

Feasibility of assessing training of primary care dental practitioners in endodontics of moderate complexity: mapping process and learning

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Key points

Provides awareness of learning from measuring training GDPs upskilled to the level of dentists with enhanced skills (DES) in endodontics in primary care dental services.

Suggests ways in which outcomes can be measured in primary care as part of routine practice

Suggests ways in which primary care can be engaged in research.

Objectives To explore the feasibility of measuring quality of endodontic care provided by general dental practitioners (GDPs), using clinical, radiographic and patient-related outcomes, as well as understanding practitioner views and estimating financial costs. **Methods** Multi-faceted mixed-methods two-part study involving retrospective analysis of the educational component (course assessments, endodontic training blocks and analysis of a sample of teeth treated at the beginning and end of training), and prospective analysis of patients treated by these dentists after completion of training. **Participant** Dentists working in and patients treated in primary dental care in London. **Intervention** Twenty-four-month training in endodontics. **Comparison** Dentists enrolled in the training at different time points. **Outcome** Measuring outcome of endodontic treatment. **Results** Eight dentists (mean 36 years, SD = 8.2 years) participated in training. Subsequently, five of these dentists (mean 34.2 years, SD = 7.08 years) contributed to the prospective study and recruited 135 patients. Thirty-five patients completed all patient-related outcome questionnaires, and of these there were 16 cases with complete clinical and radiographic data (12%) at follow-up (10.1–36.4 months). Preliminary analysis revealed that a minimum of 45 cases of complete data would be required for multivariate analysis, requiring the recruitment of in excess of 375 patients to future studies to account for this level of loss to follow-up. **Conclusions** Findings suggest it is possible to carry out mixed-methods and treatment-related outcome-based research in primary care. Measurement/data capture tools developed were tested and used successfully in measuring the adherence to treatment processes and outcome of endodontic treatment.

Introduction

Providing affordable quality healthcare has become a challenge and current global healthcare providers are said to be insufficient to meet the needs of the population, with rising patient expectations and demand.¹ In England, following an investigation into NHS Dental provision in 2008,² the Steele Report³

introduced the care pathway for patients in 2009, recommending training and development of the current workforce in order to use the workforce imaginatively to ensure cost-effective, high quality dental services. Dental care is generally provided in 'primary care' (within general dental practices and community dental services) with a small proportion of complex care provided in 'secondary care' (NHS hospital), with intention for shifting even more of these services into primary care.⁴

Following the introduction of a revised dental contract for primary care in 2006 (established to ensure that NHS services are relevant to need, and make sure that NHS resources are used effectively), the House of Commons Health Committee report (2007/8) on dental services reported a 45% decrease in the number of root canal treatments provided

