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Ten-year outcome of root fillings in the General Dental Services in England and Wales

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Abstract

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Aim To consider the survival of root canal treatment provided within the General Dental Services in England and Wales, with failure being defined as re-treating of a root canal, apical surgery or extraction.

Methods A data set was established consisting of patients, 18 years or older, whose birthdays were included within a set of randomly selected dates and whose restoration records contained the placement of one or more direct restorations or crowns in courses of treatment between September 1990 and January 2002. The history of each root canal-treated tooth was consulted, and the next date for an intervention on the root canal of the tooth, defined as a re-treatment, apical surgery or extraction, was obtained. Thus, a data set was created of root canal-treated teeth, with the dates of root canal filling placement and the dates, if any, of re-intervention.

Results Data for over 80 000 different adult patients were analysed, and a total of 30 843 root canal-treated teeth identified from the data over a period of 11 years. The proportion surviving without further treatment of the root canal was estimated at 74% within an observation time of up to 10 years, with survival being strongly correlated with the characteristics of the patient, including age and treatment history, with older patients having root canal treatment with earlier re-intervention than those of younger patients.

Conclusion Within the data set analysed, an estimated 74% of root canal-treated teeth pass through 10 years without re-treatment, apical surgery or extraction.

Keywords: general dental services, root filling, survival.

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Introduction

Direct placement restorations comprise the largest volume of restorations placed within the National Health Service General Dental Services (GDS) in England and Wales. However, there are also a substantial number of teeth which receive root canal treatment in any given year. For example, 1 001 675 root canal fillings were placed within the GDS in the year to March 2004, at a cost of £50.5 million (DPB Digest of Statistics 2004). It may therefore be considered that the survival of restorations, including root canal treatment, is of interest, not only to patients, but also to third-party funders, government, the clinician (and his or her managers) and to tax payers.

Root canal-treated teeth may be lost for a variety of reasons, including persisting or emerging periapical disease, recurrent caries, root fracture or periodontal disease.

It may be considered difficult to keep cohorts of patients together for long enough to provide meaningful data, so a number of studies have examined the outcome of nonsurgical root canal treatment using large dental databases. For example, Salehrabi & Rotstein (2004) using the data held at the Delta Dental Insurance Data Centre in Seattle, USA, followed

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1 462 936 teeth in 1 126 288 patients over 8 years, with a total of 97.1% of these teeth being retained at the end of the observation period, and, Caplan *et al.* (2005) utilized the data from the Kaiser Permanente Dental Care Programme in Portland, USA, with the aim of comparing survival times of root canal-treated teeth and nontreated teeth. Their results indicated that, at 8 years, root canal-treated teeth had substantially worse survival than their nonroot canal-treated counterparts. Analysis of the data quoted in the paper shows that of 216 root-filled teeth, 96 were extracted during the duration of the study, at a failure rate of 44.4%.

Aim

The aim of this study was to examine the recorded interval to re-intervention (defined as re-treatment, apical surgery or extraction) on teeth which have received root canal fillings, and the factors that may influence this. The data were obtained from a large representative sample of patients treated in the GDS of England and Wales between 1991 and 2001, full details of which have earlier been published (Lucarotti *et al.* 2005a), and consisted of items obtained from the payment claims submitted by GDS dentists to the Dental Practice Board (DPB) in Eastbourne, UK [now known as the NHS Business Services Authority (Dental Services Division)].

Materials and methods

The patients included in this study have been described previously (Lucarotti *et al.* 2005b), as well as the restoration records (Lucarotti *et al.* 2005a). These records were further restricted to those which related to courses of treatment starting on or after the patient's 18th birthday, in which one or more teeth had received root canal treatment. The data were extended to include all treatment records on any of the payment schedules from January 1991 to March 2002 for all patients who had root canal treatment on at least one tooth. The subsequent history of intervention on each tooth was consulted, and the next date of intervention (defined as a root canal treatment, apical surgery or extraction) ascertained, if any could be found in the data set. In this study, the date of the initial root canal treatment was taken to be the last date recorded in the payment claim in respect of the course of treatment. In most cases this was the date when the dentist discharged the patient at the end of the course of treatment. The date of the apparent failure of root canal treatment was taken as the date of acceptance for the next course of treatment in which the tooth received a root canal treatment, apical surgery or extraction. A data set was thereby created of root canal-treated teeth, with the dates of initial treatment and the dates, if any, of re-intervention on the root of the root canal-treated tooth.

