The ultimate guide to restoration longevity in England and Wales. Part 6: molar teeth: restoration time to next intervention and to extraction of the restored tooth

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Key points

Overall, over 6.3 million restorations in molar teeth were included, of which, overall, circa 41% of restorations have survived without re-intervention at 15 years, 50% at 10 years and 66% at 5 years. Factors influencing survival include patient age and patient treatment need. There is little difference, overall, between the upper and lower arches.

In terms of time to re-intervention, small amalgam restorations perform better than large, and crowns perform optimally. However, when the data are re-analysed with regard to time to extraction of the restored tooth, crowns perform less well, especially in the youngest age groups.

Crowns on molar teeth enhance the survival of the tooth only in the oldest age groups. The need to place a root filling leads to a reduced life expectancy of the restored tooth.

Aim It is the aim of this paper to present data on the survival of restorations in molar teeth by analysis of the time to re-intervention on the restorations and time to extraction of the restored teeth, and to discuss the factors which may influence this. **Methods** A data set was established, consisting of General Dental Services' patients, this being obtained from all records for adults (aged 18 or over at date of acceptance) in the GDS of England and Wales between 1990 and 2006. The data consist of items obtained from the payment claims submitted by GDS dentists to the Dental Practice Board (DPB) in Eastbourne, Sussex, UK. This study examined the recorded intervals between placing a restoration in a molar tooth and re-intervention on the tooth, and the time to extraction of the restored tooth. **Results** Data for more than three million different patients and more than 25 million courses of treatment were included in the analysis. Included were all records for adults (aged 18 or over at date of acceptance). More than six million restorations involving molar teeth were included in the analysis. **Conclusions** Overall, 41% of restorations in molar teeth have survived without re-intervention at 15 years. Overall survival of restored molar teeth without extraction is 83% over fifteen years. Factors influencing survival are patient age, dentist age, and patient treatment need. With regard to tooth position, there is minimal difference in molar tooth survival to extraction with respect to upper vs lower arch, but survival time to extraction of upper third molar teeth is the least good. On molar teeth, when survival of the restored tooth to extraction is examined, crowns do not represent the optimally performing restoration in under-40 year age groups, leading to earlier loss of the tooth; in older age groups (over 40 years) a crown presents the best survival, to extraction, of the restored tooth. In general, only mesial-occlusal-distal (MOD) amalgams and glass ionomers perform less well than crowns in terms of time to extraction.

Introduction

Satisfactory survival of restorations is of importance to patients, dental professionals, epidemiologists, third-party funders, governments, and other interested parties. The provision of accurate information on restoration survival, and the factors which may influence this, is therefore of relevance to many persons and organisations. It is also important that the data are derived from general dental practice (as opposed to secondary care), given that it is in this arena that the majority of dental treatment, worldwide, is provided and given that it is there where the majority of dentists operate and where the majority of restorations are placed. Using the methodology described in Paper 1 in this series,[1] it has been possible to produce precise information regarding the survival of restorations in molar teeth and the factors which may influence this.

It is therefore the purpose of this paper to investigate the survival of direct-placement restorations and crowns in molar teeth, by assessing:

- Time to re-intervention and patient and dentist factors associated with this
- Time to extraction and the factors associated with this.

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Results

Characteristics of the sample population

More than three million different patient IDs and more than 25 million courses of treatment were included in the analysis, each of which includes data down to individual tooth level. Included were all records for adults (aged 18 or over at date of acceptance). Of these, 6,311,720 restorations involved molar teeth.

Fig. 1 Time to re-intervention of restorations in molar teeth, overall

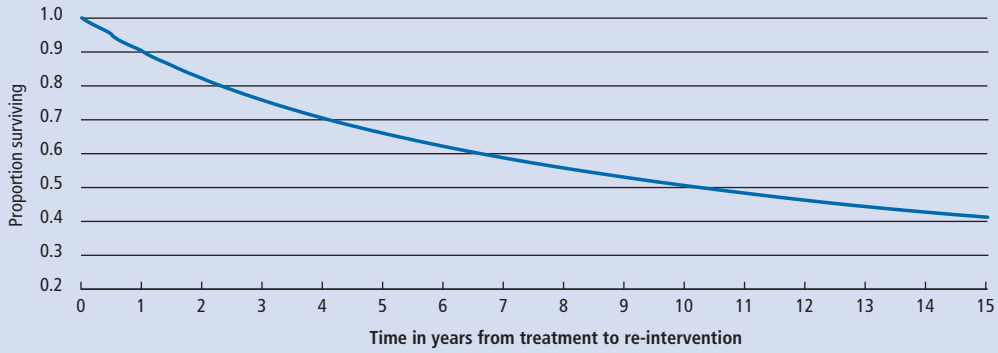


Fig. 2 Time to extraction, overall, of restored molar teeth

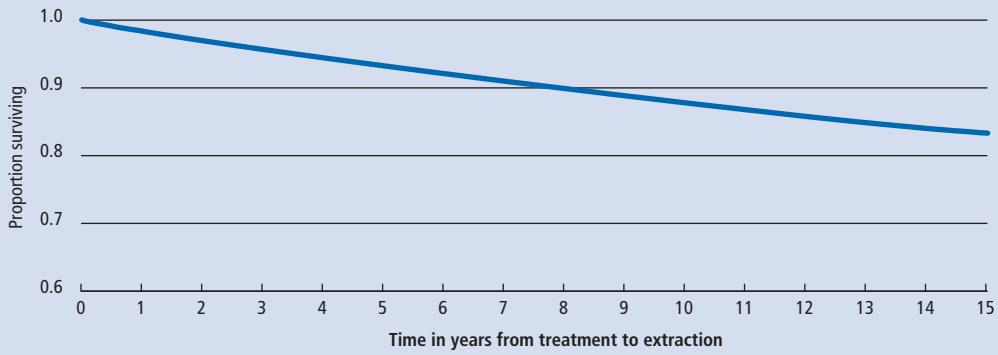


Fig. 3 Time to re-intervention of restorations in molar teeth, with regard to the most commonly placed restorations