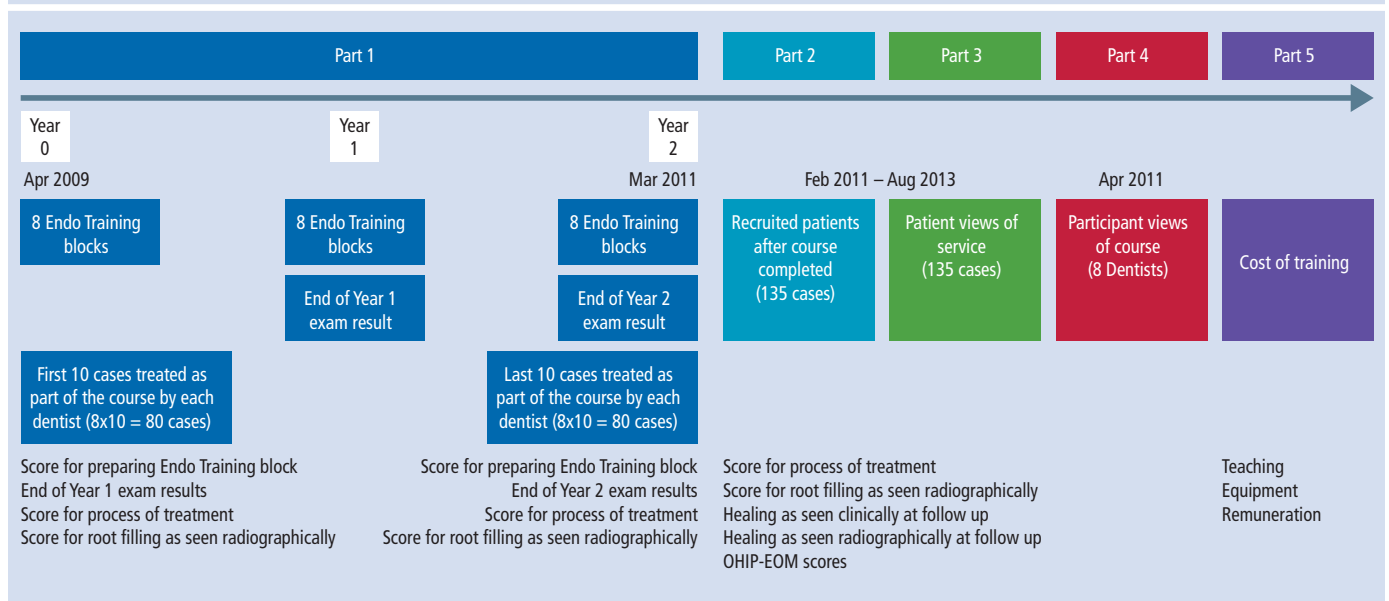
since 2004, and an increase in the number of extractions provided.^{5–7} Additionally, it has been suggested that fewer graduates are qualifying with confidence to manage technically challenging dentistry in such areas as oral surgery, endodontics and prosthodontics.^{8–10} The decline in the provision of complex restorative dental treatments has been linked to a decline in the quality of care within the NHS.^{6,8}

The demand for dentistry of 'moderate complexity'¹¹ is largely unmet, resulting in patients within London complaining to the then primary care trusts in 2007/8. In order for more patients to have access to high quality endodontic treatment of moderate complexity within NHS primary care, a novel training pilot was developed.^{11–14} It aimed to build expertise in the primary care setting and enable dentists who were generalists to develop enhanced skills in a

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Fig. 1 Overall plan for this feasibility and pilot study



distinct field while still continuing to work as a generalist for part of their time, after similar initiatives in medicine.¹⁵ Following Steele³ and the *Five-year forward view*,¹⁶ this concept is being taken forward across dentistry under the title 'dentists with enhanced skills' or more often dentists with enhanced skills (DES).¹⁷ There is still a need to develop a workforce able to provide what is described as 'Tier 2' or treatment of 'moderate complexity' in primary care with impending commissioning guides/standards for restorative dentistry, for which DES are ideally suited.^{11,18}

There is a concern that clinical outcomes produced in hospital settings (secondary care) may not necessarily reflect the clinical outcomes achieved in general practice (primary care), thus prompting the recommendation that research should be conducted in 'real world' settings.¹⁹⁻²² There are a few studies assessing the outcome of training in terms of the outcome of root canal treatment of primary care GDPs in Scandinavian countries.^{23,24} Articles have reported on three broad studies,²³⁻²⁹ and were useful in the exploration of measuring process and outcome in primary care. None of the studies identified were in primary care within the UK nor did they use scoring systems reflective of current clinical practice. This suggests the need for the development and testing of measurement instruments reflective of what occurs in everyday clinical practice in endodontics, as well as evaluating the outcomes of post-graduate training using these instruments. The feasibility of achieving this in a primary care setting in the UK is unknown.

This study is a pragmatic health services research project exploring the possibility of assessing post-graduate education and training in endodontics³⁰ in terms of knowledge and technical skill but also in terms of outcomes of the treatment provided (clinical healing, radiographic healing and patient-related outcomes). For the purposes of this study, the quality of care provided would be limited to patients with teeth requiring root canal treatment within teeth described as a difficulty level of 'moderate complexity'.¹¹ An overview of this study is presented in Figure 1.

Methodology

Traditional methods for outcome-based research have involved quantitative analysis measuring objective change. Although this indicates if there is a change and if so, the direction of the change, there is little scope for exploring the causes or reasons for the said change. Therefore, a combination of quantitative research to look for a change and a qualitative analysis to understand the factors underpinning the change were used (mixed methods research) in this study.

