

Needs Assessment Report on
Endodontics

October 2008



Published by NHS Health Scotland

Edinburgh office

Woodburn House
Canaan Lane
Edinburgh EH10 4SG

Glasgow office

Elphinstone House
65 West Regent Street
Glasgow G2 2AF

© NHS Health Scotland, 2008

ISBN: 978-1-84485-440-0

NHS Health Scotland is a WHO
Collaborating Centre for Health Promotion
and Public Health Development

Members of the working group

Derek Richards, Consultant in Dental Public Health, NHS Forth Valley, Chair of the Working Group

Gillian Ainsworth, Associate Specialist in Oral Surgery, Glasgow Dental Hospital

Eric Canning, Patient Representative

Sandhip Dhar, Senior House Officer in Dental Public Health, Glasgow Dental Hospital

Alan Donaldson, Specialist Registrar in Restorative Dentistry, Glasgow Dental Hospital

Andrew Hadden, Dental Advisor, MDDUS

Lorna McCaul, Consultant in Restorative Dentistry, Edinburgh Dental Institute

Alistair McDonald, Specialist Practitioner, Glasgow

Jennifer Rodgers, Locum Consultant in Dental Public Health, NHS Forth Valley

Lee Savarrio, Consultant in Restorative Dentistry, Glasgow Dental Hospital

William Saunders, Professor of Endodontology, Dundee Dental Hospital

Jim Young, General Dental Practitioner, Bathgate

With thanks to Imran Shafi for compiling the Glossary of Terms

Cover image reproduced with permission from Brown & Herbranson Imaging, 3D Interactive Tooth Atlas (www.brownandherbranson.com/index.shtml).

Contents

1	Executive summary and recommendations	7
2	Aims and objectives of the report	11
3	Introduction	13
4	Endodontics in Scotland	17
a	Current NHS activity	18
b	Endodontic need and demand	19
c	Criteria for success and failure	21
d	Endodontic treatment costs	25
5	Strategies	29
a	Prevention strategies	30
b	Model of care	31
6	Conclusions	33
7	Appendices	35
8	References	53

Glossary of terms/synonyms

Apical	refers to the direction towards the root tip of the tooth
Apicectomy	surgical procedure where the tooth root tip is removed and a root end cavity is prepared and filled with a biocompatible material
Chlorhexidine	antiseptic with fungicidal and bactericidal properties
Continuing Professional Development (CPD)	continued education of health care professionals to affirm their competency and registration
Coronal	refers to the direction towards the crown of the tooth
Demineralisation	loss of mineral from tooth or bone
Dental caries	disease process that destroys the structure of the tooth
Dental implant	artificial tooth root replacement made from metal titanium that is surgically inserted into the mouth
Endodontics	field of dentistry that deals with the tooth pulp and the tissues surrounding the root of a tooth
Fistula	abnormal connection between two structures that normally do not connect
Fixed bridge	prosthesis used to replace missing teeth, utilising the teeth on either side of the gap, not removed by the patient
Managed Clinical Network (MCN)	network of a variety of health staff and organisations, working together to make sure that high-quality, clinically effective services are fairly distributed
Obturation	procedure to block the cleaned and shaped dental root canal
Orthograde treatment	root treating the tooth through the crown (non-surgical)
Partial denture	replacement teeth for functional or aesthetic reasons that the patient can remove and reinsert themselves

Pathology	study of disease: its causes, processes, development, consequences, and anatomic and functional manifestations
Periapical	descriptive term to signify around the tip of the root of the tooth
Periodontal ligament	fibres that attach the tooth to the bone
Periodontitis	inflammatory diseases that affect the tissues supporting and surrounding the teeth
Periradicular	descriptive term to signify the area around the root of the tooth
Post system	a rod that a dentist has positioned and then cemented in the canal space in a tooth's root, to assist in its restoration
Pulp	centre of a tooth made up of living soft tissue, cells, nerves and blood vessels
Pulpectomy	intervention that results in all of the dental pulp being removed
Pulpotomy	intervention that results in some of the dental pulp being removed
Radiolucency	a descriptive radiographic term that shows a dark area, which may be indicative of changes to or infection in a tooth
Re-section	removal of part of an organ or structure
Root canal therapy (RCT)	the treatment of disease or inflammation of the dental pulp or root canal
Rotary endodontic system	motorised hand-held dental system used to undertake endodontic treatment
Smear layer	organic and inorganic debris layer produced during dental procedures
Sodium hypochlorite	commonly known as bleach; is frequently used as a disinfectant in endodontic treatment
Zinc oxide eugenol	intermediate restorative material used as filling or cement

Chapter 1

Executive summary and recommendations

1 Executive summary

This Scottish Dental Needs Assessment Programme (SDNAP) report considers endodontic treatment provision in Scotland.

This report found that endodontic treatment was an effective method of retaining teeth that had suffered irreversible damage to the dental pulp. Endodontic provision under the NHS has decreased in recent years and there is variation in the willingness of some practitioners to carry out endodontics. Pain and cost were cited by patients as reasons for not having endodontic treatment.

Recommendations

Prevention

- 1 There is a need to improve primary prevention of endodontic problems through positive changes to an individual's lifestyle concerning diet and oral hygiene.
- 2 The need for endodontics due to trauma should be reduced by encouraging the use of sports mouth guards from a young age and reducing alcohol-related violence.
- 3 Prevention programmes for adult patients should be addressed by the individual NHS health boards in Scotland and represented in their health plans.
- 4 In recent years, there has been significant investment in oral health promotion programmes for children. In the long term this will have an impact on the adult population. However, as water fluoridation would provide an effect throughout life, this prevention option should be kept under review.

Treatment quality

- 5 Many factors influence the outcome of root canal treatments. The profession as a whole should be made aware of these, via specialist and CPD courses, to increase the prognosis of treatments within general practice.
- 6 Guidance on which teeth are restorable by RCT should be developed.
- 7 NHS payment structure for endodontic treatment should be re-structured with incentives to improve the quality of endodontic treatment.
- 8 There is a need for better quality routine information on both the type of root canal treatment provided and the outcome of treatment within the NHS in Scotland.

Service delivery

- 9 There is inadequate specialist endodontic provision in Scotland. This should be addressed by the development of a managed clinical network (MCN) for endodontic treatment whose members should take part in regular audit and CPD.
- 10 There is a variation across Scotland in the willingness of individual practitioners to carry out endodontics. The anecdotal evidence points to the current level of remuneration but all possible reasons should be investigated.
- 11 The workforce review should consider how many endodontists or dentists with a special interest (DwSI) in endodontics are required in Scotland.
- 12 The profile of endodontics in dental schools should be raised to that of other dental specialities. The teaching should ideally be delivered by specialists.

Research

- 13 There is a need for high-quality, long-term studies to detect differences in methods of treatment, materials and types of care. A coordinated approach throughout Scotland should be applied when planning studies to ensure that all areas of research are represented and there is no duplication of work.

Chapter 2

Aims and objectives of the report

2 Aims and objectives of the report

This report will discuss endodontics using both already available data and information collected specifically using a needs assessment approach.

Needs assessment is a systematic method of identifying unmet health care needs of a population and making changes to meet these needs. Needs assessment is used to improve health and other service planning, priority setting and policy development.

Economists will argue that the capacity to benefit is always greater than the available resources, so needs assessment should also incorporate the cost-effectiveness of the available interventions.

The report looks at the available information on endodontic need in Scotland, criteria for success and failure and endodontic strategies. It will also address the issue of endodontic treatment costs. It is hoped that it will inform those who are interested in the subject of endodontics and help to guide in the development of endodontic services in Scotland.

The group compiled a list of questions that they considered important in relation to the provision of endodontic treatment. These are detailed in Appendix 1. Although not all questions are addressed by this report, they still help to inform the discussions when considering the aims and objectives of the report.