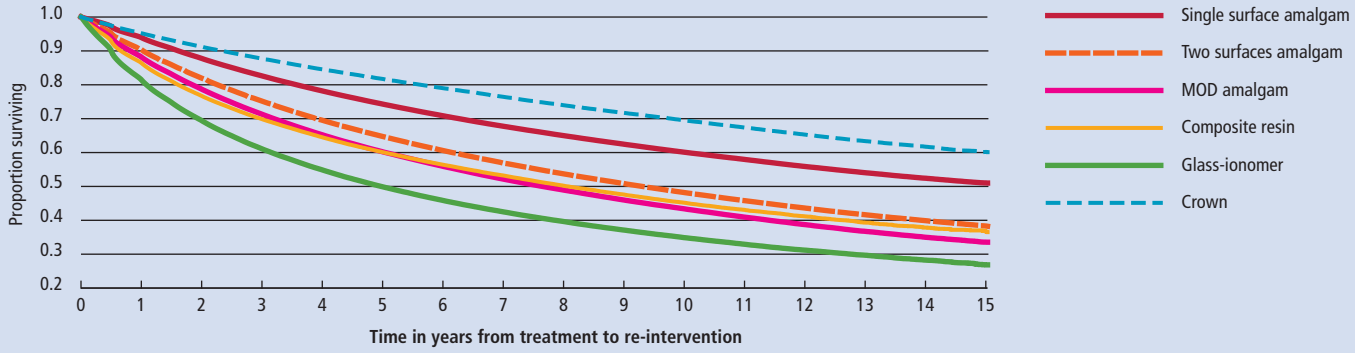
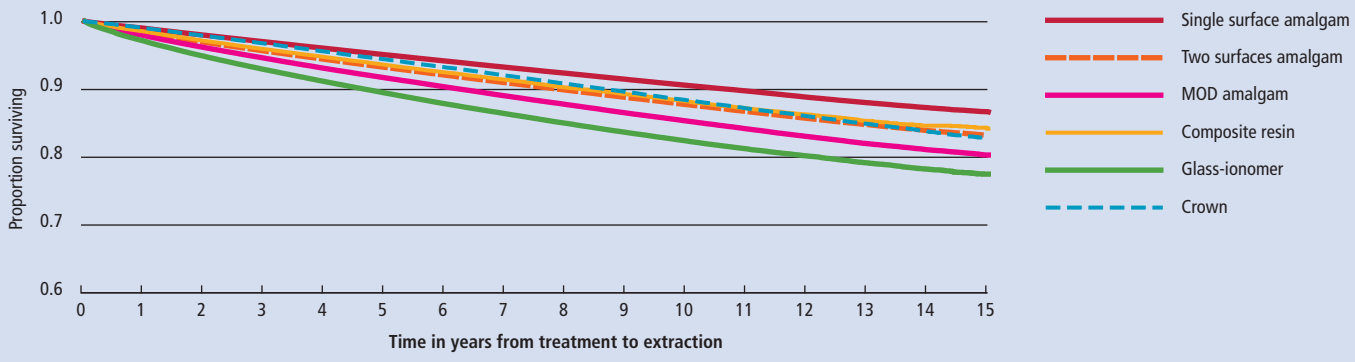


Fig. 4 Time to extraction of restored molar teeth, with regard to the most commonly placed restorations



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Restorations in molar teeth

When the survival of restorations in molar teeth is examined with respect to time to re-intervention, it is apparent that, overall, circa 41% of restorations have survived at 15 years, with 50% having survived to ten years and 66% having survived to five years (Fig. 1). When the data are re-analysed with regard to time to extraction, it is apparent that circa 83% of restored molar teeth have survived for 15 years, with 93% having survived to five years and 88% to ten years (Fig. 2).

Over sixteen different types of restoration (including a variety of crowns) could be placed in molar teeth under the General Dental Services (GDS) Regulations at the time of this study, so the analysis was confined to more commonly used restoration types, namely, amalgam restorations, glass ionomer (GI) restorations, resin composite restorations and crowns. It should be noted that, under the Regulations, GI and composite materials may not be placed in loadbearing situations in molar teeth. With regard to re-intervention, it is apparent that crowns outperform other commonly provided restoration types (Fig. 3), with smaller amalgams performing more favourably than large, and with GI restorations performing least favourably. However, when the data are analysed with regard to time to extraction of the restored tooth, the chart (Fig. 4) tells a different story. Crowns no longer represent the optimally performing restoration, since, at 15 years, Class I and II amalgams, and resin composite restorations (over fifteen years) are performing more favourably in terms of time to extraction of the restored tooth. Only MOD amalgams and GI perform less well than crowns in terms of time to extraction.

The exact figures for survival at one, five, ten and fifteen years are given in Tables 1 and 2, together with the number of cases used in the analysis (n).

Restorations in molar teeth with respect to patient age

When the data are analysed with regard to patient age and restoration survival to re-intervention, it is apparent that restorations in molars perform less well in older than in younger patients (Fig. 5 and Table 3). When the data are re-analysed with regard to patient age (<40 and >40 years) and restoration type in molars, crowns out-perform other restoration types in terms of survival to re-intervention in the under-40 years age group (Fig. 6). Again, in

Table 1 Survival of molar tooth to re-intervention, with regard to type of restoration

Type of treatment	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Single surface amalgam	94	74	60	51	1,537,328
Two surfaces amalgam	90	65	48	38	2,729,025
MOD amalgam	88	60	43	34	846,484
Composite resin	86	60	45	37	296,970
Glass ionomer	81	50	35	27	558,833
Crown	95	82	70	60	339,229
All restorations	90	66	50	41	6,307,869

Table 2 Survival of molar tooth to extraction, with regard to type of restoration

Type of treatment	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Single surface amalgam	99	95	91	87	1,537,328
Two surfaces amalgam	98	93	88	83	2,729,025
MOD amalgam	98	92	85	80	846,484
Composite resin	98	94	88	84	296,970
Glass ionomer	97	89	82	78	558,833
Crown	99	94	88	83	339,229
All restorations	98	93	88	83	6,307,869

Table 3 Survival to re-intervention of restored molar teeth, with regard to patient age

Patient age	Survival (%) at				
	1 year	5 years	10 years	15 years	n
18 or 19	95	74	58	46	221,776
20 to 29	94	72	56	45	1,544,636
30 to 39	91	67	52	42	1,688,014
40 to 49	89	64	49	40	1,284,711
50 to 59	87	61	46	38	840,519
60 to 69	86	58	43	35	472,892
70 to 79	85	55	40	32	206,806
80 or over	85	54	41	33	48,515
All restorations	90	66	50	41	6,307,869

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50 to 59	98	91	84	79	840,519
60 to 69	97	89	81	74	472,892
70 to 79	96	86	76	69	206,806
80 or over	96	84	73	66	48,515
All restorations	98	93	88	83	6,307,869

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Fig. 5 Time to re-intervention of restorations in molar teeth, with regard to patient age

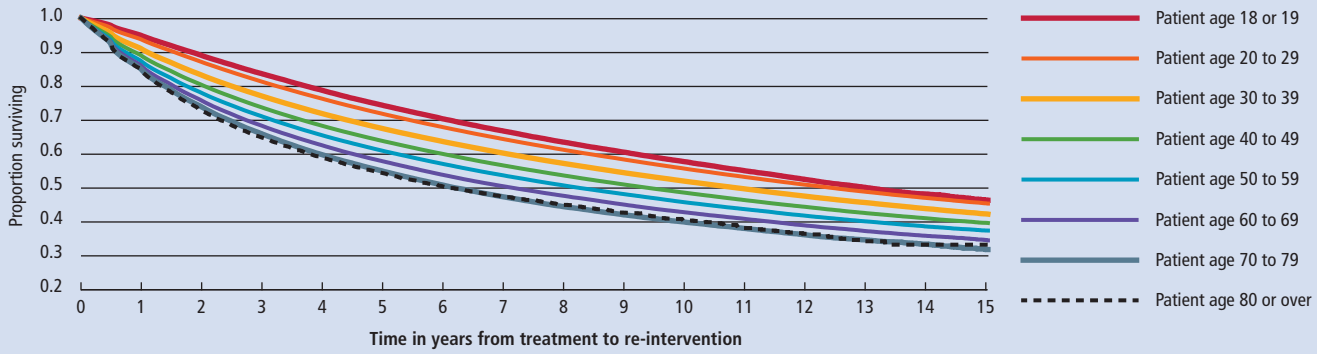

Fig. 6 Time to re-intervention of restorations in molar teeth, in patients aged under 40 years of age