Within this multifaceted feasibility study, there was a retrospective analysis of educational components of a training course,³¹ designed to enhance root canal treatment skills of a selected group of dentists, using educational assessment tools, endodontic training blocks (*in vitro*) completed as part of the course assessments, and analysis of a sample of treated teeth at the beginning and at the end of the course (*in vivo*). The prospective component of the study involved

NHS patients recruited by DES treated within London during and at the end of the training programme. The quality of root canal treatment performed by DES was measured by scoring the quality of the process of providing root canal treatment and measuring the outcome of the treatment (radiographic assessment of the appearance of the root filling and healing, clinical assessment of the healing process and patient-related outcomes measured using a previously developed oral health impact profile for endodontic outcome measures, OHIP-EOM). Patient perspective on the service and dentist perspectives of the training course, as well as the cost of training were also ascertained.

This study received Full Committee Ethical Approval (Ref No. 10/H0718/69), and research governance approval from all associated primary care trusts and King's College Hospital, London (Ref no. KCH11-006). Informed consent was obtained from the dentists who participated in the study and from the patients who received treatment as part of the study. The London Deanery supported this research during the training course with necessary consent from dentists and patients. Informed consent for post-training research was separately obtained from all those involved.

Participants for the above training programme were selected, via a combined nomination process by their PCT, and an interview panel consisting of members from the London Deanery, course teachers, and PCT representatives including a consultant in dental public health. At the interview, records of cases treated in primary care were assessed.

Twenty dentists were nominated by ten PCTs; nine of whom were selected via the interview process (from eight PCTs). During the training, a variety of techniques were taught including hand filing and cold lateral condensation to start with, followed by rotary instrumentation and warm vertical compaction, with an emphasis on achieving biological endodontic objectives, rather than set protocols for instrument use.

Some of the data capture instruments (for endodontic training blocks and examination) were developed as part of the course, not specifically for this study, and piloted before use, as validated data capture instruments were unavailable. Other instruments were developed and adopted by the dentists as a way of recording clinical practice in the patients' clinical notes and therefore were not verified against the clinical notes. These formed a logbook or portfolio of clinical cases. Ascertaining the treatment process from the logbooks was preferred to questioning the dentists on their clinical practice as there is evidence that dentists' perception of the treatment provided exceeds the everyday practices recorded in the clinical notes.³² The descriptors and scoring system for the end of year examinations were simple and reliant on experience of the examiners. The marking scheme for the examinations used broad descriptors as well as comparison to the criteria of moderate difficulty. The development of measurements tools for scoring the quality of root canal treatment has been published.³³ A validated Oral Health Impact Profile (OHIP) questionnaire especially for endodontics, called the OHIP – Endodontic Outcome Measure (OHIP-EOM), with 16 questions modified from OHIP-49 was used to understand the changes in quality of life of patients who underwent endodontic treatment.³⁴

Logbook data (including radiographs) were randomised and blinded during assessment and analysis. This ensured anonymity of the dentists and patients, as well as reducing examiner bias during scoring of the radiographs. All data were coded after collection. Potential DES and patients treated during the course were aware from the outset that they would be evaluated but unaware of which aspects of the recorded data from their logbooks were being used for research. Bias introduced by dentist knowing that they were to be assessed, was overcome by not informing the dentists of the aspects of treatment that would be scored as part of quality. It was recommended that all cases treated during the course formed the logbook to eliminate reporting bias. There was reliance on the dentists adhering to recommended

record-keeping recommendations. Allocation concealment was not possible, as the patients were not randomly chosen for each dentist. The primary investigator (SE) collected, randomised and blinded data approximately three months before scoring radiographs. Bias introduced by assessors knowing which were pre- and which post-training, was overcome by the operator and stage of training being randomised and blinded to all examiners during scoring. Randomisation was carried out using computer-generated tables (Excel, Microsoft Office 2010, Microsoft, Redmond, WA, USA). Ten percent of the radiographs were randomised and re-scored independently by both examiners approximately three months after initially scoring. All examiners were also blinded to the course participant, the stage of training, the treatment process and the patient-related outcomes when assessing the root filling as seen radiographically, healing as seen radiographically and scoring complexity of the cases.