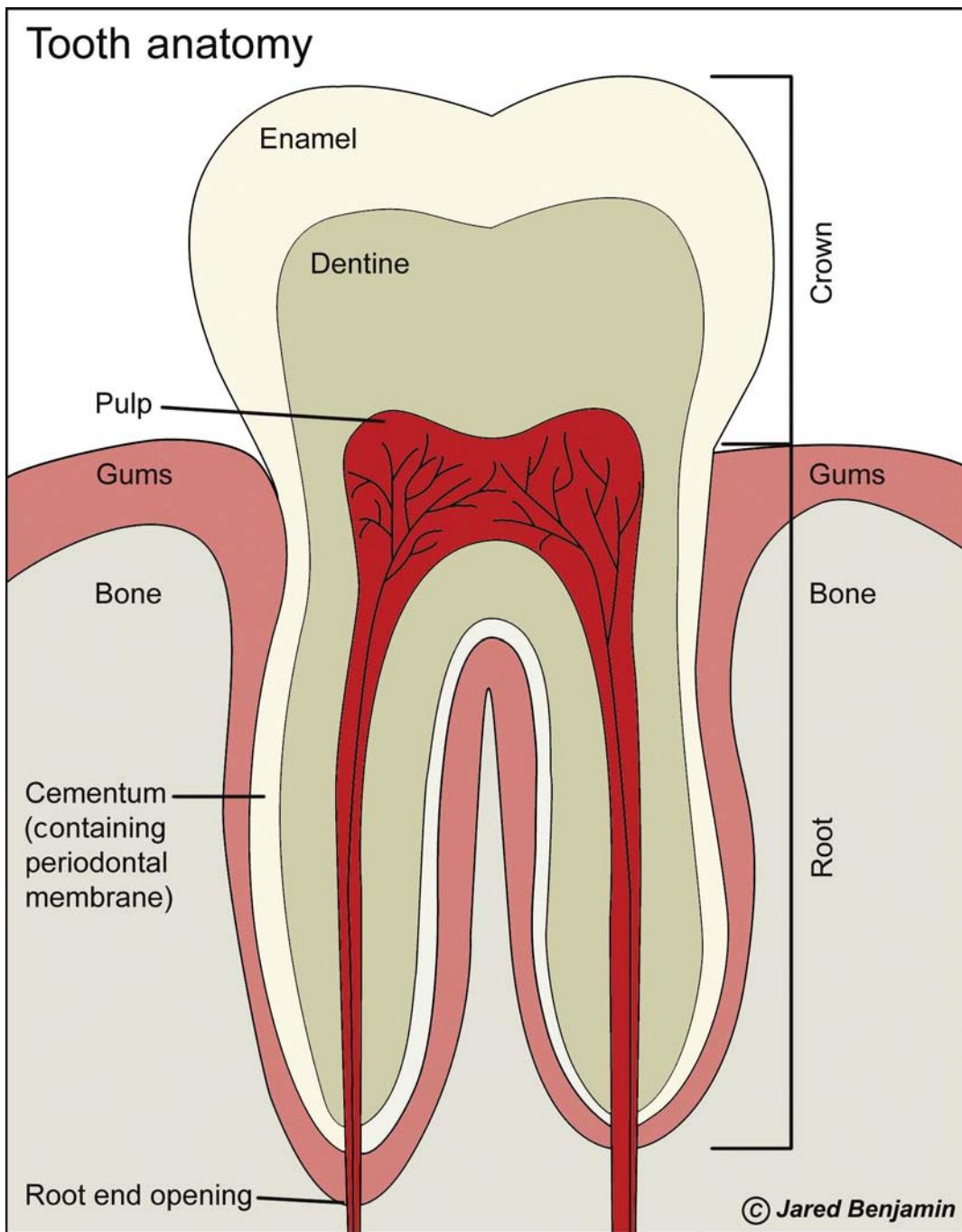
Chapter 3

Introduction

3 Introduction

Endodontics is the branch of dentistry concerned with the aetiology, prevention, diagnosis and treatment of diseases and injuries affecting the dental pulp, tooth root and periapical tissue.

The speciality of endodontics incorporates both non-surgical root canal treatment, carried out via the crown of the tooth, and surgical root canal therapy carried out directly on the root end of the root of the tooth.



Non-surgical root canal treatment is a well established method of managing the irreversibly damaged pulp. It involves removal of the damaged pulp, shaping and filling of the space occupied by the pulp and, finally, restoring the crown of the tooth. However, if this does not bring about a satisfactory resolution of the clinical condition, further intervention may be required. This may take the form of non-surgical re-treatment, surgical treatment or tooth extraction.

Surgical root canal treatment (surgical endodontics) aims to maintain the tooth within the arch, thus eliminating the dilemma of having to fill a space in the dental arch.

Surgical endodontics is usually performed either after non-surgical endodontics has been unsuccessful, or the clinician has deemed this approach inappropriate or impossible. This may be due to the particular anatomy of the tooth, failure to complete the root canal treatment because of the presence of persistent infection, or the presence of a cyst. Teeth that have been post-crowned also pose a particular dilemma to the clinician. It may not be feasible to remove the post without jeopardising the tooth and the patient preference may be a surgical approach.

This report will focus on root canal treatment, re-treatment and surgical endodontics in adult patients. It also addresses prevention strategies and the criteria for success and failure and suggests a model of care. A literature review was carried out, details of which are in Appendix 5.

The majority of patients requiring root canal treatment do so as a result of infection or irreversible damage to the pulpal tissues due to dental caries or trauma. The main aim of the treatment is to clean the root canal system of damaged or infected material and fill it, thereby sealing it, from the periradicular tissues as well as the oral cavity.

The last decade has seen many advances in techniques and materials for root canal treatment and the increasing development of endodontics as a speciality. It has also seen a downward trend in the provision of treatment within NHS dental practice. The potential reasons for this will be considered in the report.

Chapter 4

Endodontics in Scotland

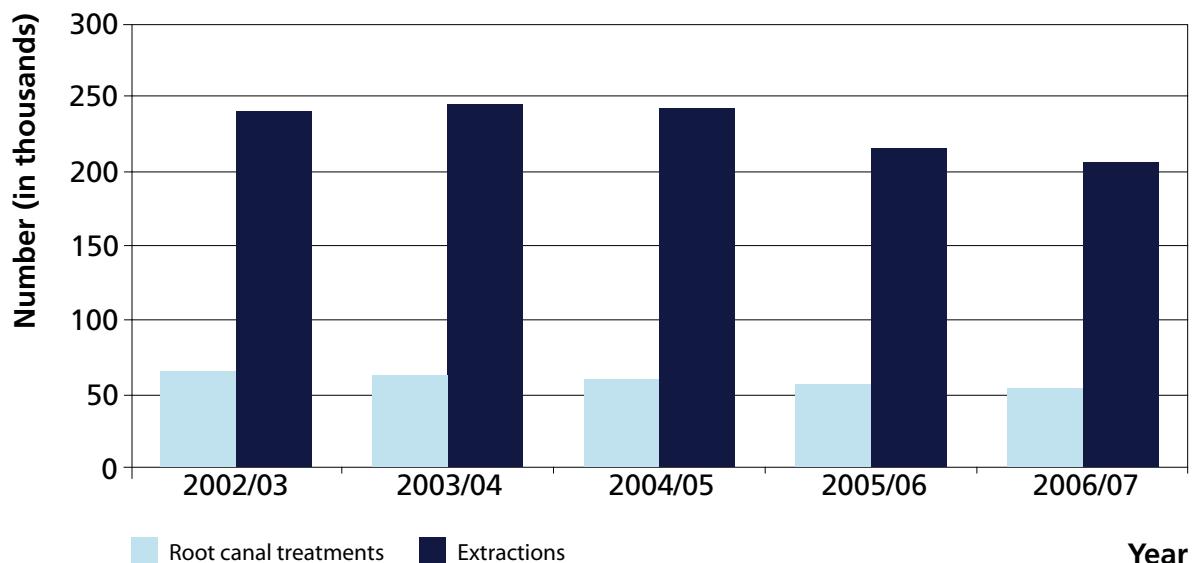
4 Endodontics in Scotland

a Current NHS activity

Over the last five years, the statistical information in the Scottish Dental Practice Board's annual reports shows a decrease in the number of root canal treatments in adults, falling from 128,000 in 2002/03 to 103,000 in 2006/07. This is shown in Figure 1. The Scottish Dental Practice Board Annual Report for 2006/07 shows more root treatments are carried out on anterior teeth compared to posterior teeth, with 26,188 molar root treatments being carried out compared to 30,857 in the incisor and canine region. It also shows that the procedures are more frequently carried out on upper teeth compared to lower teeth.

As the number of extractions in adults has also fallen in the same time period, the fact that a decrease in root filling numbers has also occurred suggests that either the oral health is improving and fewer procedures are required or many dentists only offer endodontic procedures privately, rather than on their NHS lists. Figure 1 shows the changing pattern of root canal treatments and extractions in Scotland over the last five years.

Figure 1: Number of root canal treatments and extractions in NHS general dental practice in Scotland from 2002/03 to 2006/07



Source: Scottish Dental Practice Board Annual Reports ISD

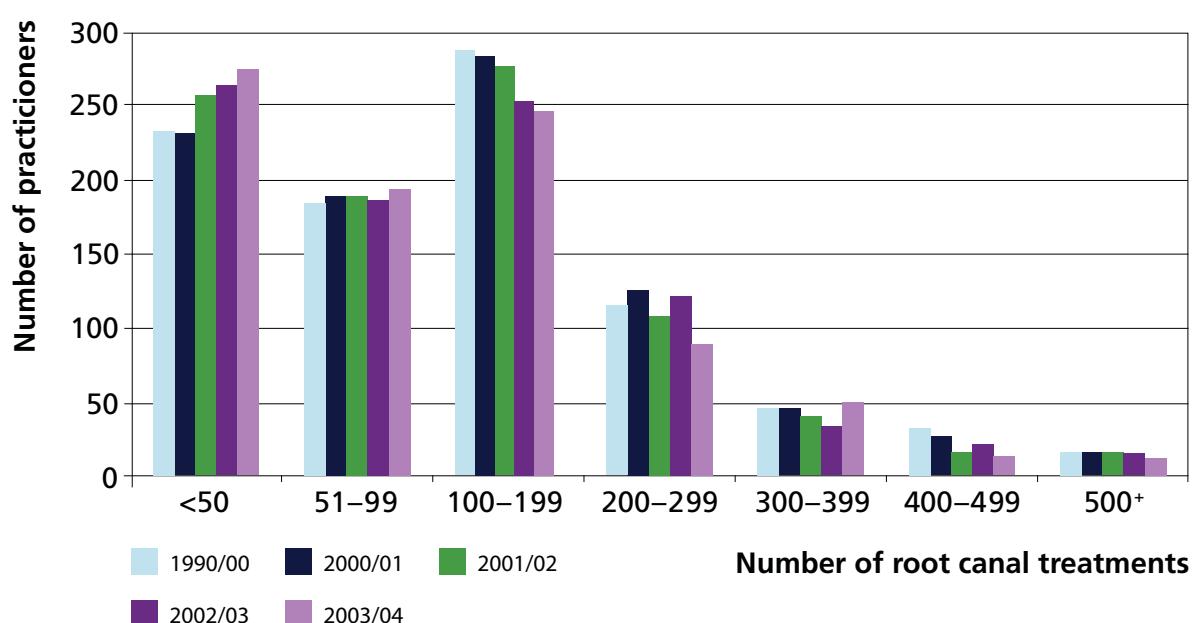
The number of root canal treatments per 100 courses of treatment has also fallen over the past six years and the trend is repeated across all NHS health boards in Scotland (with only two exceptions). This is shown in Appendix 2.