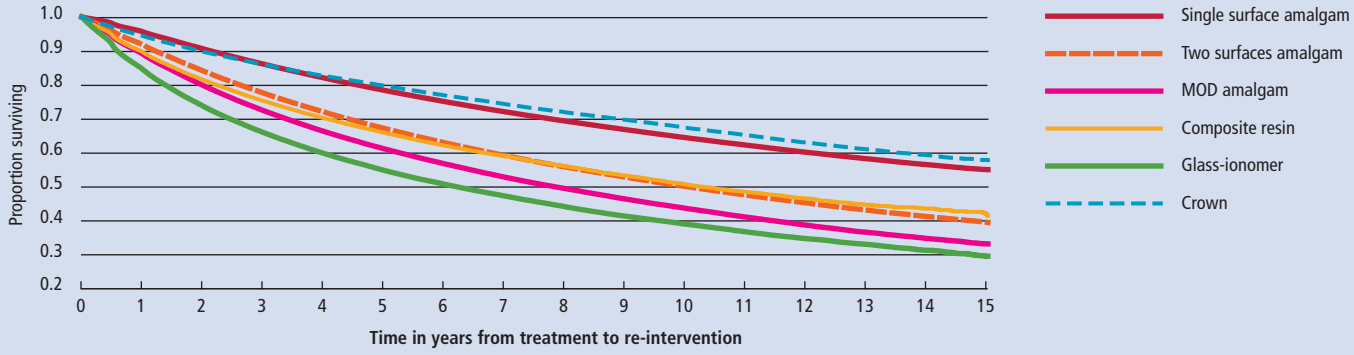

Fig. 7 Time to re-intervention of restorations in molar teeth, in patients aged over 40 years of age

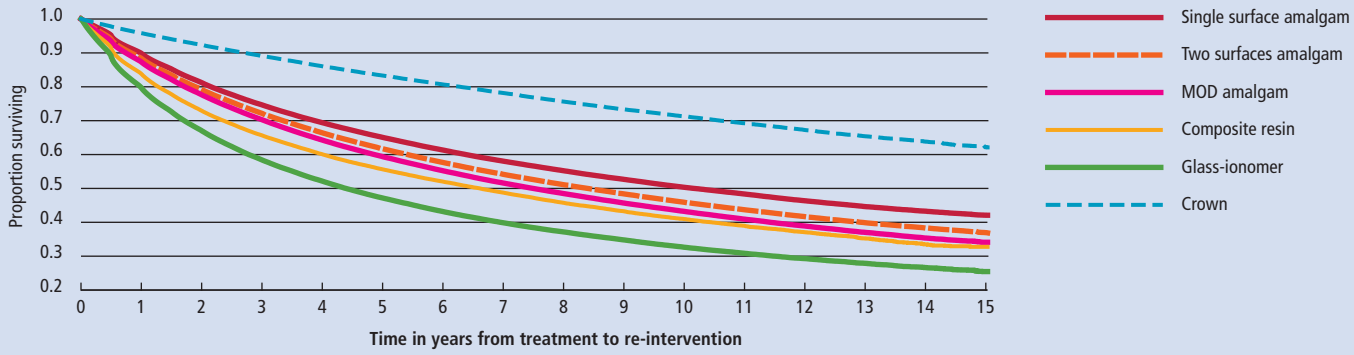

Fig. 8 Time to extraction of restored molar teeth, with regard to patient age

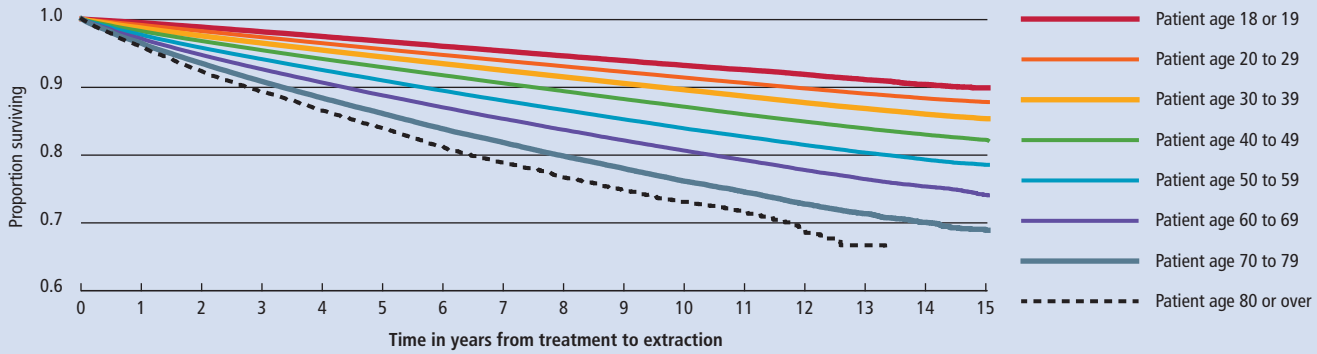

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Table 5 Ten-year survival to re-intervention of restored molar teeth, with regard to patient age and type of restoration

	Patient Age							
Treatment Type	18 or 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 or over
Single surface amalgam	65	65	63	56	49	44	40	41
Two surfaces amalgam	52	51	49	48	45	44	42	43
MOD amalgam	44	44	44	44	44	42	40	44
Composite resin	60	54	47	43	41	39	39	43
Glass-ionomer	49	41	37	34	33	32	31	34
Crown	62	65	69	71	72	71	67	68

Table 6 Ten-year survival to extraction of restored molar teeth, with regard to patient age and type of restoration

	Patient Age							
Treatment Type	18 or 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 or over
Single surface amalgam	96	94	92	88	83	78	74	70
Two surfaces amalgam	91	90	89	87	85	82	78	77
MOD amalgam	86	87	87	86	84	81	77	76
Composite resin	96	94	91	88	85	81	79	78
Glass-ionomer	93	89	87	84	79	76	71	67
Crown	85	87	89	89	89	87	84	85

this age group, MOD amalgams and GI restorations perform least favourably in terms of time to re-intervention. When the over-40 years age group is examined (Fig. 7) in terms of time to re-intervention, a crown represents a much enhanced treatment option of over 20 percentage points better survival than the next best performing restorative option, a one surface amalgam restoration.

When time to extraction of the restored molar tooth is examined (Fig. 8 and Table 4), there is a similarly strong inverse correlation between the age of the patient and the survival of the tooth to extraction. The contrast in type of restoration already noted between survival to re-intervention and survival to extraction remains when the under-40 age group is analysed with regard to restoration type (Fig. 9), but there is now a bigger difference in cumulative survival between crowns and single surface amalgam restorations. Further analysis indicates that in the under-20 age group, crowns represent the worst outcome of any treatment modality in terms of years to extraction of the restored tooth (Fig. 10). However, at the opposite end of the age spectrum, crowns again represent a good option in terms of years to extraction of the restored tooth (Fig. 11) in the 60 to 69 year age group. This effect is similar in the over 70 age group. Indeed, Tables 5 and 6 give the ten-year survival rates cross-classified by age of patient and type of treatment.