Retrospective analysis of change in skills during training

In this study, the impact of training was measured in terms of change in skills, which in turn were inferred from academic knowledge as well as the quality of laboratory and clinical work. Academic knowledge was scored from course assessments at the end of Year 1 and Year 2, by one external and one internal examiner. The quality of performance of the dentists on endodontic training blocks (*in vitro*) was scored for three domains: 1. Lack of procedural errors; 2. Establishment of the correct working length (within 2 mm of the apex); 3. Taper and shape achieved. The quality of endodontic treatment performed on

patients (*in vivo*) during training was assessed by scoring the 'treatment process' related to the quality aspects of clinical treatment provision that may influence the outcome of treatment and by scoring the radiographic appearance of the root canal filling with emphasis on the occurrence and correction of procedural errors, the presence of voids, and the extent and taper of the obturation.³³

Prospective analysis of maintenance of acquired skills following training

The quality of endodontic treatment performed on patients (*in vivo*) following completion of training was assessed by scoring the 'treatment process' related to the quality aspects of clinical treatment provision that may influence the outcome of treatment and by scoring the radiographic appearance of the root canal filling as described above.³³ The outcome of root canal treatment in this study was measured by assessing clinical signs and symptoms as well as radiographic development or resolution of apical pathology.³³ The quality of life of patients who underwent endodontic treatment was assessed using the OHIP-EOM.³⁴ It was anticipated that the recall rate would be around 35% from completion of endodontic treatment to one-year review.³⁵

Participant (patients) perception of the service and participant (dentists) perception of the training were gathered via anonymised written questionnaires.³¹ Total cost of the course was estimated by summing the available data. Average cost per dentist were calculated and compared to that of enrolling in recognised monospeciality training in endodontics. The research question is shown in Table 1 and the

Table 1 Summary of research questions with unit of analysis, point of comparison, sample size for future studies

Research question	Unit of analysis	Point of comparison	N =
I In GDPs, does additional training/experience in endodontic techniques improve their performance <i>in vitro</i> (endodontic training blocks) and <i>in vivo</i> (clinical cases using data from logbook and radiographs) compared to their performance before training/experience?	Dentists enrolled in study	The same dentists at two time points (at the beginning and end of the course)	64 dentists
II What is the quality of root canal treatment provided by this cohort of GDPs with enhanced skills in root canal treatments (post completion of training)?	Patients enrolled in the study	None (descriptive)	375 patients
III What are the views of patients on the service they received after this initiative?	Patients	None (descriptive)	375 patients
IV What are the views of course participants on this training and implications for their patients in the National Health Service (NHS)?	Dentists	None (descriptive)	64 dentists
V What was the cost of providing this model of training?	Dentists	None (descriptive)	64 dentists