Success rates and outcomes of endodontic procedures do vary and are dependent on a variety of issues such as the clinician's experience and expertise, type of tooth, complex nature of the procedure and a myriad of other clinical and biological factors. Although there have been many advances in current endodontic therapy, success ultimately depends on a sound tooth and restoration post treatment. There are many reasons for endodontic failure and a number of teeth are retreated, but this is still preferable to extraction for many patients.

The practice of endodontics also depends on how willing the dental practitioners are to carry out the procedure in their practices. Jenkins, Hayes *et al*¹ found that, in a study of 720 UK dentists, while some dentists use the techniques currently taught in dental schools, a large proportion use techniques and materials which are not currently favoured by expert opinion. Furthermore, Saunders and Saunders² data showed that in a study of the periradicular status of crowned teeth in an adult population in Scotland, 19% had radiographic signs of periradicular disease. The majority of teeth (62%) had a distinct widening of the periodontal membrane space, which is considered to be an early sign of periapical disease.

Figure 2 shows the number of root canal treatments carried out by general dental practitioners in Scotland.

Figure 2: Number of root canal treatments carried out by general dental practitioners in Scotland from 1999 to 2004



b Endodontic need and demand

Data on endodontic demand can be assessed by looking at the endodontic activity in NHS dentistry in Scotland. However, true endodontic need in a population is difficult to collect and there is no easy way of estimating it. The figures shown in the graphs above only took into account the treatments in the NHS dentally registered population – there was no account of the endodontic need in the unregistered population or the population who receive their dental treatment privately. There is anecdotal evidence from specialists that significant numbers of registered patients on the whole seem to want to save teeth even where the likelihood of success may be limited.

The group devised a short audit to try to obtain an estimation of the endodontic need of the patients attending NHS general dental practice. The audit was carried out between November 2006 and January 2007. A self-completing questionnaire asked the dentists to analyse the teeth extracted over a course of the following five working days and to assess if they were suitable for endodontic therapy. If the dentist deemed them suitable for endodontic therapy, they were asked to give a reason for the extraction.

Following a pilot study, a random 10% sample of Scottish general dental practitioners was sent the questionnaire and a response rate of 62% was achieved. The results of this audit are summarised in Appendix 3.

Table 1 shows the different categories of teeth and the numbers of teeth where endodontic treatment was deemed possible by the dentist.

Table 1: Categories of extracted teeth where RCT was deemed possible by the dentist

Tooth type	RCT possible	RCT not possible
Incisor/Canine	25 (36.2%)	44 (63.8%)
Premolar	43 (45.7%)	51 (54.3%)
Molar	84 (49.1%)	87 (50.9%)
Total	152 (45.5%)	182 (54.5%)

Table 1 shows that, of those dentists who gave an opinion, overall, more than 45% of extracted teeth from the sample were deemed possible for endodontic therapy by the general dental practitioners. Fear, pain, time and cost of the treatment were the most common reasons for the patients choosing not to have endodontic treatment carried out.

The practitioners were also asked if they carried out endodontic treatment on various different tooth types and if they carried out the procedure privately or under NHS regulations. The results are shown in Table 2.

Table 2: Endodontic treatment on different tooth types

Tooth type	NHS		Private	
	Yes	No	Yes	No
Incisor/Canine	85.2%	13.9%	53.9%	45.2%
Premolar	86%	13%	52.1%	46.9%
Molar	84.3%	14.7%	52.1%	46.9%

This shows that a high percentage of this sample of general dental practitioners do provide endodontic therapy under the NHS regulations, on all types of tooth.

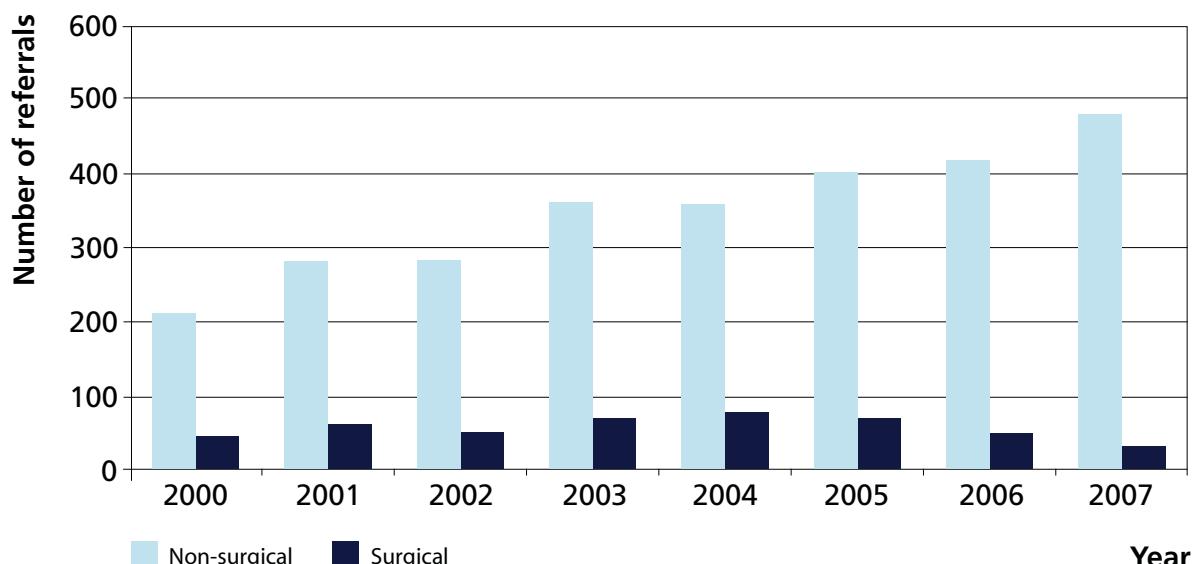
The main reason for undertaking this audit was to obtain information on the level of endodontic need in the Scottish population. Although the audit included information from general dental practices, this is not necessarily only from registered patients. Most practices also treat casual patients for toothache, and their information will also have been included in this audit.

Secondary care provision

While there are a small number of specialist endodontic practitioners in Scotland, most of the specialist treatment is carried out in Dundee and Glasgow Dental Schools, and at the Edinburgh Dental Institute.

Information has been collected on all referred patients to the restorative department of Dundee Dental Hospital since January 2000. The data break the referrals down into different restorative categories, showing surgical and non-surgical endodontic treatment as two different categories. The number of referrals for non-surgical endodontic treatment has steadily increased over the seven-year period while the number of surgical referrals has been more constant. Figure 3 shows the patterns of referrals for the two treatments.

Figure 3: Number of referrals for non-surgical and surgical endodontic treatment from 2000 to 2007



c Criteria for success and failure

The traditional concept of success and failure in endodontics is based on strict criteria proposed by Strindberg³. He stated that there was only one satisfactory post-operative outcome, after a predetermined period. This was a symptom-free tooth that showed, on radiological examination, the presence of normal periradicular tissues. Of course this does not take into account a tooth that may still have radiological evidence of pathology in the periradicular tissues and yet is healing. Thus, it could be argued that Strindberg's criteria are the ideal and should be interpreted as such⁴. A more pragmatic approach may be feasible, especially in relation to the retention of the root filled tooth as a functional unit⁵.

There are three methods by which the outcome of endodontic treatment can be assessed.

1 Clinical examination

Questioning of the patient will provide information regarding symptoms associated with the treated tooth. Pain, swelling, tenderness of the adjacent soft tissues and the presence of a fistula are indicative of failure. The tooth may be symptomless but this does not necessarily mean it is free of disease.

2 Radiological examination

Periapical radiological examination is an important way to assess the progress of healing. An assessment should be made of the treated tooth and the periradicular tissues. There are a number of drawbacks to relying wholly on radiographic interpretation. It may be that a radiolucency may not be evident despite disease being present due to insufficient demineralisation of the tissue. Conversely, the presence of a radiolucency may be the result of scar formation and there may be no disease present⁶.

The variables involved with interpretation of radiographs and the bias that results has resulted in the development of the periapical index⁷. This allows the use of reference radiographs showing varying degrees of severity of the disease process, thereby allowing more consistent interpretation of the radiograph.