A technique for analysing incomplete survival data with individual dates of 'life' and 'death' was developed by Kaplan and Meier in 1958 (described in Collett 1994). If it were known that all patients with restorations who had not yet received re-intervention were still attending their dentists at 1st January 2002, then Kaplan–Meier analysis could be applied directly, using 31st December 2001 as the censoring date. Most published longitudinal studies have the benefit of explicit records of when participants ceased to be included, for example because the patient failed to attend for an annual re-examination, or because the patient ceased to be a member of the insurance scheme. However, for patients who are free to choose their own re-attendance interval, as in the case of the UK GDS, it is unrealistic to suppose that all the patients would re-attend, just as it is unrealistic to assume that they ceased to be potential re-attenders, immediately after their last recorded attendance. A technique has been devised by Lucarotti (Lucarotti 2004) to modify Kaplan–Meier analysis to allow for the probability that a patient would eventually re-attend, dependent on the time interval from the last record of attendance by the patient to the end of the observation period (31st December 2001), together with the age of the patient. For direct restorations in general, this method resulted in a difference, compared with assuming all patients would eventually re-attend, of four percentage points at 5 years and eleven percentage points at 10 years, in the estimated percentage survival probability (Lucarotti *et al.* 2005a). This modified Kaplan–Meier analysis has been used to quantify the distribution of survival times of teeth with root canal fillings and examine factors which might influence the survival time. Factors investigated were:

- Tooth position and mouth quadrant
- Gender of dentist and gender of patient
- Region in which dentist practised and its fluoridation status
- Dentist's status (assistant, principal or Vocational Dental Practitioner [VDP]), dentist's age, and dentist's country of qualification

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- Year and month of placement
- Patient's age, charge-paying status, treatment incidence (as measured by annual gross fees spent) and attendance pattern
- Patient's change of dentist, or not

The whole set of analyses was repeated on a second and nonoverlapping random sample selected in the same way.

The influence of the coronal restoration in the tooth is the subject of another paper.

Results

In this section, survival is defined as survival to re-intervention on the root of the root canal-filled tooth, defined as re-treatment, apical surgery or extraction.

Characteristics of the sample population

The characteristics of the sample population are as follows:

1. Just over 80 000 different adult patients were identified, of whom 46% were male and 54% female.

2. Between them they accounted for 719 009 claims for payment sent to the DPB.

3. 30 843 teeth with root canal fillings under crowns or direct-placement restorations were identified.

4. Overall, survival of root canal-treated teeth to re-intervention,as illustrated in Fig. 1, was found to be 95.9% (standard error 0.1%) at 1 year, 84.1% (SE 0.3%) at 5 years and 73.7% (SE 0.6%) at 10 years.

5. Translated into 95% confidence intervals: (i) 1-year survival is estimated to be between 95.7 and 96.1%; (ii) 5-year survival is estimated to be between 83.6 and 84.8%; (iii) 10-year survival is estimated to be between 72.5 and 74.9%.

Factors influencing survival of teeth with root canal filings

With such a large sample, even very slight correlations give rise to statistically significant results in tests such as the Log-Rank test. Accordingly, a threshold of $P = 0.005$ has been used instead of the customary 0.05 or 0.01.

First, with this threshold, the factors which were found not to influence survival of root canal fillings were:

- Mouth quadrant (significance level 0.006)
- Gender of dentist and gender of patient (significance level 0.006)
- Region in which dentist practised and its fluoridation status
- Dentist's status
- Dentist's age
- Dentist's experience and country of qualification
- Year and month of placement

An example of a survival curve of a factor which did not influence survival is presented in Fig. 2 (mouth quadrant).

Dentist factors were found to have little influence on survival of root canal-treated teeth, but in common with directly placed restorations (Burke *et al.* 2005), survival was found to be profoundly influenced by patient factors. Patients' age (Fig. 3), patients' charge-paying status (Fig. 4), patients' treatment incidence (as measured by mean annual gross fees incurred) (Fig. 5), and median interval between courses of treatment (Fig. 6) were all found to have an effect. With regard to patients' age, it is clear that older patients are associated with root canal fillings having poorer survival than younger patients, with survival at 10 years of root canal fillings in patients aged between 70 and 79 years being 62%, compared with survival of root