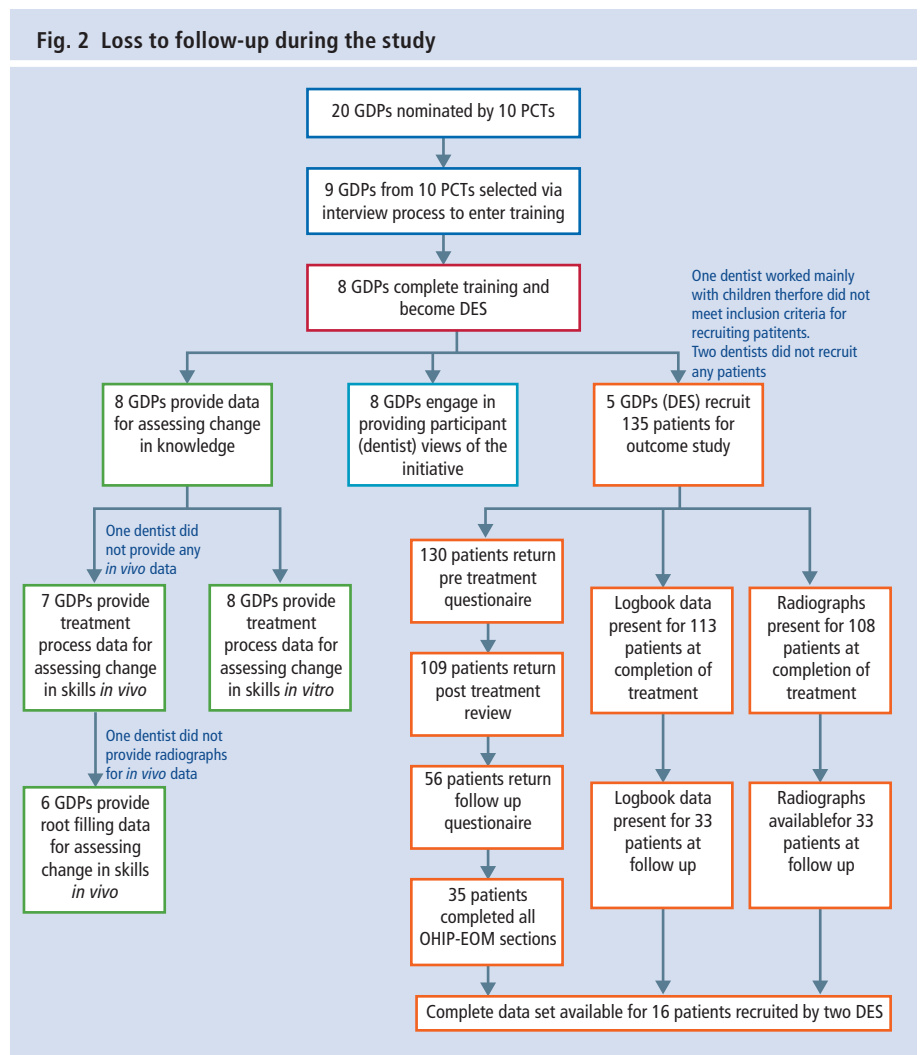
loss to follow-up during various parts of this study is shown in Figure 2.

Results

Eight dentists (four male, four female, age range 27–51 years, mean 36 years, SD = 8.2 years) participated in the course and contributed to data for measuring change in skills during the training course. The mean time since qualifying as a dentist was 12.1 years (SD = 8.2 years, range 4–27 years). Six of the dentists worked in general dental practice settings and two worked within the community dental services. One of the participants had undertaken previous post-graduate training in endodontics. A ninth dentist, who participated in this study, failed to complete the end of Year 1 examination with a satisfactory grade and therefore did not complete the course, and hence, was excluded from the study.

In the assessment of academic knowledge of participant dentists, eight participant trainee dentists with enhanced skills in endodontics provided data at the end of Year 1 and again at the end of Year 2. The score for the ninth dentist was not included in the end of Year 1 scores. In the assessment of performance on endodontic training block (*in vitro*), seven of the eight participants provided endodontic training blocks for all time periods (Year 0, Year 1 and Year 2). The participants spent the assessment day preparing an endodontic training block in the clinical skills laboratory before and after their examination. The endodontic training blocks were routinely completed and collected as part of the regular course evaluation. One dentist was unable to stay for the entire examination day to complete an endodontic training block due to a difficult family situation. The ninth dentist scored zero for all domains of the quality of endodontic training blocks at Year 0 and Year 1, however, the data was not included in the analysis.

The assessment of dentist performance on patients (*in vivo*) included amalgamating the score for the clinical process of providing treatment and that for the radiological appearance of the root filling. Seven of the dentists contributed data for these patients treated during the training course. One dentist failed to provide any cases for this assessment. A total of 133 teeth were assessed using radiographs. The post-operative radiographs were used to score the radiographic quality of the treatment using four domains: 1. Absence of procedural errors; 2. Establishment of the correct working length (within 2 mm of the apex); 3. Achievement



of the correct taper and shape achieved; and 4. Absence of voids within the root filling. Nine pre-treatment (four in Year 0 and five in Year 2) and six post-treatment (five at Year 0 and one at Year 2) radiographs were unusable due to the quality of the radiograph itself and therefore were recorded as such, effectively being treated as missing data in the analyses. It is possible that the pre-operative radiographs were radiographs sent by the referring practitioner.