3 Quality of root canal filling

The length of the root filling in relation to the radiographic apex of the root and the density of the obturation should be noted. These are not the most important criteria, however, as it is not possible to determine either the amount of infection present or the extent of cleaning that has been carried out during root canal treatment from a radiograph.

There is evidence to show, however, that the extent of the root filling does influence the success rate, with root fillings ending within two millimetres of the radiographic apex having a higher success rate than those that are over- or under-extended.

To assess success rates, follow-up studies have been conducted for root canal treatment, and both surgical and non-surgical re-treatment. The study material varies enormously and it is difficult to make direct comparisons. Friedman has collated the information and has reviewed all the available evidence⁸. Among the variables are:

- Tooth type. Some studies include only single-rooted teeth while others include all tooth types
- Treatment conducted. This category includes operator experience, prevention of bacterial contamination, and methods by which the root canal system was prepared and cleaned and how it was obturated
- Recall rate
- Observation period
- Evaluated subject. Some studies take each root as the subject while others examine the tooth
- Evaluation criteria
- Radiological signs and clinical symptoms, as outlined above.

Few of these studies report on tooth retention as opposed to the perceived absence or otherwise of disease.

Levels of treatment outcome

Many studies have three levels of outcome: success, failure and uncertain. Uncertain healing may include cases where a periradicular radiolucency persists but it may indicate incomplete healing, healing by scar formation or early failure⁹. Therefore, longitudinal radiographic monitoring is necessary after root canal treatment, perhaps for up to five years.

Clinician

The results of the randomised controlled trials identified in the literature review indicate that endodontically treated teeth have a high rate of survival in the mouth, whether carried out by either generalists or specialists. However, when further analysed, the teeth treated by the specialists did have increased survival. Studies by Alley *et al*¹⁰ and Doyle *et al*¹¹ reported that the survival rate is as high or better than that reported for dental implants. The type and quality of the final restoration also has a bearing on the success of the endodontic treatment.

Prognostic factors in root canal treatment

A number of factors have been shown to influence the outcome of root canal treatment. These have been classified as pre-operative, intra-operative and post-operative factors.

1 Pre-operative factors

The presence of periradicular periodontitis has a negative effect on outcome. Lesions of two to five millimetres in diameter have a better prognosis than larger lesions. However, pulpal status does not seem to affect outcome. The effect of age, gender, tooth location and general health is equivocal, except in the case of diabetes, where there is reduced prognosis.

2 Intra-operative factors

The apical extent of the root canal filling has an effect on prognosis and the effect of enlargement of the root canal system apically is equivocal.

The number of appointments to complete treatment remains controversial, although recent work suggests that single-visit treatment does not allow adequate cleaning of the apical portion of the root canal system¹². There is very little evidence to support one method or material used in endodontics from another¹³. A systematic review by Sathorn *et al*¹⁴ suggests, however, that single-visit root canal treatment may be more successful than multiple visit, but the quality of studies is relatively poor.

3 Post-operative factors

There is growing evidence to support the role of the coronal restoration in the outcome of endodontic treatment, especially in relation to tooth retention¹⁵.

A summary of good practice points is available in Appendix 4.

d Endodontic treatment costs

This chapter looks at the costs incurred by NHS general dental practitioners in Scotland in order to carry out endodontic treatment. However, it does not examine the alternative costs of extraction of a tooth and the subsequent restoration. Tooth extraction is the obvious alternative to endodontics as it immediately eliminates the damaged or diseased tooth from the mouth and thus the problem. It offers immediate relief from toothache, eliminates the source of infection in a dental abscess and removes a tooth damaged by trauma. However, once the tooth has been extracted the space left behind has to be considered. The decision can be made to leave the patient with a space in the mouth or fill the space with a partial denture, a fixed bridge or a dental implant. Each option has to be considered carefully, with the patient's input, to find the one most suitable for the individual case. As well as the cost, factors such as fear, pain and time availability for the treatment also impact on the decision.

The Scottish Needs Assessment Programme Report of 2004 (Dental Implants)¹⁶ addressed the advantages and disadvantages of dental implants and their use.

NHS costs for root canal treatment have risen 14.2% since 1999, during which time the number of root canal treatments carried out has fallen (as shown in Table 3). The costs, as a proportion of NHS service fees, have remained roughly stable at just over 4%.

Table 3: NHS root canal treatment costs 1999 to 2007

	1999	2000	2001	2002	2003	2004	2005	2006	2007
No. of root fillings (000s)	147	144	141	131	128	120	115	107	103
Cost of root fillings (£000s)	5,208	5,509	5,581	5,351	5,470	5,245	5,254	5,216	5,951
Item of service fees (%)	4.2	4.4	4.4	4.2	4.1	4.0	4.0	3.9	4.4

Source: ISD

In terms of provision of endodontic treatment, there are two main cost elements – instrument/material costs and surgery running costs.

Instrument/material costs

The most significant cost in provision of endodontic treatment is that of endodontic instruments. These now require to be single use, due to the inability to decontaminate instruments (CMO (2007)⁵). Indicative costs of three main instrument types – stainless steel, nickel-titanium and rotary – are shown in Table 4, based on the average number of instruments used per case by a GDP member of the working group. There will also be additional costs for disposables, temporary/permanent filling materials and local anaesthetic agents.

Table 4: Indicative costs of the three main instrument types

Stainless steel	Nickel - titanium	Rotary
£22.5	£29.5	£38

Surgery running costs

Surgery running costs vary with location due to rent, number of surgeries and a range of other variables, so an average running cost of £100 per hour has been used. Time taken to complete a routine endodontic treatment (RCT and permanent restoration) on the three main tooth types was estimated as two hours per molar, one hour for a premolar and one hour for an incisor. These costs are shown in Table 5. Cost estimates have only been calculated for routine endodontic cases. It should be noted that a number will be more complex, requiring 10 to 20% additional time to complete, resulting in an increase in costs. It should be noted that NHS dental practices are eligible to receive a range of allowances that can be used to offset surgery running costs. As these can vary markedly between practices, they have not been included here.

Table 5: Endodontic costs per tooth type based on surgery running costs

	Molar	Premolar	Incisor
Time (minutes)	120	60	45
Running costs @ £100/hr	£200	£100	£75

Table 6 shows the estimated treatment costs calculated as material and running costs. These range from £97.50 to £238.00. It should be noted that, in practice, root treatments are usually conducted with a mixture of hand (stainless steel, nickel-titanium) and rotary instruments.

Table 6: Estimated treatment costs based on material and running costs

	Molar	Premolar	Incisor
Stainless steel	£222.25	£122.25	£97.50
Nickel-titanium	£229.45	£129.45	£104.50
Rotary	£238	£138	£113

Cost impact of increasing endodontic treatments

The only alternative to endodontic treatment is tooth extraction. Consequently, if teeth are root treated rather than extracted, there are other costs involved. In 2006/07, over 407,000 teeth were extracted at a cost to the NHS of £4,273,000 or £10.49 per tooth. As an estimate of the average cost of providing a root canal treatment, fees for the various tooth times can be averaged out at £62.93 (averaging is likely to underestimate costs as fees for molar root canal treatment are more than twice those of incisors). From the audit undertaken for this needs assessment it could be anticipated that 45.51% of those teeth extracted (185,226) could have been root treated. This is shown in Table 7.

Table 7: Estimated NHS general dental services costs

A	Cost of extracting teeth 2006/07		£4,273,000*
B	Extra estimated cost of RCT for those 45.51% teeth that were extracted	185,226 x £62.93	£11,655,327
C	Cost of extracting only teeth not suitable for RCT		£2,328,377
D	Estimated cost of RCT and extraction of teeth unsuitable for RCT	B + D	£13,983.684
E	Estimated additional cost of undertaking RCT on saveable teeth	D - A	£9,710,684
F	Estimated additional cost if all the additional teeth root treated were incisors		£4,006,588
G	Estimated additional cost if all the additional teeth root treated were molars		£13,036,341

* Actual figure, all other costs estimated

The figures in Table 7 suggest that if all the teeth estimated by dentists to be root treatable were root treated, the additional cost to the NHS would be in the order of £9,710,684. As different fees are paid for different tooth types (incisor, upper premolar, lower premolar, molar) it could lie between £4,006,588 and £13,036,341.

However, data from the audit suggested that only one in four patients who had teeth suitable for RCT would have the treatment. It should be noted that one of the reasons patients declined root canal treatment was because of the additional cost of treatment.

In addition to the extra NHS costs associated with carrying out a root canal treatment, there would also be additional costs associated with completing the restoration of the tooth. These costs could range from a large amalgam restoration at £21.25 to a bonded crown at £122.35.

Currently, those patients who are not exempt from having to pay dental charges would be required to pay 80% of the costs of dental treatment. Consequently, the price differential for a patient who needed to have a root treatment on an upper premolar and a bonded crown compared with an extraction is significant. This is shown in Table 8. It is thought that for a large number of the population this may be a barrier to appropriate care.