Influence of dentist factors (gender and age)

There are no differences in survival of restorations to re-intervention in molars with regard to dentists' gender. However, when dentists' age is examined, the chart indicates that restorations in molar teeth placed by younger dentists outperform those placed by older dentists by around five percentage points from five years onwards (Fig. 12). When time to extraction of the restored tooth is examined, there are still differences, albeit less marked, in relation to dentists' age. Tables 7 and 8 give the survival rates at one, five, ten and fifteen years.

Influence of patient paying for treatment or not?

When the influence of patients who are exempt from, or have remission from payment for treatment is examined, there is little influence on restoration survival to re-intervention. However, when this exercise is repeated with regard to time to extraction of the restored molar tooth, the chart indicates a three percentage point difference at 15 years, with the teeth of charge-payers surviving longer than those who do not pay (Fig. 13 and Table 9).

Influence of tooth position

With regard to tooth position, there is minimal difference in molar restoration survival to re-intervention with respect to upper vs lower arch, with restorations in upper molar teeth performing about one percentage point more favourably than those in the lower arch. However, this masks considerable differences between individual tooth positions (Fig. 14), with restorations in upper and lower third molars surviving much better to re-intervention than restorations in first molars.

When time to extraction is examined, it is apparent that survival of upper molar teeth is, overall, about three percentage points less good than for lower molar teeth. This effect may be explained by examination of the chart for all molar teeth (Fig. 15), which indicates the least good survival time to extraction of upper third molar teeth by about ten percentage points less than lower molar teeth. Tables 10 and 11 give the detailed figures.

Influence of patient treatment need

Frequency of attendance and annual spend on treatment may be considered as proxies for patient treatment need; accordingly, the influence of these on restoration survival can be examined. With regard to restoration

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Fig. 9 Time to extraction of restored molar teeth in patients under 40 years of age, with regard to restoration type

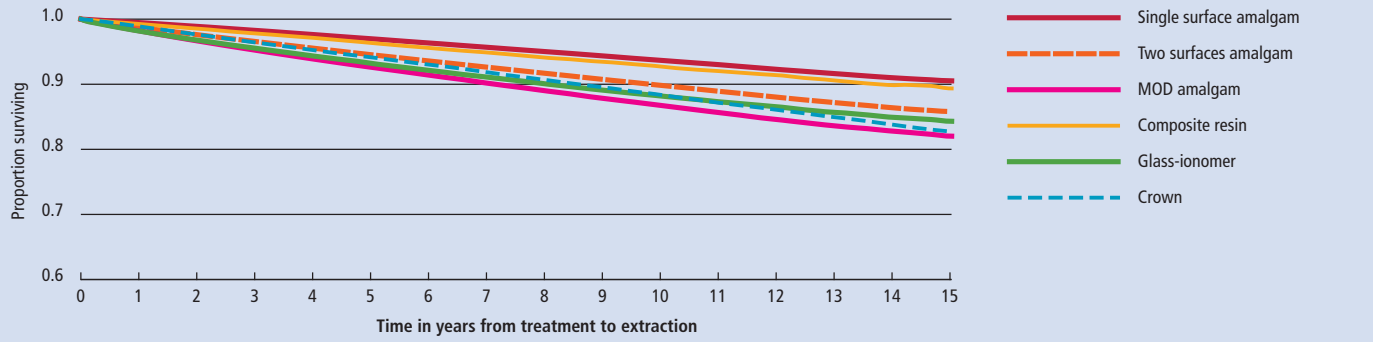


Fig. 10 Time to extraction of restored molar teeth in patients of 18 to 19 years, with regard to restoration type

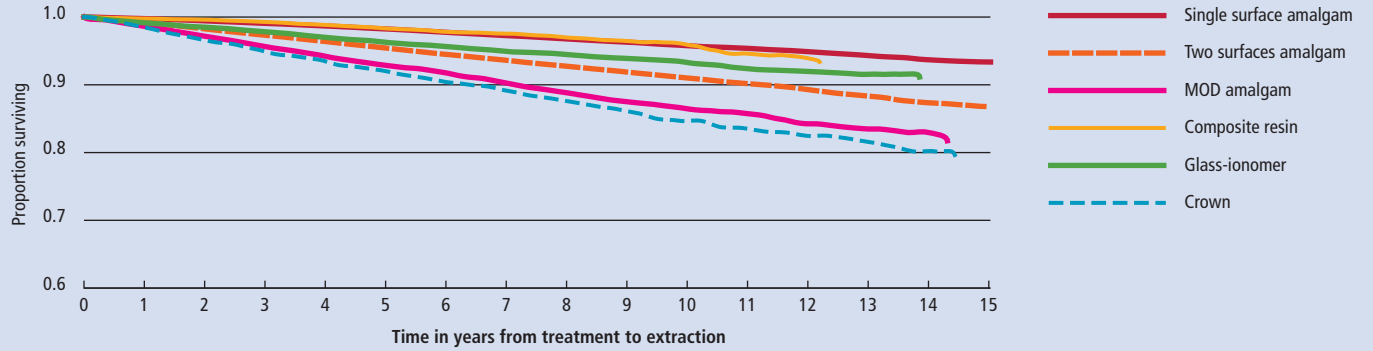


Fig. 11 Time to extraction of restored molar teeth in patients aged 60 to 69 years of age, with regard to restoration type

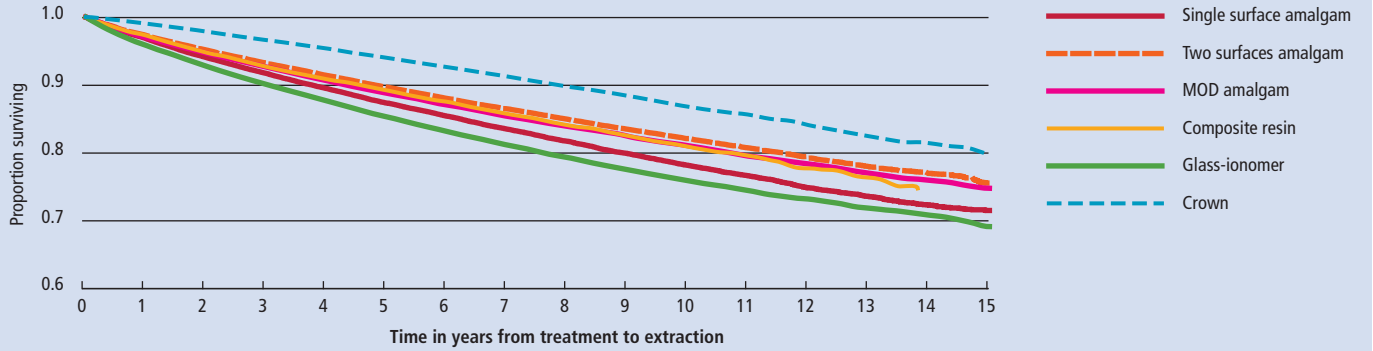
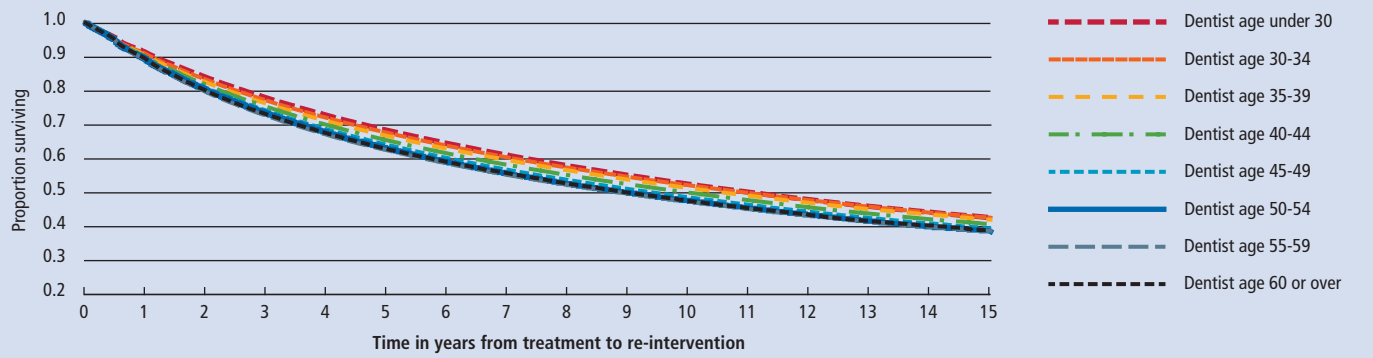