Of these seven dentists who provided *in vivo* data during training, five dentists (three male and two female) with an age range of 27–44 years (mean 34.2 years, SD = 7.08 years) contributed data to the measurement of outcomes of the treatment provided after completion of the training course. The mean time since qualifying was 10.2 years (SD = 7.16 years, range 4–22 years). Four of the dentists worked in general practice settings and had not undertaken postgraduate training in endodontics. One worked within the community dental services and had undertaken previous post-graduate training in endodontics. These five dentists (63%) recruited 135 patients to

the study. Data to assess complexity were available for 113 patients, with complete data available for 90 patients (67%). Of the 135 patients recruited to the study, treatment process data were available for 113 patients (84%) and post-operative radiographs for 108 patients (80%). Post-operative and review radiographs were available for 31 patients (23%) and two of these were unusable. The fact that these radiographs were unavailable from the DES may indicate that the follow-up was with their original dentist, in line with the local NHS agreements. Two dentists contributed the largest proportion of data for this analysis. Follow-up data (including data for the presence of a coronal seal) were available for 34 patients (25.2%) and two dentists contributed the largest proportion of data for this analysis. Complete data were available for 21 patients (16%). The follow-up assessment and coronal restoration were not the responsibility of the DES and not funded by the service through commissioning arrangements.

The initial response rate for patient completed outcome questionnaires was good with pre-treatment questionnaires being returned

by 130 patients (96%) and post-treatment questionnaires by 109 patients (81%). One hundred and six patients (79%) returned both pre- and post-treatment questionnaires. At follow-up (>12 months following completion of treatment), clinical and radiographic data were available for 33 patients (24%). Fifty-six patients (42%) returned the follow-up questionnaires. Fifty patients (37%) returned all three questionnaires, of which 35 were fully completed (26%). These questionnaires also captured participants' (patients') views of the service.

In this feasibility study, the overall proportion of missing data within the submitted logbook forms was 19% (n = 14 of 72 teeth) at the beginning of the course (Year 0), 4% (n = 3 of 75 teeth) at the end of the course (Year 2) and 17% (n = 23 of 135 teeth) after completion of training. That for radiographs was 19% (n = 14 of 72 teeth) at Year 0, 16% (n = 12 of 75 teeth) at Year 2 and 24% (n = 32 of 135 teeth) after completion of training. In the prospective component of this study, of the 135 patients recruited there were 35 patients who had completed all OHIP-EOM questionnaires, and of these 16 cases with complete clinical and radiographic data (12%) at follow-up (which ranged from 10.1–36.4 months). Preliminary analysis revealed that a minimum of 45 cases of complete data would be required for multivariate analysis. This would require the recruitment of in excess of 375 patients to future studies to account for this level of loss to follow-up. This sample size is not dissimilar to other reported multivariate analyses.³⁶

The ability to capture participant (dentists') views of the impact of additional training on themselves, their organisation and wider health-care following training was established. The findings suggest adult learning theories, when implemented, achieve self-perceived behavioural change. This learner feedback provides invaluable insight into achieving behavioural change in primary care GPs for future training and development of services. The full details of the findings have been published elsewhere.^{11,31,35,37}

The costs of the course delivery were determined by collecting data on the costs of teaching, materials and equipment. The costs were estimates only and there were difficulties in accessing the actual costs as a result of deconstruction of the primary care trusts involved as part of modernising the NHS during this time. The training course described in this study consisted of 168 hours of didactic teaching and hands-on workshops delivered over 24 months including seminars, lectures and hands-on training in simulation laboratory. As such, it was

difficult to accurately estimate the costs involved because of the multiplicity of factors involved. The London Deanery and PCTs absorbed the cost of the training including purchasing of some of the equipment. It is estimated that each PCT provided on average £25,000 per person towards this training. Materials were provided for the teaching days by QED (Quality Endodontic Distributors Ltd, Peterborough, UK).