Table 8: Differential prices for root canal treatment with restoration compared to extraction

	Gross fee	Patient's charge
Premolar extraction	£7.60	£6.08
Premolar (upper) root treatment and MOD filling	£82.10	£65.68
Premolar (upper) root treatment and bonded precious metal crown	£183.20	£146.56

Source: 07/08 fees

While the cost information provided gives an indication of the potential for an increase in costs to the NHS of increasing the provision of endodontic treatment, the benefits of retaining fully functional natural teeth should be borne in mind. However, it is also worth noting that while there are a significant number of teeth that could be root treated effectively being extracted, it may not always be clinically justifiable to restore the tooth. Some work has been undertaken to develop an index to assess restorability but this is not in widespread use¹⁷.

Chapter 5

Strategies

5 Strategies

a Prevention strategies

The most common reasons for tooth loss are uncontrolled dental caries, destructive periodontal disease or trauma.

If bacteria and other irritants from the oral cavity invade the root canal system due to the progression of dental decay or trauma, the dental pulp may undergo pathological changes. The major objectives of RCT are the removal of the irreversibly damaged pulp, cleaning and shaping of the root canal system, disinfection of contaminated root canals and pulp, and obturation of the root canal system to prevent re-infection. This then enables the tooth to be retained in the mouth as a functional unit.

Primary prevention

Dental caries is a preventable disease and its prevalence can be reduced through positive changes in individual's lifestyles, concerning diet and oral hygiene, and through environmental change e.g. provision of optimally fluoridated water.

Teeth may also be damaged or lost through trauma. Trauma frequently results from accidental damage sustained through sporting or recreational activities but may also result from physical violence. The appropriate use of well constructed mouth guards during sporting activities may reduce the extent of damage to the teeth. Moderation in the consumption of alcohol can reduce the incidence of alcohol-related violence.

Secondary prevention

Secondary prevention strategies include appropriate and thorough planning and stabilisation of current oral diseases through regular visits to a dentist. All reasonable efforts should be made to restore damaged and diseased teeth and their supporting structures using conventional methods. Restoring teeth and lost tooth tissue normally involves fillings, crowns or bridges, which sometimes involve endodontic treatment to be initially carried out on the tooth.

Tertiary prevention

Patients who have had endodontic treatment carried out on one or more of their teeth should maintain optimal standards of oral hygiene in order to preserve the restoration covering the tooth.

b Model of care

The majority of NHS endodontic treatment is still carried out in general dental practice. However, there is a declining trend in the provision of endodontic procedures in NHS general practice, affecting both simple and complex cases. While success rates for endodontic treatment carried out by general practitioners are good, they are higher for those with specialist training as some cases are complex and outside the scope of some practitioners. There is a shortage of specialist endodontists in Scotland, which may be addressed with the development of an MCN.

In an ageing population, that has experienced significant restorative dentistry, patients can have narrowed, calcified canals, which can result in the endodontic treatment being much more difficult. This can increase the demand for more complex restorative treatments.

Currently, most practitioners treat the endodontic cases with which they are comfortable and refer their other cases to Dundee or Glasgow dental hospitals or the Edinburgh Dental Institute. This has resulted in long waiting times in these three establishments. There is also a growing trend of practitioners referring patients to specialist practitioners who have carried out a recognised higher qualification in endodontics, or in smaller numbers to generalists known to take endodontic referrals locally.

Endodontics is one of the mono specialities recognised by the General Dental Council in restorative dentistry and there are formal training programmes in place. Currently in Forth Valley there is a primary care/specialist registrar training programme, linked to Dundee Dental School. In addition, there is the development of Practitioners with a Special Interest (PwSIs) in endodontics and the Department of Health (DH) in England has developed guidelines for the appointment of Dentists with Special Interests (DwSIs) in endodontics. The DH document defines a DwSI as a primary care dentist who:

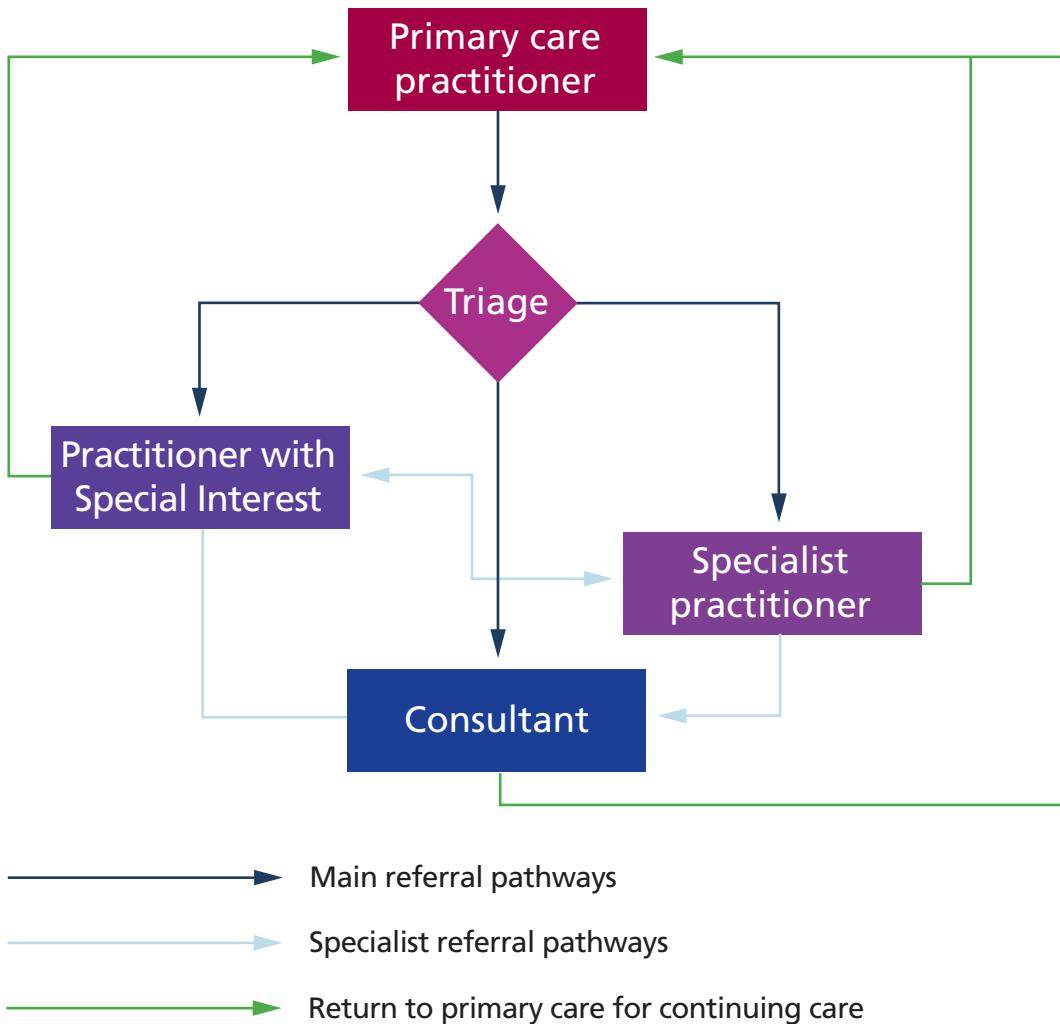
- is able to demonstrate a continuing level of competence in their generalist activity
- is able to demonstrate an agreed level of competence in endodontics.

The audit undertaken for this report suggests that 45% of extracted teeth could have been treated endodontically. This, taken together with the presence of lengthy waiting lists at the secondary care departments and the presence of dentists with a range of specialist skills and training, provides an opportunity for the development of an MCN approach to the provision of endodontic treatment, seeing patients with more complex treatment needs being treated by the more specialised practitioners, and allowing practitioners with an interest to work in the field.

An MCN is designed to benefit populations, individual patients and staff. Patients benefit by getting better and quicker treatment. Staff can benefit by improving links between primary and secondary care, working in a service designed to be fit for purpose with appropriate use of staff members and shorter delays in treatment. All staff would benefit from a clinical governance perspective, with research and training all being facilitated through an MCN.

The key to the development of an MCN is a robust case assessment process or triage system, assigning the cases to the most appropriate level of practitioner (see Figure 5). Several tools are available to assist with this. The one developed by the American Association of Endodontists, which identifies three levels of difficulty – minimal, moderate and high – is widely used but it is by no means the definitive tool.

Figure 5: Managed clinical network diagram



The triage needs to be undertaken by a specialist in endodontics who is able to allocate the patients appropriately, with the overall network developing the protocols, organising audits, training and CPD.

Data collected for this report indicated that only 1.7% of the sample had an additional qualification. However, many of the respondents replied that they had attended courses on the subject suggesting that there are dentists available throughout Scotland who would be well placed to participate in such a network. At present, because of the current system of NHS dental charges, patients receiving their care from specialist practitioners and practitioners with special interest will be required to pay for some or all of their treatment costs whereas those receiving care from a consultant would not. This is consistent with other areas of dentistry and requires further consideration.

Chapter 6

Conclusions

6 Conclusions

This report concludes that well conducted endodontic treatment, endodontic re-treatment and surgical endodontic treatment are all effective methods of saving teeth with irreversibly diseased pulp, which have been damaged by bacteria or bacterial invasion following trauma.

There is limited published literature on the subject of endodontics and more research is required to detect differences in methods of treatment, materials and types of care.

There is variation across Scotland in the willingness of individual practitioners to carry out endodontics but the introduction of a regional or national MCN may improve provision of endodontics across the board and would allow those clinicians with an interest to work within the speciality.

