaplan–Meier analysis is a well established means of investigating the longevity of dental restorations. In the Kaplan–Meier method, the life time of restorations that have failed as well of those that remain in service is taken into account. The observation time of each single restoration starts at time 0 in the graph. Restorations that fail result in a drop of the graph, whilst restorations that have not failed by the end of the study or follow-up period are called censored observations, and these restorations are only included for as long as they are observed. This leads to the increase in size of the steps downward at the end of the graph, typical for the Kaplan–Meier analysis, due to the decreasing number of restorations still under observation. Since information of both failed and non-failed restorations is used optimally, the Kaplan–Meier method is considered as the gold standard in longevity assessment.[1] Differences in the longevity of restorations of different materials and types as analysed with Kaplan–Meier may be statistically tested with log-rank tests. In certain situations, Cox's proportional hazard model may be preferred to demonstrate the influence of different factors on survival.[2]

Unfortunately, longitudinal studies on the longevity of dental restorations, in particular longitudinal studies undertaken in the general dental practice setting are scarce[3–5] given cost considerations, dependence on detailed record keeping by general dental practitioners (GDPs) and the availability and willingness of patients to attend for long-term follow up recalls. The usual alternative is cross-sectional studies in which observations made by GDPs on a sample of their typically large population of restorations form the study data set. From such data sets, the median and mean survival times of failed restorations are calculated and used as a measure of the longevity of the restorations. Whilst data on median and mean ages of failed restorations both are of interest, the median age of failed restorations tends to have been selected as the relevant measure in cross-sectional restoration longevity studies.[6–31]

Review papers on the longevity of dental restorations placed by GDPs include those by Manhardt et al.[32] and Hickel et al.[33] Although it is acknowledged in these reviews that the median survival time of failed restorations underestimates the longevity of restorations[2,34] it is the best available data on which to judge the longevity of restorations of different materials and types placed in different clinical settings. Furthermore a study by Jokstad et al.[13] showed that the age distributions for failed restorations and restorations which were considered to remain clinically acceptable were similar, indicating the validity of using the mean or median age of failed restorations as a criterion for restoration performance in general dental practice.[34]

However, there is still a lack of appreciation of the difference between survival data calculated from the median age of failed restorations as compared to the gold standard of Kaplan–Meier analysis.[2] Therefore, the present study was undertaken to compare longevity of restorations, as calculated by means of the Kaplan–Meier method, with the longevity according to the median survival time of failed restorations, both in suitable longitudinal clinical data sets, and in simulated data sets, highlighting different failure characteristics.

2. Materials and methods

Firstly, three clinical datasets (CDs) were employed:

CD1 A 22-year comparison between posterior composite restorations of two materials (Herculite, Kerr; P50, 3M-ESPE). The 17-year results of these investigations were published by Da Rosa Rodolpho et al.[5]

CD2 A 9-year comparison between ''sandwich'' and ''total etch'' composite resin restorations.[35]

CD3 A longitudinal clinical dataset of 2015 large dental amalgam and composite resin restorations placed between 1982 and 2003.[36]

They were selected on criteria of longitudinal data collection with long term follow-up. For each of the three data sets, the annual failure rate (AFR, from Kaplan–Meier) and the median and mean age of failed restorations were calculated. Differences in AFR and median age of failed restorations between different groups of restorations within each dataset were investigated using log-rank and *t*-tests.

For the third data set (CD3), an additional analysis was undertaken. It was assumed that the GDP had taken part in a

Table 1 – Annual failure rates and median/mean age of failed restorations calculated for the clinical datasets.

	Experimental groups	Maximum observation (years)	Annual failure rate (%)	Log-rank test	Age of failed restorations		
					Median	*t*-Test	Mean
CD1	P50	22	1.5%	$p = 0.198$	8.7	$p = 0.069$	9.9
	Herculite		2.2%		11.8		11.8
CD2	Sandwich	9	3.8%	$p < 0.001$	6.6	$p = 0.135$	7.1
	Total-etch		1.4%		5.6		6.1
CD3	Composite	13	2.6%[a]	$p = 0.02$	4.9	$p < 0.001$	5.0
	Amalgam		3.0%[a]		11.4		11.5
CD3[b]	Composite	25	Identical to CD3		6.7	$p < 0.001$	8.0
	Amalgam				19.9		19.2

[a] Annual failure rate over 13 years.
[b] Extrapolated to give 2007–2008 observations.