The total cost of training is estimated to have been £664,400. This is an average of £83,050 per dentist for both years including equipment. The number of teeth treated, as part of this training was approximately 1600, which equates to a total cost of £415.25 per tooth. If these teeth were to be treated by a specialist in endodontics in primary care the cost is likely to be approximately £500–£600 per tooth. If these teeth were to be treated in secondary care the cost is likely to be approximately £464 per tooth; however, it is unlikely that the majority of these cases will be accepted for treatment due to the level of complexity. For the same cost as the entire course, if the treatment was provided by a specialist or in a hospital setting, between 1,074 and 1,338 teeth could have been treated. If, instead of the training provided by the London Deanery, these eight dentists were enrolled in a part-time two-year Master's (MSc) programme in endodontics, the cost would be £191,200. This would not include the purchasing of equipment for the practice at which the dentist would eventually work, nor would it include the provision of endodontics in primary care for 1600 teeth. If the same model is used and in addition to the two-year MSc the same number of teeth were to be treated, the same costs of equipment and fee per treatment would apply.

The participant dentists spend a minimum of 18,072 hours and a maximum of 58,096 hours on improving their technical skills during the training course. There was no statistically significant difference in the number of appointments taken to complete treatment before and after training for those dentists who participated in the prospective part of this research (n = 5). There was a statistically significant difference in the number of appointments taken for completion of treatment both at Year 0 and Year 2 for those that did recruit patients for the second part of the study (N = 5) and those that did not (N = 2). One dentist failed to provide data for teeth/patients treated during and post-training. The increased number of appointments taken for completion of the treatment may, however, be related to the complexity of the patients being treated rather than the complexity of the tooth.

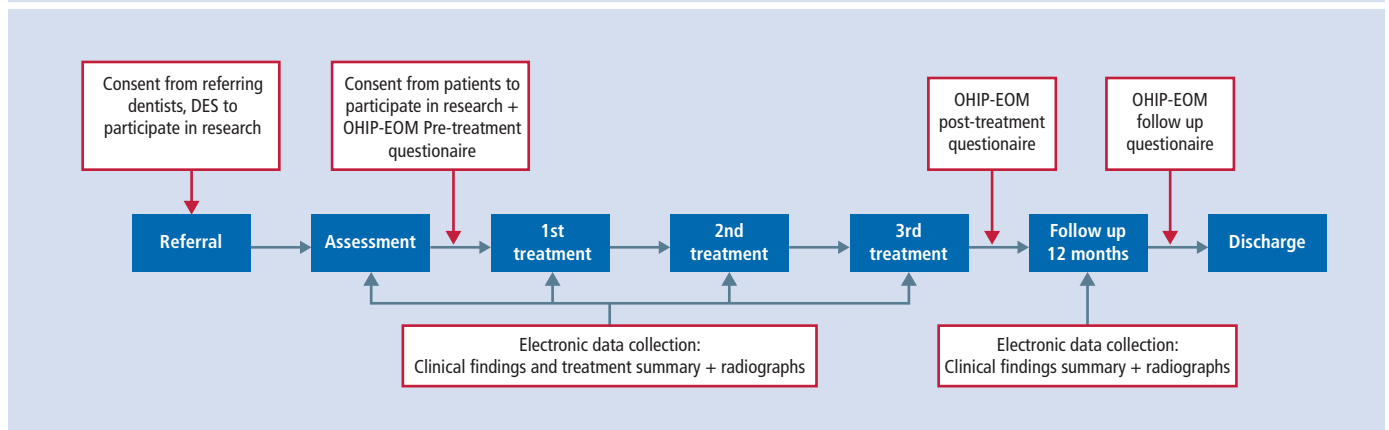
Discussion

This feasibility study demonstrated that it was possible to conduct mixed-method research in primary general dental care settings to explore the quality of treatment and in turn the outcome of additional training post-graduation from dental school. Using this methodology, larger scale studies of this design can gather quality data for root canal treatment in everyday practice and as a measurement of outcomes of training in endodontics.