There does, however, need to be a recognition that an increase in the provision of endodontic treatment will lead to an increase in NHS costs.

Chapter 7

Appendices

7 Appendices

Appendix 1

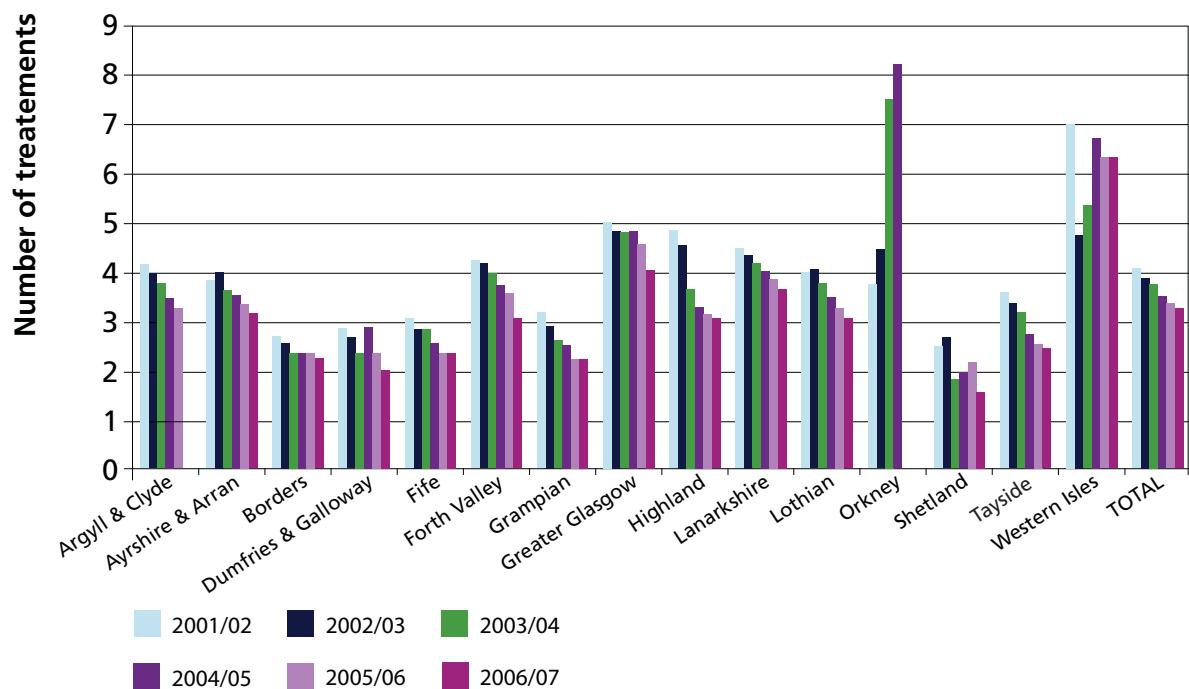
Questions considering issues relating to the provision of endodontic treatment

The group compiled a list of questions which they considered important in relation to the provision of endodontic treatment. These are detailed below. Although not all of these questions are addressed by this report, they help to inform the discussions when considering the aims and objectives of the report.

- 1 What are the criteria for success/failure in endodontics?
- 2 What are the criteria for success/failure in surgical endodontics?
- 3 What are the indications for endodontics?
- 4 What are the indications for surgical endodontics?
- 5 Is decontamination of endodontic instruments practical (cost-effective)?
- 6 Does the pre-operative state of the tooth affect the outcome of endodontic treatment?
- 7 Is the outcome of endodontic treatment affected by tooth type?
- 8 Do single-visit treatments have the same outcome as multiple-visit treatments?
- 9 In endodontically treated teeth, does final restoration type affect tooth survival?
- 10 What are the most effective methods of cleaning root canals?
- 11 What are the most effective methods of shaping root canals?
- 12 What are the most effective methods of filing root canals?
- 13 How long are endodontically treated teeth retained?

Appendix 2

Number of root canal treatments in Scottish health boards per 100 courses of treatment



Appendix 3

Information collected in the audit

A questionnaire for completion by dental practitioners was developed for collecting the information, and piloted. A random 10% sample of Scottish general dental practitioners was obtained from ISD Scotland. Orthodontic practices were excluded.

In total, 186 questionnaires were sent to practitioners and, after a second mailing, 115 respondents gave a response rate of 61.8%.

The first part of the questionnaire collected information on demographics and the endodontic provision in the practice.

Of the respondents, 61.7% were male and 33% female (5.3% of respondents did not specify).

Information on endodontic provision in the dental practice was collected on the following topics.

Number of teeth extracted during a normal month

The average number of teeth extracted by the respondents during a normal month was 27.

Regular endodontic treatment in the practice

87% of respondents replied that they did perform endodontic treatment regularly and 12% of respondents did not.

Routine offer of endodontics to all patients where it may be possible

83.4% of respondents replied that they did offer endodontics routinely and 14.8% did not.

Number of endodontic treatments during a normal month

The average number of endodontic treatments carried out by the respondents during a normal month was 10.

Number of respondents with an additional qualification

Two respondents (1.7%) had an additional endodontic qualification and 112 respondents (97.3%) replied that they did not.

The practitioners were asked if they carried out endodontic treatment on various different tooth types. They were also asked if they carried out the procedure privately or under NHS regulations. The results are shown in Table 9.

Table 9: Endodontic treatment on different tooth types

Tooth type	NHS		Private	
	Yes	No	Yes	No
Incisor/Canine	85.2%	13.9%	53.9%	45.2%
Premolar	86%	13%	52.1%	46.9%
Molar	84.3%	14.7%	52.1%	46.9%

Appendix 4

Good practice points for improved outcome of root canal treatment

- 1 A correct diagnosis should be made to:
 - a) ensure that the problem is endodontic in origin
 - b) ensure that the correct tooth is identified.
- 2 Treatment of the tooth should not be carried out in isolation. RCT should be carried out only as part of the overall oral care of the patient.
- 3 Adequate analgesia should be achieved.
- 4 Rubber dam isolation should be used to prevent further microbial contamination of the root canal system.
- 5 Adequate access to the root canal system should be achieved, ensuring that the roof of the pulp chamber is removed and all root canals are identified and instrumented. The use of an electronic apex locator provides a reliable method of determining the apical constriction.
- 6 The canals should be shaped to improve penetration of the irrigant solution and allow proper obturation.
- 7 Use irrigants that are anti-microbial, tissue dissolving and remove the smear layer.
- 8 The irrigant should be placed so that all parts of the root canal system are affected.
- 9 The root canal should be obturated to help slow down subsequent penetration of the system with micro-organisms. The preparation and obturation should be to within two millimetres of the radiographic apex. The placement of a base over the root filling has been shown to improve the outcome.
- 10 A suitable coronal restoration should be placed as soon as possible after treatment to:
 - a) prevent coronal leakage
 - b) protect the remaining tooth structure
 - c) restore the tooth to function, mindful of aesthetic considerations.

Appendix 5

Literature review

This section aims to consider the current literature on endodontics and assess the evidence on the indications for endodontics, the criteria for success/failure in endodontics, the pre-operative state of the tooth affecting the outcome of treatment, the outcome of single-visit treatments compared to multiple-treatment visits, the effective methods of cleaning, shaping and filling the canal and the survival of the endodontically treated tooth.

A search strategy was developed, based on medical subject headings for Endodontics, using the MEDLINE database, with the searches conducted up until July 2007. The search strategy follows. The identified articles were limited to human subjects and English language. Sensitive and specific methodological search filters identified four categories of information: systematic reviews, randomised controlled trials, diagnosis studies and prognosis studies. The results were subdivided and identified only 90 systematic reviews, 371 randomised controlled trials, 404 diagnosis and 322 prognosis papers. Ultimately, the diagnosis and prognosis papers were considered in the systematic review and randomised controlled trial sections.

Systematic reviews

1 Cochrane review

A Cochrane review of surgical versus non-surgical endodontic re-treatment for periradicular lesions was published in July 2007 by Del Fabbro *et al*¹⁸. Although its overall conclusion revealed no apparent advantage in using a surgical over non-surgical approach for the re-treatment of periapical lesions, in terms of long-term outcome, the cases were not followed up for a long time period (most for only one year). At a one-year follow-up, the success rate for surgical treatment was slightly higher than that of non-surgical treatment. Overall, it recommended the need for high-quality long-term randomised studies to detect any differences.

2 Other systematic reviews

Of the 90 systematic reviews identified, only 16 were relevant to the questions posed by this needs assessment report, outlined in the Introduction section. These 16 covered outcomes of endodontic surgery, fibre-based post systems, direct post and cores, the effectiveness of single- versus multiple-visit endodontic treatment, success rate of endodontic treatment of teeth with vital and non-vital pulps, the outcome of endodontic re-surgery, acute apical abscesses, retrograde obturation materials, acute apical periodontitis, outcomes of endodontic re-treatment, determining the optimal obturation length, antibiotics, non-surgical endodontic treatment, intercanal medicaments and endodontic failure. A summary of the conclusions reached by the systematic reviews is shown later in this appendix.

The majority of these reviews identified that there is limited evidence from which conclusions could be drawn and, in some cases, the results were inconclusive. There have been few clinical trials published and very few high-level studies available. There is a clear need for better quality studies to be carried out.