Fig. 12 Time to re-intervention of restorations in molar teeth, with regard to dentists' age



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survival to re-intervention, the chart (Fig. 16) indicates a dramatic difference between those with the least and the highest accumulation of treatment fees, with those with the highest spend having restorations which survive nearly forty percentage points less well at fifteen years than those with the least spend (Table 12). With regard to time of survival to tooth extraction, the chart (Fig. 17) for time of survival of the restored tooth is similarly dramatic. At fifteen years, patients with higher treatment need have teeth with nearly twenty percentage points worse survival than those patients with minimal treatment need. In terms of likely tooth loss, this equates to a four or five-fold increase, from around 7% to around 25% (Table 13).

Other factors

Figure 18 presents the chart relating to whether a root filling was placed in the same course of treatment as the restoration placed on the molar tooth, and indicates compromised survival of the restoration. When time to extraction is examined, it is apparent that the placement of a root filling in the same course of treatment leads to a reduced life expectancy of the tooth, by 14 percentage points in cumulative survival at fifteen years (Fig. 19). Tables 14 and 15 give the detailed figures.

Finally, the data indicate that survival of restorations in molar teeth has not improved, either in terms of time to re-intervention or time to extraction (Fig. 20), during the timespan of this study.

Discussion

General

This work presents the analysis of 25 million courses of treatment being linked over 15 years, using a new dataset which was released to the research community in August 2012 by the UK Data Service.[2] This dataset is the largest ever to become available for analysis of the survival of dental treatment. Not only does this allow a means of assessing restoration survival to re-intervention but it also facilitates the analysis by restoration type of survival of the restored tooth to extraction. In other words, survival of the tooth rather than survival of the restoration per se. The authors are unaware of other publications relating to large studies which have been able to assess the influence of restorations in this way.

This set of data faithfully represents the decisions and outcomes observed within the GDS of England and Wales. It does not provide evidence as to what the outcome would be if two competing restorations were to be applied to two different teeth in identical circumstances. However, it is reasonable to assume that each decision has been made using the practitioner's best clinical judgement, mediated by the wishes of his patient. The findings of this paper may help to add further insight to such decisions in the future, but they do not replace the other factors which the clinician must consider. There may be an overwhelming case for choosing a particular type of restoration for a particular patient, in which case this paper simply gives an indication of the likely longevity of the restoration. Any conclusions about decision-making must be prefaced by 'other considerations being equal'.

Table 7 Survival to re-intervention of restorations in molar teeth, with regard to dentists' age

Dentist age	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Dentist age under 30	91	68	53	43	1,056,512
Dentist age 30–34	91	68	52	43	1,122,638
Dentist age 35–39	90	67	51	42	1,077,353
Dentist age 40–44	90	65	50	41	991,908
Dentist age 45–49	89	64	49	40	848,624
Dentist age 50–54	89	63	48	39	639,568
Dentist age 55–59	89	63	47	39	400,812
Dentist age 60 or over	89	63	48	39	170,454
All restorations	90	66	50	41	6,307,869

Table 8 Survival to extraction of restorations in molar teeth, with regard to dentists' age

Dentist age	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Dentist age under 30	98	93	88	83	1,056,512
Dentist age 30–34	98	94	88	84	1,122,638
Dentist age 35–39	98	93	88	84	1,077,353
Dentist age 40–44	98	93	88	83	991,908
Dentist age 45–49	98	93	87	83	848,624
Dentist age 50–54	98	93	87	83	639,568
Dentist age 55–59	98	93	87	83	400,812
Dentist age 60 or over	98	93	87	82	170,454
All restorations	98	93	88	83	6,307,869

Table 9 Survival to extraction of restored molar teeth, with regard to whether the patient is exempt from charges, or not

Charge paying status	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Full charge	98	93	88	84	4,310,522
Exemption or remission	98	93	87	81	1,997,347
All restorations	98	93	88	83	6,307,869

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Fig. 13 Time to extraction of restored molar teeth, with regard to whether the patient is exempt from charges, or not

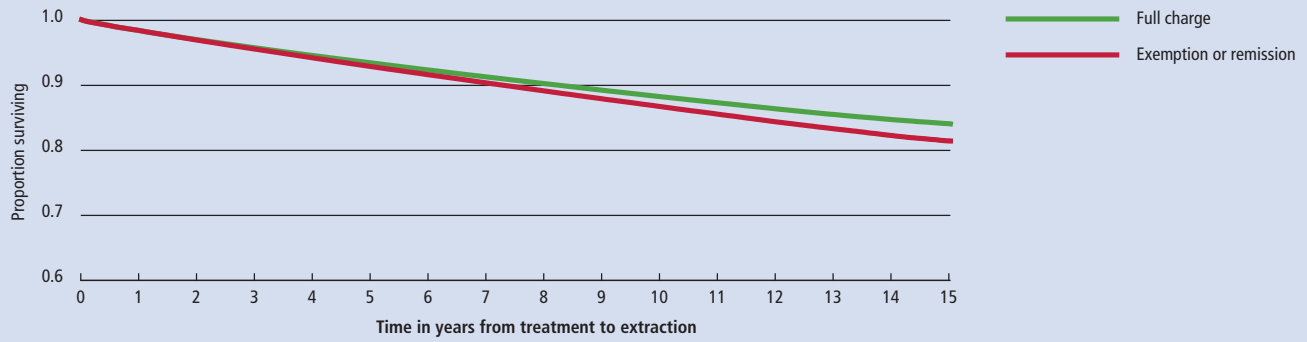


Fig. 14 Time to re-intervention of restorations in molar teeth, with respect to tooth notation and dental arch