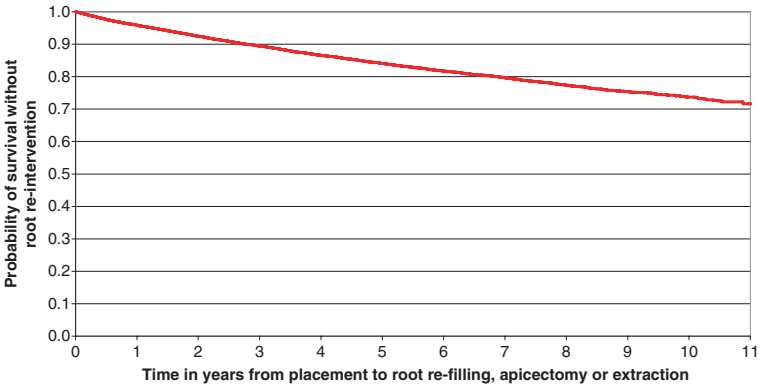

Figure 1 Survival of root-filled teeth: overall.

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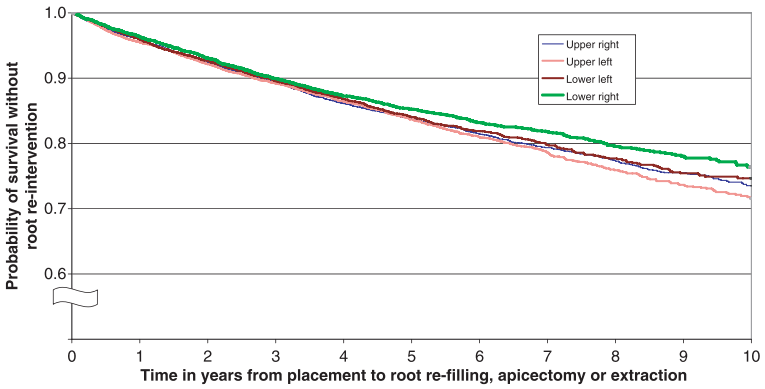

Figure 2 Survival of root-filled teeth: by mouth quadrant.

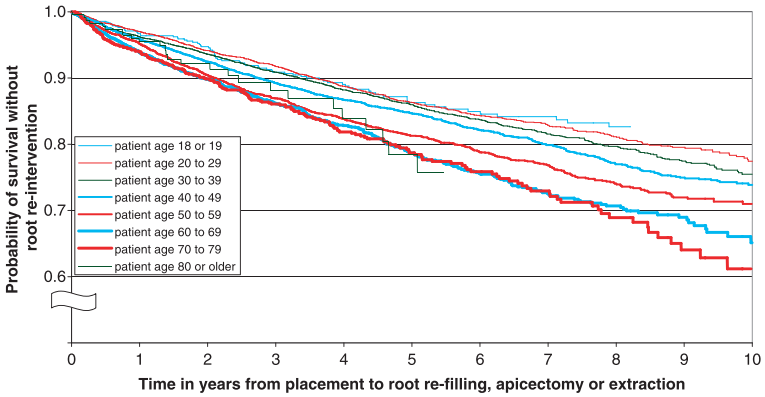

Figure 3 Survival of root filled teeth: by patient age.

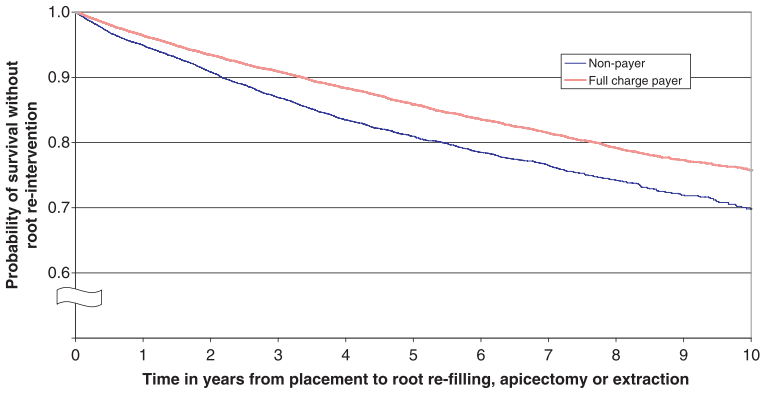

Figure 4 Survival of root-filled teeth: by patient charge-paying status.