Randomised controlled trials

There were 371 randomised controlled trials identified from the initial search, of which eight relevant to this needs assessment report were of high-quality design, although a greater number had been included in the systematic reviews. These covered the effects of chlorhexidine, the efficacy of low-level laser therapy, a comparison of survival of teeth following endodontic therapy by generalists compared to specialists, periapical status and quality of endodontic treatment, intracanal use of a corticosteroid-antibiotic compound and the use of calcium sulphate. A summary of randomised controlled trials is found later in this appendix.

Clinical guidelines

The search did not identify any clinical guidelines for endodontic treatment.

The Guidelines for Surgical Endodontics from the Royal College of Surgeons of England¹⁹ were published in 2000 and appear to be the most up-to-date set of guidelines available. These guidelines cover the indications, clinical and radiological assessment and clinical management. These guidelines recommend that well defined research or audit should be carried out to provide significant information that is lacking in the current literature.

Economic evaluations

There were no economic evaluations identified in the search.

Conclusion

There were limited numbers of systematic reviews and randomised controlled trials that addressed the key questions identified by the group. However, the broad conclusions show that endodontic treatment, endodontic re-treatment and surgical endodontic treatment is effective in saving teeth. Further well designed studies should be carried out to address the lack of high-quality randomised controlled trials available from the literature.

MEDLINE search strategies

Endodontic search

- 1 endodontic.mp. or exp ENDODONTICS/
- 2 dental pulp disease.mp. or exp Dental Pulp Diseases/
- 3 exp Apicoectomy/ or apicectomy.mp.
- 4 'root canal therapy'.mp. or exp 'Root Canal Therapy'/
- 5 'root canal filling materials'.mp. or exp 'Root Canal Filling Materials'/
- 6 pulpotomy.mp. or exp PULPOTOMY/
- 7 pulpectomy.mp. or exp PULPECTOMY/
- 8 periapical diseases.mp. or exp Periapical Diseases/
- 9 or 1 – 8
- 10 limit 9 to human

Systematic review search

- 11 meta-analysis/
- 12 exp review literature/
- 13 (meta-analy\$ or meta analy\$ or metaanaly\$).tw.
- 14 meta analysis.pt.
- 15 review academic.pt.
- 16 review literature.pt.
- 17 letter.pt.
- 18 review of reported cases.pt.
- 19 historical article.pt.
- 20 review multicase.pt.
- 21 11 or 12 or 13 or 14 or 15 or 16
- 22 17 or 18 or 19 or 20
- 23 21 not 22
- 24 animal/
- 25 human/
- 26 24 and 25
- 27 24 not 26
- 28 23 not 27

Randomised controlled trial

- 29 randomised controlled trial.pt.
- 30 controlled clinical trial.pt.
- 31 randomised controlled trials/
- 32 random allocation/
- 33 double-blind method/
- 34 single-blind method/
- 35 29 or 30 or 31 or 32 or 33 or 34
- 36 animal/
- 37 human/
- 38 36 and 37
- 39 36 not 38
- 40 35 not 39

Guidelines

- 41 guideline.pt.
- 42 practice guideline.pt.
- 43 exp guidelines/
- 44 health planning guidelines/
- 45 41 or 42 or 43 or 44

Prognosis

- 46 incidence/
- 47 exp mortality/
- 48 follow-up studies/
- 49 prognos\$.tw.
- 50 predict\$.tw.
- 51 course.tw.
- 52 46 or 47 or 48 or 49 or 50 or 5

Summary of systematic reviews

The following tables show a summary of the systematic reviews identified in the literature search grouped under their relevant headings of the questions posed by this needs assessment report (as laid out in Appendix 1).

Criteria for success/failure in endodontics

There appear to be statistically significantly better success rates for teeth with vital compared to non-vital pulps, canals filled to two millimetres of the apex and for teeth without periradicular lesions.

Obturation materials within one millimetre of the apex and confined only to the canal space had a higher success rate.

Author, date, journal	Title	Aim	Main findings
Longman, 2000, <i>Journal of Dentistry</i>	Endodontics in the adult patient; the role of antibiotics	To review the published work on the indications and efficacy for antibiotic therapy in endodontics	Systematic antibiotics should only be prescribed to treat dental infections on the basis of need
Kojima, 2004, <i>5 O's and Endodontics</i>	Success rate of endo Rx of teeth with vital and non-vital pulps	To determine success rates of endo Rx looking at apical limit, status of pulp, periapical status	Statistically significantly better success rates were found for teeth with 1) vital pulps compared to non-vital pulps 2) canal filled to two millimetres of apex 3) teeth without periradicular lesions
Paik, 2004, <i>Journal of Endodontics</i>	Levels of evidence for the outcome of endodontic re-treatment	To complete a search of published literature related to clinical studies on the successes and failures of non-surgical re-treatment	No high-level RCTs were identified
Torabinejad, 2005, <i>Clinical Research</i>	Levels of evidence for the outcome of non-surgical endodontic treatment	To search for clinical articles pertaining to success and failure of non-surgical root canal treatment	There were six high-quality RCTs and 12 low-quality RCTs Predictors of success can be divided into pre-, intra- and post-operative factors but no consistent relationship was found Pre-operative factors include age, gender, tooth, lesion size, pulp state Intra-operative factors include clean, shape, fill, materials, technique Post-operative factors include restoration

Criteria for success/failure in surgical endodontics

Periapical surgery appears to be effective in saving natural teeth.

Author, date, journal	Title	Aim	Main findings
Peterson, 2000, <i>International Endodontic Journal</i>	The outcome of endodontic re-surgery: a systematic review	To establish an outcome standard for the assessment of healing after re-surgery of persistent periradicular lesions	The results of this systematic review show that the outcome rates of re-surgery success and failure are nearly equivalent – it suggests it is in the patient's best interest to re-treat
Mead, 2005, <i>Journal of Endodontics</i>	Levels of evidence for the outcome of endodontic surgery	To search for clinical articles pertaining to success and failure of periapical surgery	Very few high-level studies available Periapical surgery is effective in saving natural teeth

Indications for endodontics and surgical endodontics

In the management of acute apical periodontitis, current interventions used in endodontic therapy are effective in relieving pain.

Also cited as important is the pre-operative state of the tooth.

Author, date, journal	Title	Aim	Main findings
Matthews, 2003, <i>Journal of Canadian Dental Association</i>	Emergency management of acute apical abscesses in the permanent dentition	To assess effectiveness of interventions in the management of acute apical abscesses in the permanent dentition	Results were inconclusive
Sutherland, 2003, <i>Journal of Canadian Dental Association</i>	Emergency management of acute apical periodontitis in the permanent dentition: a systematic review of the literature	To examine the effectiveness of interventions used in emergency management of Acute Apical Periodontitis	Current interventions used in endodontic therapy are effective in relieving pain

Outcome of endodontic treatment as affected number of visits

Single-visit endodontic treatments appear to be slightly more effective than multiple visits.

Author, date, journal	Title	Aim	Main findings
Sathorn, 2005, <i>International Endodontic Journal</i>	The effectiveness of single-versus multiple-visit endo Rx of teeth with apical periodontitis	To compare success of single-visit RCT without CaOH dressing to multiple visit RCT with CaOH dressing	Only three small RCTs met inclusion criteria These state that single-visit RCT appeared to be slightly more effective than multiple visit

Effective methods of cleaning/shaping/filling

Cleaning, shaping and irrigation greatly reduce the number of bacteria within the canal.

Author, date, journal	Title	Aim	Main findings
Neiderman, 2003, <i>International Endodontics Journal</i>	A systematic review of <i>in vivo</i> retrograde obturation materials	To establish effectiveness of obturation materials as determined by reduction in periapical radiolucency and signs and symptoms	Composite, EBA and gold leaf may be more effective than GI or amalgam
Law, 2004, <i>Clinical Research</i>	An evidence-based analysis of the antibacterial effectiveness of intercanal medicaments	To evaluate the antibacterial effectiveness of intercanal medicaments used in the management of apical periodontitis	The studies evaluated in this review showed a strong correlation between apical periodontitis and the presence of bacteria in root canals CaOH antibacterial effect on primary infection of the root canal is only partially effective Cleaning, shaping and irrigation reduce the number of bacteria
Theodospoulou, 2005, <i>Clinical Research</i>	A systematic review of <i>in vitro</i> retrograde obturation materials	The aim was to 1) determine which retrograde obturation material best prevents retrograde dye/ink penetration <i>in vitro</i> and 2) compare these results to the results of <i>in vivo</i> studies	Amalgam appears to lose its sealing ability over time Gutta Percha appears to maintain its sealing ability over time Glass ionomer cement appears to increase its sealing ability over time EBA appears to lose its sealing ability over time Composites appear to maintain their sealing ability over time IRM appears to reduce its sealing ability over time MTA appears to reduce its sealing ability over time
Schaeffer, 2005, <i>Clinical Research</i>	Determining the optimal obturation length: a meta-analysis of the literature	The purpose of this meta-analysis was to determine the optimal terminal point for RCT to improve prognosis	In terms of percentage rates of success, the meta-analysis showed that obturation up to 1mm short of the apex was better than obturation 1mm–3mm short of the apex; both were better to obturation beyond the apex The hypothesis was proved – confining obturation materials to the canal space did correlate with a higher success rate

Retention of endodontically treated teeth

Poor coronal restorations, microleakage around the post and inadequate canal sealing can compromise the endodontic procedure and thus affect the retention of the endodontically treated tooth.