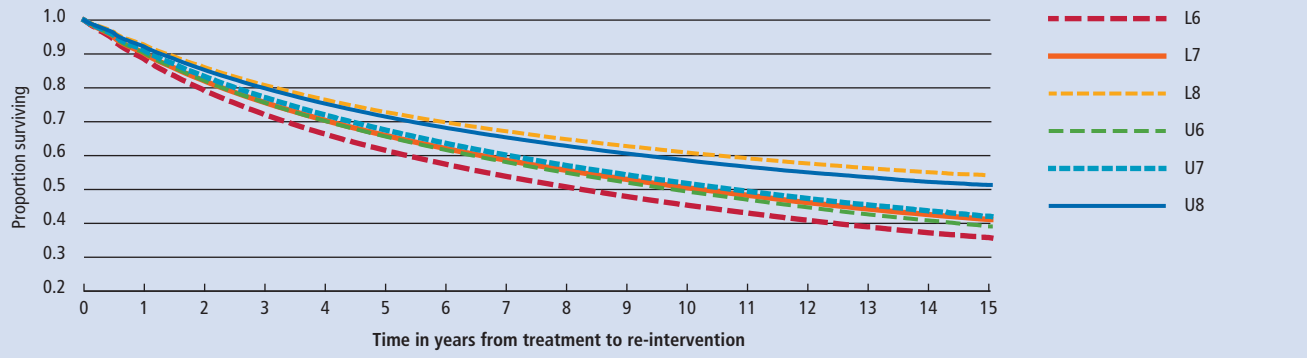
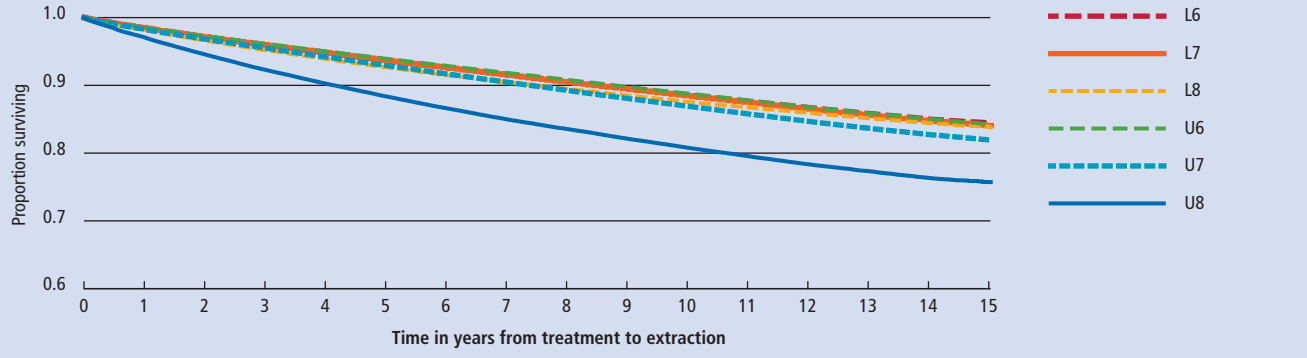


Fig. 15 Time to extraction of restored molar teeth, with regard to tooth position



Restoration survival

While the results of the present work, in respect of time to re-intervention and time to extraction of the restored tooth, may initially appear to be contradictory, the analysis confirms that, when a molar tooth is restored with a crown, the time to re-intervention outperforms all other restoration types at all ages. Indeed, unlike all other restorations, the performance of crowns improves with the patient age (Table 5), reaching an optimum for patients aged between 50 and 59.

However, when time to extraction of the restored tooth is examined, important differences may be observed. Crown performance again improves with patient age, but starts from a poor performance level relative to other restorations (Table 6). For the two youngest age groups, crowning a tooth is indicative of a reduced lifespan of the crowned tooth, even though the crown performs best in terms of restoration survival. The reasons for this may only be surmised. Compared with a full coverage (crown) restoration, the direct placement restoration has more factors which lead to failure, such as lengthy margins and secondary caries, whereas the crown may be considered to 'protect' underlying tooth substance. However, the data suggest that, when a crown fails, it is more likely to be due to a catastrophic failure, possibly due to ingress of caries, failure of the (dentine or material) core which then challenges the loss of tooth substance involved in tooth preparation for a crown. At the end of the day, however, it is retention of the (restored) tooth as opposed to

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survival of the restoration which is arguably most important.

The particular reasons for crowning a tooth at a young patient age are not known – in an anterior tooth it may be due to trauma, but this is unlikely to be a major player in a posterior tooth, where aesthetic concerns are unlikely to play a part. More likely, large carious cavities may have weakened the tooth to such an extent that a large restoration is needed, and/or a cusp is lost and a crown is considered by the clinician to replace a significant amount of lost tooth substance. In the past, texts on restorative dentistry advised the placement of a crown if and when 'teeth are so carious that they cannot be restored with amalgam or a gold inlay' or, by inference, if a cusp was lost.[3] The results of the present study indicate that this is now outmoded thinking and that restoration of the molar tooth by a direct restoration is advisable if the longevity of the tooth is to be assured. In other words, the placement of a crown in a patient under the age of 30 years may signify a challenged tooth and this results in the tooth being lost earlier than if it is restored with a direct placement restoration. However, the opposite argument is that a molar tooth should be restored with a directly placed restoration for as long as possible, because crowned teeth have poorer prognosis in terms of time of extraction. The crowning of a tooth, with the attendant need to remove tooth substance in a tooth which might already be challenged, places the tooth one step further on the road towards extraction, with sequelae such as the need for root canal treatment, given that results of research from Glasgow and Dundee Dental Schools have indicated that 19% of crowned teeth which were examined radiographically showed a periradicular radiolucency.[4] In that regard, Figures 18 and 19 indicate the poorer prognosis of a tooth which receives a root filling. On the other hand, it can be argued that it is better, in many cases, for the patient to retain a given tooth by having it root filled rather than having it extracted.

Of course, other factors can come into play to lead to extraction, such as periodontal problems, but this is unlikely to be a factor except for very few patients in the youngest age groups. The clear message is to maintain the viability of a molar tooth by restoring it with direct restorations until these become unviable, even if this course of action requires more re-interventions as the restorations fail. The cost effectiveness of these different means of restoring molar teeth is another factor which should be assessed, but this is beyond the scope of the present paper.