fillings in patients aged 20–29 years being 77% at 10 years (Fig. 3). It is also clear that root canal treatment provided for patients who are exempt from NHS treatment charges had a poorer survival than patients who pay full NHS charges for their treatment (Fig. 4). Similarly, root canal treatment for patients with high treatment incidence (as measured by mean annual gross fees spent or incurred) (Fig. 5), and short median interval between courses of treatment (Fig. 6), both of which could be considered to be a proxy for high treatment needs, had poorer survival than root canal treatment for patients who required less treatment and attended less frequently. In this respect, the interval between two successive courses of treatment is taken as the interval between the two dates of acceptance, where the date of acceptance is generally the date when the dentist examines the patient at the start of the course of treatment. The median is taken

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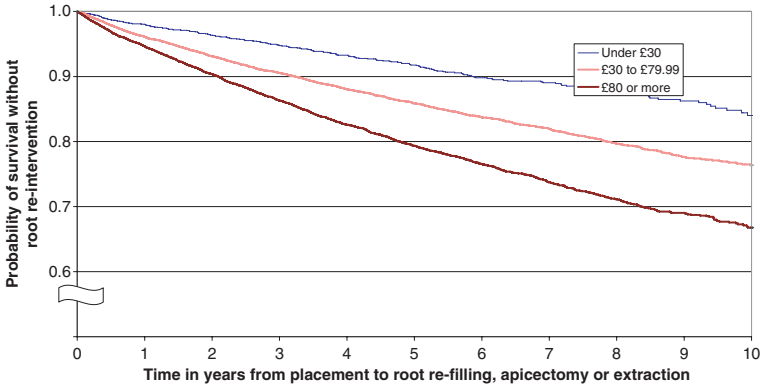

Figure 5 Survival of root-filled teeth: by patient's mean annual gross fees.

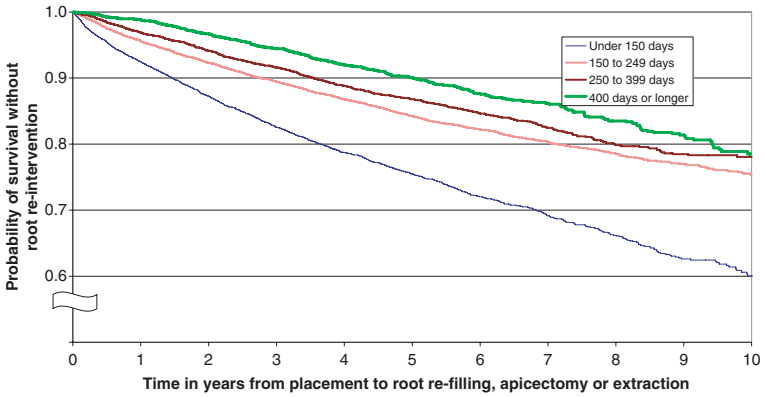

Figure 6 Survival of root-filled teeth: by patient's median attendance interval.

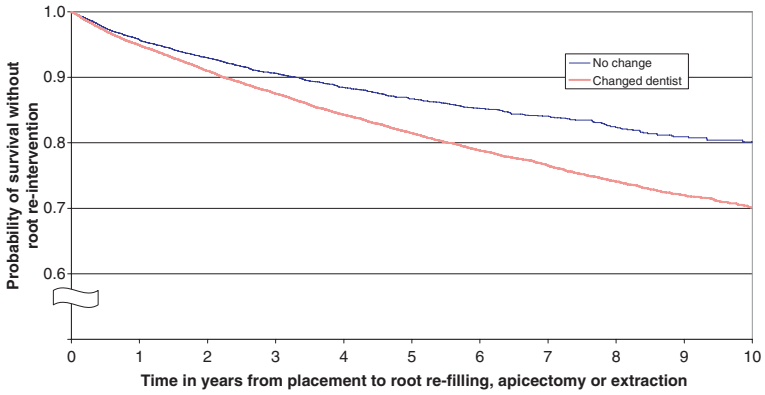

Figure 7 Survival of root-filled teeth: by whether patient changed dentist.

over all pairs of successive courses of treatment reported for the patient over the 11-year observation period. Additionally, root canal treatment for patients who changed their dentist had a shorter survival time (Fig. 7).