Author, date, journal	Title	Aim	Main findings
Heling, 2002, <i>Journal of Prosthetic Dentistry</i>	Endodontic failure caused by inadequate restorative procedures: review and treatment recommendations	A review of the literature was performed to determine whether prompt placement of coronal restorations can positively influence the long-term prognosis of teeth after RCT	Based on the 41 articles reviewed: 1) poor coronal restorations, as well as inadequate root canal obturation may allow bacteria or endotoxins to penetrate the root canal and initiate periapical inflammation 2) microleakage can be minimised when post preparation is performed as soon as possible after obturation and when 3mm of filling is preserved 3) it may be prudent to use permanent restorative materials for provisional restorations to prevent inadequate canal sealing
Heydecke, 2002, <i>Journal of Prosthetic Dentistry</i>	The restoration of endo Rx, single-rooted teeth with cast or direct posts and cores: a systematic review	To compare the clinical and in vitro performance of cast post and core to that of direct core and pre-fabricated posts	No conclusive evidence favours cast over direct post and core restorations
Bateman, 2003, <i>BDJ</i>	Fibre-based post systems: a review	To review of the published literature examining fibre-based post systems	Very few clinical trials have been published – those that have suggest reasonable success for fibre-based post restorations

Summary of randomised controlled trials

The following tables show a summary of the randomised controlled trials identified in the literature search grouped under their relevant headings of the questions posed by this needs assessment report (as laid out in Appendix 1).

What are the criteria for success/failure in endodontics/surgical endodontics?

Author, date, journal	Title	Aim	Main findings
Pecora, 2001, <i>International Endodontic Journal</i>	The use of calcium sulphate in the surgical treatment of a 'through and through' periradicular lesion	To evaluate the adjunctive effect of calcium sulphate grafts on the treatment of through-and-through lesions	The results of this study demonstrate that the addition of calcium sulphate as a bone graft during conventional treatment of through-and-through lesions improves clinical outcomes
Kreisler, 2004, <i>Oral and Maxillofacial Surgery</i>	Efficacy of low-level laser therapy in reducing post-operative pain after endo surgery-randomised double blind clinical study	To evaluate the effect of low-level laser application on post-operative pain after endodontic surgery in a double blind randomised clinical study	The results revealed that the pain level in the laser group was lower than that of the placebo. The differences were only significant on the first post-operative day (Mann-Whitney U-test, P<0.05)
Alley, 2004, <i>Oral Surgery, Medicine, Pathology, Radiology + Endodontics</i>	A comparison of survival of teeth following endodontic treatment performed by general dentists or by specialists	To compare success of endodontic treatment provided by specialists versus generalists	The success rate of the endodontists, at 98.1%, was statistically significantly better than the rate for generalists at 89.7%. Endodontically treated teeth have a high rate of survival, especially when treated by specialists. This survival rate is as high or better than the survival rate reported for dental implants

Does the pre-operative state of the tooth affect the outcome of endodontic treatment?

Author, date, journal	Title	Aim	Main findings
Loftus, 2005, <i>International Endodontic Journal</i>	Periapical status and quality of endodontic treatment in an adult Irish population	To determine the prevalence of apical periodontitis and the quality of root fillings in an adult Irish population using retrospective analysis of OPG	Results indicated that many root fillings were failing: 53% of root fillings were deemed inadequate and of these teeth, 46% had apical periodontitis Posterior teeth had a greater frequency of apical periodontitis compared to anterior teeth Root-filled teeth that had no restoration within the access cavity had the highest incidence of apical periodontitis

Is the outcome of endodontic treatment affected by tooth type?

Author, date, journal	Title	Aim	Main findings
Salehrabi, 2004, <i>Clinical Research</i>	Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study	To study the outcomes of initial endodontic treatment done in 1,462,936 teeth in 1,126,288 patients across the USA over an eight-year period	After eight years, a total of 97.1% teeth were retained in the oral cavity A significant difference was found between covered and non-covered teeth for all tooth groups tested ($P<0.001$)

What are the most effective methods of cleaning root canals?

Author, date, journal	Title	Aim	Main findings
Zamany, 2003, <i>Oral Surgery, Medicine and Pathology</i>	The effects of chlorhexidine as an endodontic disinfectant	To establish whether addition of 2% chlorhexidine rinse to a conventional treatment protocol enhances the successful disinfection of the root canal system <i>in vivo</i>	Cultivable bacteria were retrieved at the conclusion of the first visit in one out of 12 chlorhexidine cases whereas in the control group, seven out of 12 cases showed growth. This difference was significant ($P<0.05$)
Ercan, 2004, <i>Journal of Endodontics</i>	Antibacterial activity of 2% chlorhexidine gluconate and 5.25% sodium hypochlorite in infected root canal: <i>in vivo</i> study	To compare the activity of different antibacterial solutions in teeth with pulpal necrosis and periapical pathogenesis	Chlorhexidine gluconate was significantly more effective than sodium hypochlorite for both sampling periods
Negm, 2001, <i>Oral Surgery, Oral Medicine, Oral Pathology</i>	Intracanal use of a corticosteroid-antibiotic compound for the management of post treatment endodontic pain	The aim of this randomised, double blind study was to determine the effect of a corticosteroid-antibiotic combination when used as an intercanal medication for the Rx of post Rx pain	Intercanal use of the corticosteroid-antibiotic medication significantly reduced the mean pain score quite rapidly and was significantly superior to the placebo until the end of the study ($P<0.05$)

Chapter 8

References

8 References

- 1 Jenkins S.M., Hayes S.J., Dummer P.M. (2001). A study of endodontic treatment carried out in dental practice within the UK. *Int Endod J*, 2001 Jan, 34(1):16–22.
- 2 Saunders W.P. Saunders E.M. (1998). Prevalence of periradicular periodontitis associated with crowned teeth in an adult Scottish subpopulation. *Br Dent J*, Aug 8, 185(3):137–40.
- 3 Strindberg L.Z. (1956). The dependence of the results of pulp therapy on certain factors. An analytic study based on radiographic and clinical follow-up examination. *Acta Odont Scand*, 14, 1–174 (Suppl 21).
- 4 Chong B.S. (2004). *Managing Endodontic Failure in Practice*. Quintessence Publishing Co Ltd, London.
- 5 Friedman S., Mor C. (2004). The success of endodontic therapy-healing and functionality. *J Calif Dent Assoc*, 32, 493–503.
- 6 Molven O., Halse A., Grung B. (1996). Incomplete healing (scar tissue) after periapical surgery-radiographic findings 8 to 12 years after treatment. *J Endod*, 22, 264–8.
- 7 Orstavik D., Kerekes K., Eriksen H.M. (1986). The periapical index: a scoring system for radiographic assessment of apical periodontitis. *Endod Dent Traumatol*, 2, 20–34.
- 8 Friedman S. (1998) Treatment outcomes and prognosis of endodontic therapy. In Orstavik D., Pitt Ford T.R. eds. (2007). *Essential Endodontontology: Prevention and Treatment of Apical Peridontitis*. Blackwell Science, Oxford.
- 9 Halse A., Molven O. (2004) Increased width of the apical periodontal membrane space in endodontically treated teeth may represent favourable healing. *Int Endod J*, Aug, 37(8),552–60.
- 10 Alley B.S., Kitchens G.G., Alley L.W., Eleazer P.D. (2004). A comparison of survival of teeth following endodontic treatment performed by general dentists or by specialists. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, Jul, 98(1),115–8.

- 11 Doyle S.L., Hodges J.S., Pesun I.J., Baisden M.K., Bowles W.R. (2007). Factors affecting outcomes for single-tooth implants and endodontic restorations. *J Endod*, **Apr**, 33(4), 399–402. Epub 2007 Feb 23.
- 12 Salehrabi R., Rotstein I. (2004). Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study. *J Endod*, **Dec**, 30(12), 846–50.
- 13 Nair P.N., Henry S., Cano V., Vera J. (2005). Microbial status of apical root canal system of human mandibular first molars with primary apical periodontitis after 'one-visit' endodontic treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. **99**, 231–52.
- 14 Sathorn C., Parashos P., Messer H.H. (2005). Effectiveness of single- versus multiple-visit endodontic treatment of teeth with apical periodontitis: a systematic review and meta-analysis. *Int Endod J*, **38**, 347–55.
- 15 Fouad A. (2003). Diabetes mellitus as a modulating factor of endodontic infection. *J Dent Educ*. **67**, 459–67
- 16 Scottish Needs Assessment Report: Dental Implants. (2004).
- 17 Bandlish R.B., McDonald A.V., Setchell D.J. (2006). Assessment of the amount of remaining coronal dentine in root-treated teeth. *J Dent*. **34(9)**, 699–708.
- 18 Del Fabbro M., Taschieri S., Teston T., Francetti L., Weinstein R.L. (2007). Surgical versus non-surgical endodontic re-treatment for peri-radicular lesions (review). *Cochrane Review*.
- 19 Guidelines for Surgical Endodontics. (2000). Royal College of Surgeons of England, London.