An additional patient factor is their treatment need. There are dramatic differences in restoration performance among patients, with those with high treatment need having restorations which perform less well in either of the methods described in this work. This

Table 10 Survival to reintervention of restored molar teeth, with regard to tooth position

Tooth/jaw	Survival (%) at				
	1 year	5 years	10 years	15 years	n
L6	88	62	45	36	1,486,537
L7	90	66	50	41	1,315,193
L8	93	73	61	54	424,347
U6	90	66	49	39	1,483,623
U7	91	68	52	42	1,243,459
U8	92	71	59	51	354,710
All restorations	90	66	50	41	6,307,869

Table 11 Survival to extraction of restored molar teeth, with regard to tooth position

Tooth/jaw	Survival (%) at				
	1 year	5 years	10 years	15 years	n
L6	98	94	89	84	1,486,537
L7	98	94	88	84	1,315,193
L8	98	93	88	84	424,347
U6	99	94	89	84	1,483,623
U7	98	93	87	82	1,243,459
U8	97	88	81	76	354,710
All restorations	98	93	88	83	6,307,869

Table 12 Survival to re-intervention of restorations in molar teeth, with regard to annual spend on treatment

Mean annual fees	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Up to £20 per annum	97	86	75	65	681,562
£20 to £60 per annum	91	68	53	43	3,336,337
Over £60 per annum	86	54	37	28	2,036,221
All restorations	90	66	50	41	6,307,869

Table 13 Survival to extraction of restorations in molar teeth, with regard to annual spend on treatment

Mean annual fees	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Up to £20 per annum	99	98	95	93	681,562
£20 to £60 per annum	99	94	90	86	3,336,337
Over £60 per annum	98	90	81	75	2,036,221
All restorations	98	93	88	83	6,307,869

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Fig. 16 Time to re-intervention of restorations in molar teeth, with regard to annual spend on treatment

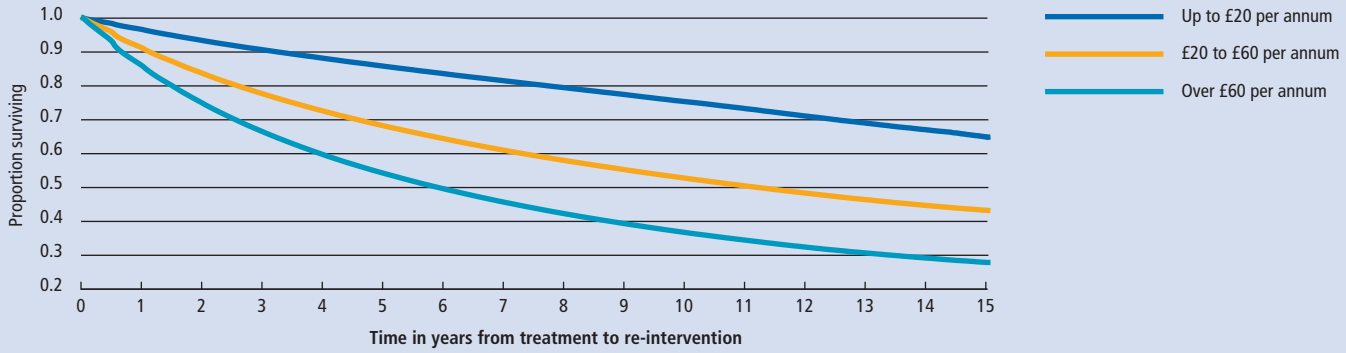

Fig. 17 Time to extraction of restored molar teeth, with regard to annual spend on treatment

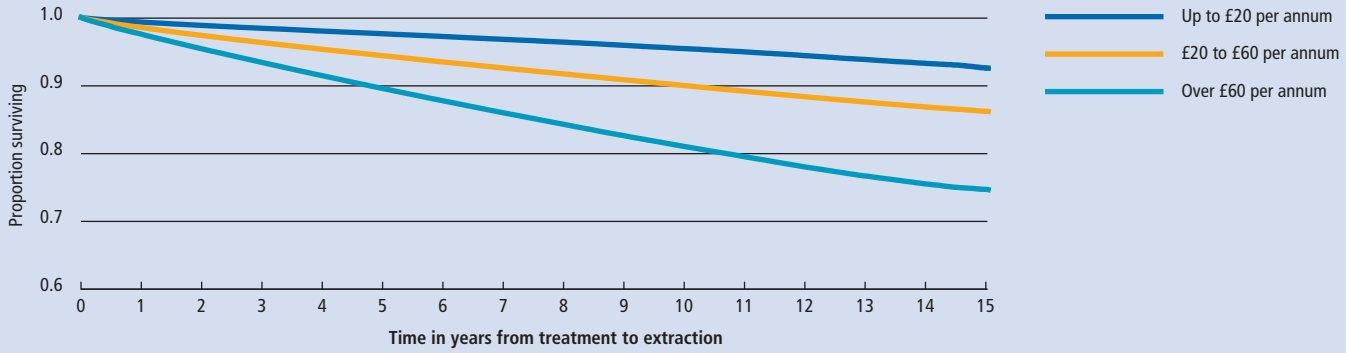

Fig. 18 Time to re-intervention of restorations in molar teeth, with regard to whether the restored tooth also received a root canal filling on the same course of treatment

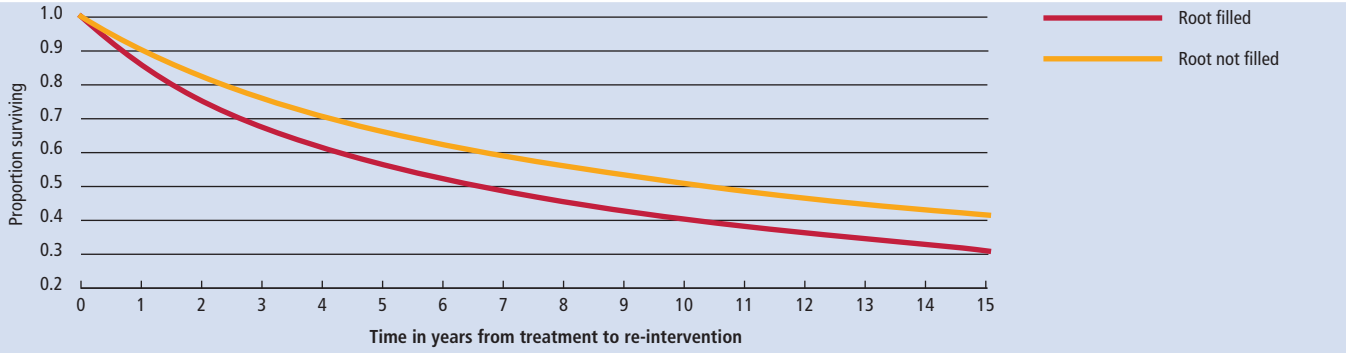

Fig. 19 Time to extraction of restored molar teeth, with regard to whether the restored tooth also received a root canal filling on the same course of treatment

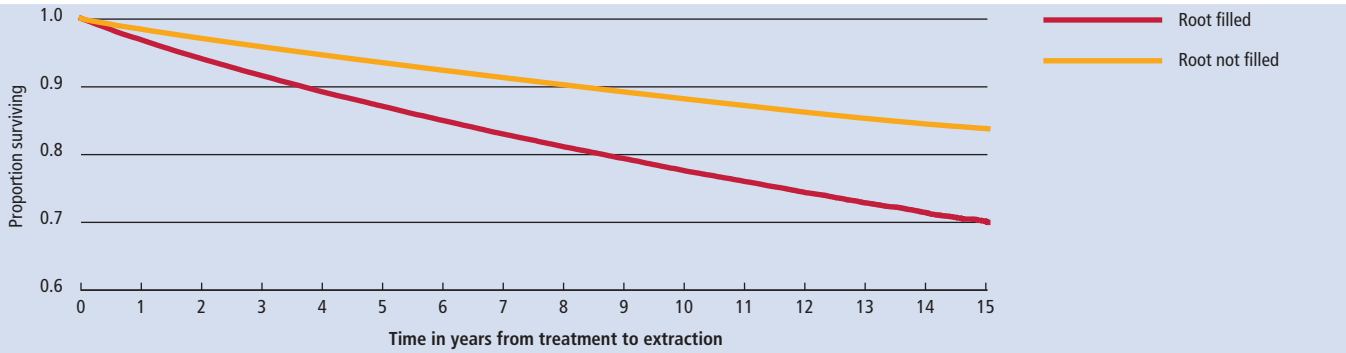

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Fig. 20 Time to extraction of the restored molar tooth, with regard to year of placement of the restoration