Regarding tooth factors, root canal treatment on central incisor (tooth position 1) and first premolar teeth (position 4) had the best rates of survival, whereas lateral incisor (position 2) and canine teeth (position 3) had least good rates of survival (Fig. 8). Overall, mouth quadrant had no effect. When maxillary and mandibular teeth are compared, there were few differences, except that root canal treatment in maxillary premolar teeth performed less well than in mandibular premolar teeth. The individual tooth in which root canal treatment performed least well was

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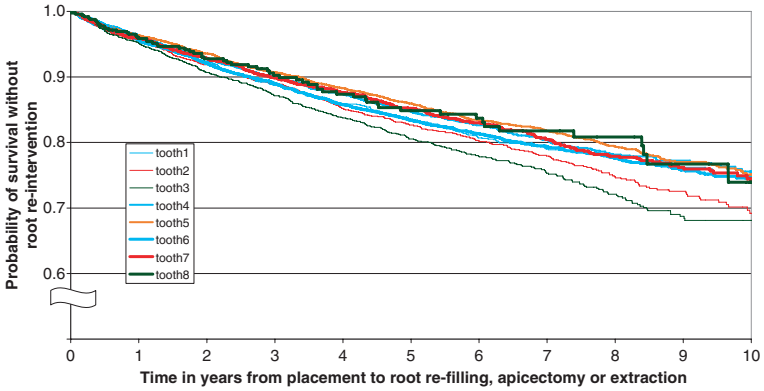

Figure 8 Survival of root-filled teeth: by tooth position.

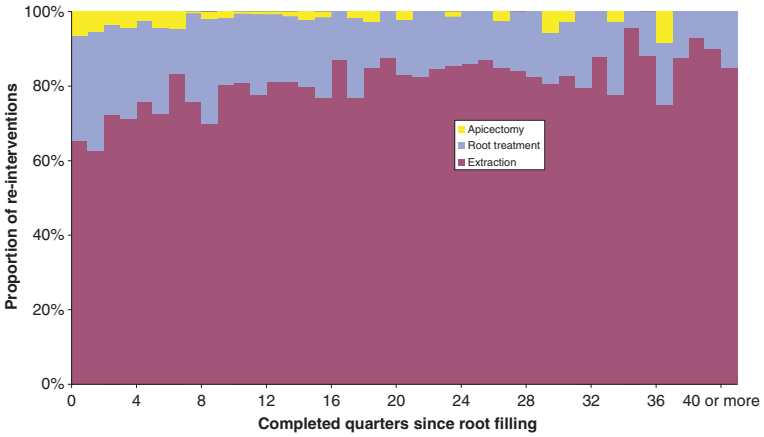

Figure 9 Type of intervention on root-filled teeth: by interval since root filling.

the canine tooth, with further analysis indicating no statistically significant difference between maxillary and mandibular canine teeth.

Figure 9 presents the treatments instituted when root canal treatment is deemed to have failed. This indicates that the most frequent treatment is extraction, with this occurring in approximately 70% of cases.

The analysis was repeated using extraction as the sole criterion for failure with the following results:

one-year survival to extraction is estimated to be between 96.8 and 97.2%; 5-year survival to extraction is estimated to be between 86.6 and 87.8%; 10-year survival to extraction is estimated to be between 76.7 and 78.7%.

Discussion

This study has analysed factors influencing the survival of root canal treatment within the GDS in England and Wales, where survival has been defined as time to a re-intervention on the tooth root, and that intervention being, most commonly, extraction and, least commonly, apical surgery. The results indicate that 74% of teeth with root canal fillings survive without further treatment to the root at 10 years, with tooth type, patient age and patient factors such as charge-paying status influencing survival. In this respect, the term 'survival' is used advisedly and may be considered to indicate retention of a root-treated tooth in the mouth, as opposed to 'success' which could be considered to indicate a tooth which was asymptomatic, but also radiographically without evidence of periradicular pathosis. Within the GDS, it may be considered that re-intervention will generally occur as a result of patient symptoms and/or signs, rather than as a result of radiographic signs of persisting or emerging disease. Hence, the use of the term *survival* in this work.

The database has the advantage of assessing large numbers of treated teeth for a relatively long period of time, but has the disadvantage of not holding information on a number of factors, such as the pre-

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operative periapical status of the teeth which were treated (this having been found to have an influence on prognosis; Hoen & Pink 2002), and attachment loss. An additional disadvantage is the lack of information on the technical quality of root fillings in terms of length and voids, although quality is monitored within the GDS by a team of Dental Reference Officers who carry out regular checks. In this respect, the only published information on the quality of root canal fillings in the GDS is that by Dummer (1998). Nevertheless, the database contains much information, including a variety of patient factors and dentists' characteristics, and the influence of tooth position.

Tooth type is a significant influence (Fig. 8), and may reflect variations in root canal morphology in different teeth, with root fillings in molar teeth having lower survival rates. This may reflect problems in identifying, negotiating, preparing and filling root canals in these teeth. Lateral incisor teeth have rates of survival which are significantly worse than central incisor teeth, and it may be postulated that the difficulty in the management of the disto-palatal curvature, found in many maxillary lateral incisor teeth, is partly responsible for this.

Root canal treatment survival was lowest in canine teeth. These teeth generally have an accessible and relatively straight root canal which might be expected to facilitate debridement and disinfection. However, canine teeth have long roots and their poor survival rates may suggest that clinicians have difficulty reaching the canal terminus with instruments (given that the standard root canal instrument is 25 mm in length, i.e. shorter than the length of many canine teeth). Incomplete instrumentation does not facilitate penetration of irrigating/disinfecting solutions and, ultimately, root filling to the desired length. In addition, the mandibular canine tooth either has a root canal with a very long oval cross section which is difficult to clean, or two separate canals. In the latter case, the lingual one may potentially remain uninstrumented because of insufficient access.

Patient factors influence survival of directly placed restorations (Burke *et al.* 2005) and, similarly, patient factors have been found to be associated with survival of root canal-treated teeth. Patient age is clearly influential, with the 10-year survival in the teeth of patients over 70 years of age being 16 percentage points less than those in the teeth of patients aged below 30 years. A reason for this may be considered to be the potentially more sclerosed canals in older patients or compromised immune systems. However, the data in the present study do not distinguish between extractions for endodontic reasons and extractions for other reasons such as periodontal disease or unrestorability of the tooth crown and, accordingly, the results may be skewed in older age groups for these reasons. Root canal treatment is time-consuming and potentially challenging, for both patient and clinician, and it may be suggested that such treatment can only be justified when the benefits clearly outweigh the cost and when the restorability of the tooth is assured.

Similar comments may be considered to apply to other patient factors. Patients with high treatment incidence and frequent rates of attendance (both being potential indicators of high treatment need) also have poorer survival than patients with lower treatment needs. Although caries may only affect the crown or root surface of a tooth, there is clearly a relationship between caries incidence/treatment need and survival of root canal treatment. Again, it might be considered that, in these groups, the loss of a tooth by extraction may not always be as a result of a failed root canal treatment, but, perhaps may be a result of the tooth crown being unrestorable—or that restoration can no longer be justified in a patient with high caries rate, poor oral hygiene and/or poor motivation, or all of these. In view of the findings of the present study, it is questionable whether root canal treatment can be justified in patients with high treatment need, or whether root canal treatment should only be attempted in such patients when the crown of the tooth is restorable, and the patient with poor oral hygiene and high caries activity has been motivated to change their behaviour.

Patient's age was a significant factor in tooth retention in the present work, but few previous studies have examined its impact. However, analysis of an insurance database indicated that the incidence of subsequent extraction for both genders increased 1–2% per decade until reaching a plateau after the age of 60 (Lazarski *et al.* 2001). This finding is in general agreement with the results of the present study.

Examination of Fig. 9 shows that extraction was the treatment most frequently instituted following failure of a root filling, with this occurring in approximately 60% of such cases in the early years post-root filling, and increasing to approximately 80% in later years. This later failure may be considered to be more likely to be managed by extraction, which is a more simple treatment option than re-treatment or apical surgery in the hands of general dental practitioners. The high proportion of extractions in the early months after placement of a root filling may

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indicate that, in the cases where extraction occurred, the root canal was performed in an attempt to prolong the life of the tooth, but in the event of apparent short-term failure the patient and dentist opted for extraction.