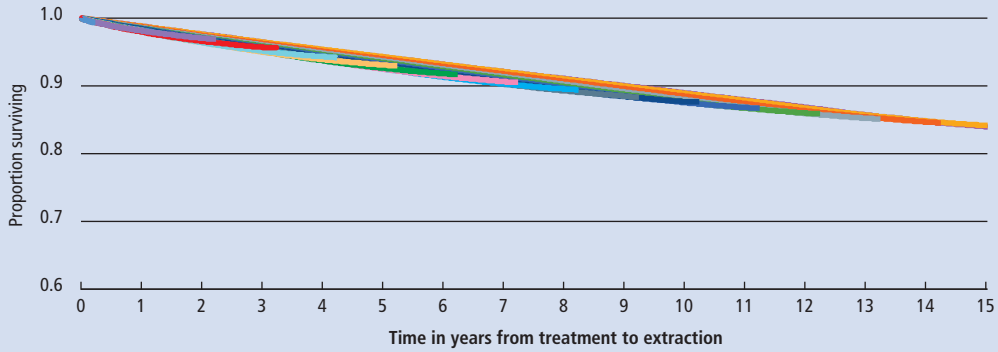

Table 14 Survival to re-intervention of restorations in molar teeth, with regard to whether the restored tooth also received a root canal filling on the same course of treatment

Root filling in same course	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Root filled	86	56	40	31	271,078
Root not filled	90	66	51	42	6,036,791
All restorations	90	66	50	41	6,307,869

Table 15 Survival to extraction of restorations in molar teeth, with regard to whether the restored tooth also received a root canal filling on the same course of treatment

Root filling in same course	Survival (%) at				
	1 year	5 years	10 years	15 years	n
Root filled	97	87	78	70	271,078
Root not filled	98	93	88	84	6,036,791
All restorations	98	93	88	83	6,307,869

could be regarded as a 'chicken and egg' situation – which came first? Patients with high caries activity will require more restorations than those with low caries activity and may be more likely to attend more frequently because of the need for emergency appointments. Either way, their restorations perform less well, perhaps indicating that some of those patients with high treatment need/high caries activity do not mend their diet or improve their oral hygiene and therefore continue to require restorations. On the other hand, the patients with high caries activity will receive larger restorations, and these fail more readily than small restorations.

When the outcome for MOD restorations is examined, it is apparent that these perform poorly in terms of re-intervention and do not perform well with regard to time to extraction of the restored tooth. The message to patients is loud and clear: a cariogenic diet and/or poor oral hygiene leading to the presence of interproximal carious lesions is well worth avoiding. To clinicians the message is also loud and clear: keeping an MOD restoration off a patient's tooth is a worthwhile course of action in molar teeth, given the previously reported potential for cusp fracture[5,6] in teeth restored with MOD amalgam restorations. The provision of two (smaller) class II restorations rather than an MOD may therefore be considered optimum treatment. In contemporary dentistry, this could involve placement of two class II (adhesive) resin composite restorations which can be placed with minimal destruction of tooth substance over and above that which has been lost through caries or trauma. In this regard, the NHS Regulations in force at the time of the data collection for this study did not permit tooth-coloured restorations in loadbearing situations. The small amount of data on composite restorations presented here relates to restorations in non-load-bearing situations such as Class V cavities.

It is interesting to note the differences in restoration survival (measured by both of the methods utilised in this work) among younger and older dentists, with restorations placed by younger dentists outperforming those placed by older dentists. This factor was also apparent with amalgam restorations, and was discussed in that paper.[7]

It is also interesting to note the effect of tooth position, with restorations in third molar teeth performing better to re-intervention than restorations in other molar teeth (Fig. 14). The number of restorations in third molar teeth is approximately one third of the numbers placed in either first or second molar teeth (Table 10), possibly indicating that, by the time that these teeth erupt, there is less potential for caries (and the associated need for a restoration), and/or that patients may be more aware of a non-cariogenic diet and may have improved oral hygiene, despite the fact that third molar teeth may be more difficult to access with a toothbrush. It may also be suggested that the clinician may experience more difficulty in viewing a restoration in a third molar tooth, making detection of its failure more problematic. On the other hand, the data indicate that upper third molar teeth survive for less time to extraction than other molar teeth (Table 11 and Figure 15), possibly indicating the difficulties which patients may experience in cleaning teeth at a remote end of their dental arch, or, potentially more likely, that these teeth may not erupt fully or into the correct/ideal position and their extraction may be indicated for reasons unrelated to their restoration history.

Finally, the recently-published comments of Opdam and Hickel[8] and Wilson and colleagues[9] are worthy of note. In writing about operative dentistry in the present changing environment, Opdam and Hickel state that, in the past, it was assumed that crowns protected damaged teeth and that 'the bur can remove more tooth

substance in a few second than caries can destroy in months or years'. The results of the present work, especially with regard to the performance of crowns on molar teeth in younger patients, reinforce these statements, insofar as the least invasive treatment involving the least removal of (sound) tooth substance should be used as the early options for carious molar teeth, with a crown only being considered when the patient is older. The longevity of the tooth, rather than the longevity of the restoration, should be the aim for all clinicians. Of course, the re-interventions which form the source information for the present work may be an indication of the dentist's attitudes, with some clinicians believing that a given restoration is unsatisfactory and intervening sooner than others. In this regard, Wilson and colleagues[9] have stated that 'two distinct patterns of care may be observed in primary care dentistry: whatever the pattern of care (regularly attending patients or new patients), the best interests of the patient are not served by unnecessary intervention.' They add that clinicians should only replace restorations as a last resort. However, throughout the present work, the data were collected at a time when there were stringent quality assurance mechanisms in place (the Dental Reference Service), so it may be assumed that clinicians acted in the best interests of the patient in the treatment that they prescribed.

Conclusions

Overall, 41% of restorations in molar teeth have survived without re-intervention at 15 years. Overall survival of restored molar teeth without extraction is 83% over fifteen years. Factors influencing survival are patient age, dentist age, and patient treatment need.

With regard to tooth position, there is minimal difference in molar tooth survival to extraction with respect to upper vs lower arch, but survival time to extraction of upper third molar teeth is the least good.

On molar teeth, when survival of the restored tooth to extraction is examined, crowns do not represent the optimally performing restoration in under-40 year age groups, leading to earlier loss of the tooth; in older age groups (over 40 years) a crown presents the best survival to extraction, of the restored tooth. In general, only MOD amalgams and glass ionomers perform less well than crowns in terms of time to extraction.

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