Few comparable data using such a large database for a long observation period are available in the literature. However, Salehrabi & Rotstein (2004) published data from the Delta Dental Insurance Data Center in Seattle, WA, USA. These researchers observed 1 462 936 teeth in 1 126 288 patients over 8 years, with a total of 97.1% of these teeth being retained at the end of the observation period. Most 'untoward events', such as re-treatment, apical surgery or extraction were recognized within the first 3 years, in contrast to the findings of the present study in which these indicators of failure of the initial treatment occurred more evenly over the period of the study. Salehrabi & Rotstein (2004) analysed the treatments carried out following root canal filling, finding that anterior teeth were more likely to receive apical surgery than molar and premolar teeth. The results of the present study reveal similar findings. Salehrabi & Rotstein (2004) also found that teeth without coronal coverage were significantly more likely to be extracted than those which were crowned. The present study did not find a significant relationship between the type of restoration in the crown of the tooth and the survival of the root filling, but a more detailed analysis of the survival of teeth with crowns is the subject of another paper.

Caplan *et al.* (2005) analysed a substantially smaller database than the one in this study obtained from the Kaiser Permanente Dental Care Programme (KPDCP), using data from 105 general dentists and specialists practising in 12 clinics in Portland, OR, USA. The aim was to compare survival times of root canal-treated teeth and nontreated teeth (Caplan *et al.* 2005). Their results indicated that, at 8 years, root canal-treated teeth had substantially worse survival than their nonroot canal-treated counterparts. Analysis of the data quoted in the paper shows that, of 216 root-filled teeth, 96 were extracted during the duration of the study, at a failure rate of 44.4%. The results presented in the present study are substantially better than this. When viewed in this light, it could be argued that the 74% survival rate of root canal fillings reported here represents extremely good value for money, not only for the patient, but also for the tax payer.

Stoll *et al.* (2005) examined factors influencing survival of 914 root canal-treated teeth (in the Dental School in Phillips University, Marburg, Germany). It is of interest to note that the 10-year survival probability recorded by Stoll and his colleagues was very similar, at 0.74%, to that recorded in the present work.

The radiographic quality of root fillings carried out in the GDS in December 1994 was evaluated by Dummer (1998) in a comprehensive assessment of 851 root canal-treated teeth. The results of this investigation indicated that 36% of the root canal fillings that were assessed completely filled the canals, that 39% of the root canal fillings terminated within 2 mm of the root apex, that 10% of canals were overfilled and 1% had a fractured instrument, concluding that the technical quality of the root canal fillings fell below accepted European guidelines. Dummer added that the technical quality does not necessarily reflect outcome, a point reinforced by the results of the present study, in which survival rates of 74% were observed at 10 years.

Marquis *et al.* (2006) examined the 4- to 6-year success rate of root canal treatment in the Phase III 'Toronto study', involving 132 teeth, classifying 85% of these as healed, and 95% as functional. It is therefore apparent that high rates of healing (85%) may be achieved for root canal treatment, and the chance of root-treated teeth remaining functional after treatment may be as high as 95%, even if some may present radiographic signs associated with disease.

Criteria for success in root canal treatment have been considered to be (European Society of Endodontology 2006): absence of pain, absence of swelling, absence of other symptoms, no sinus tract and radiographic evidence of a normal periodontal ligament space around the root. It may be postulated that failure, in the present study, would be occasioned by a patient's expression of tenderness, pain or swelling, leading to an intervention. However, there must remain a possibility that different dentists will use differing criteria before initiating further treatment (Reit 2002). This, however, is a practice-based research, which encompasses the whole spectrum of clinical practice, with dentists of differing clinical undergraduate and post-graduate experiences and also using a variety of canal preparation and filling techniques. Nevertheless, the number of root canal treatments in the present study is large and may therefore be considered to represent the overall picture of effectiveness of root canal treatment in the GDS in England and Wales.

Finally, teeth that received root treatments in the Delta Dental Insurance database had a longer survival than those in the database used in the present study. Whether this represents differences in root canal management between US and UK dentists, or whether

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there are other issues, is a matter for debate. It may also represent a difference between the methods of funding for dental treatment, given that the fees for root canal treatment are substantially lower in the GDS in England and Wales than in the USA (Schein B. personal communication, 17 December 2006). Indeed, in comparing the fees in the GDS with those in the Delta Insurance system, the fees awarded in England and Wales are between one-sixth and one-seventh of those in the Delta Insurance System (Schein B. personal communication, December 2006).

Conclusion

Within the limitations of this study, the results indicate that, overall, 74% of root canal-treated teeth survived with no re-intervention at 10 years. Patient factors such as age, charge-paying status, and treatment need significantly influenced survival of root canal fillings. Tooth type was also influential, with root canal treatment in canine teeth performing least well and that in central incisor teeth performing best at 10 years.

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