Previous reports have suggested that recruiting general dental practitioners into clinical trials within primary care is poorly understood.²² For the dentists enrolled in this training programme, between two (25%) and seven (87.5%) dentists of the eight dentists participated in providing patient-related data, when the various components of the study were considered separately. There are no other studies reporting similar mixed-methods research on primary dental care practitioners. Other research within primary care has shown low compliance (27% for patient surveys, 24% for staff and 34% for dentist surveys for those involved in dental pilots).³⁸ This study has shown that it is possible to engage both dentists and patients in primary care research and that some can be engaged over years of follow-up. In this particular study, there was little tangible gain for the dentists themselves in engaging in research and no agreed remuneration for follow-up, which is a known incentive.⁸ However, although this research did not directly incentivise the participating dentists, these dentists needed to collect this data for ensuring completion of the course and for future commissioning negotiations. Retention and engagement in research may be difficult without such motivating factors, and possible incentives, in accordance guidance.^{39–41}

It is important for future trials engaging NHS primary care practitioners in training and research, to consider research as part of the contractual agreements with NHS dental treatment providers with potential links to remuneration for each case recruited with data collected^{8,23,24} or remuneration for the treatment attached to the completion of the electronic data set,⁴² or primary care research should be considered for portfolio studies to address the extra costs of research.⁴³ As patient recruitment post-training is dependent on dentist recruitment for this design of study, steps to empower clinicians to take ownership and engage in research is important. Additional

Fig. 3 Ideal data collection pathway



incentives might be research involvement within continued professional development requirements for GDC registration. The availability of research participation with appropriate remuneration is likely to be seen as a route for income generation and possibly as a practice builder.^{8,44,45}

Lessons learned and experience gained from this feasibility study permitted the development of a process map for data collection in future studies (Fig. 3). It is imperative that electronic data collection becomes an integral part of the clinical record-keeping process to facilitate continuing outcome data collection in primary care. Ideally, an independent investigator, such as a research nurse, should carry out the OHIP-EOM data collection in order to reduce bias and to reduce burden on primary care practitioners to recruit and collate data. This would improve the efficiency and quality of data collection.

Patient recruitment post-completion of training from some dentists was high and will be linked to having a continued DES NHS contract for provision of the service. The proportion of patients recruited in comparison to the contractual agreement for the number of patients to be treated within the DES NHS contract is unknown. Retention rates were also high, with 81% of recruited patients returning OHIP-EOM questionnaires post-treatment and 42% returning questionnaires at follow-up. This was significant considering that only 8% of patients stated that they were receiving this treatment from their usual dentist, meaning that the majority would have returned to their referring practitioner for definitive restoration of the tooth as well as review and maintenance because this aspect was not commissioned from the DES. The demographics of the recruited patient group

is unlikely to be representative of the transient multi-ethnic population of London, as almost three quarters of patients recruited stated they were of white ethnic background and almost half stated being educated to university degree level or higher. This may be representative of the geographical area covered by the DES who recruited most patients or may be reflective of the types of patients willing to provide feedback or engage in research or would wish to retain a given tooth. In London, the reason for patients participating in clinical trials have been reported as mainly due to altruism and perceived potential self-benefit,^{46,47} and barriers to engaging are described as logistical reasons including not enough support for those who do not speak English.⁴⁶ In this study, Language Line London was available for those who required translation. However, this is time consuming and therefore may have been a barrier for some dentists and some patients.

Loss to follow-up of patients was expected in this research. The response rate of patients recruited into the study was 24% at follow-up if the availability of clinical and radiographic data (logbook data) were taken into account, which was 10% lower than what was expected. If only the response rate of patients who completed pre-, post-, and follow-up questionnaires was considered, the response rate was 37%, which was higher than expected.³⁴ This was a reasonable response rate considering that at the inception of the course, follow-up was considered the responsibility of the referring general dental practitioner and the DES was not funded for follow-up. These patients returning to their referring dentist for maintenance and follow-up may explain this, which hinders continued learning and audit of outcomes by each clinician providing root canal treatment. Commissioners providing remuneration for

this patient contact may encourage better follow-up. It is difficult to know if the low rate of follow-up is related to patient non-compliance or the commissioning arrangements. Additionally, data available at follow-up are likely to be low in a transient population such as that in London, and therefore must be compensated for during recruitment and through commissioning arrangements. In the future, if the care pathway protocol being piloted^{18,48} is successful, the implication is that, patients receiving this DES service are motivated to return to their dentist for review and maintenance, thereby ensuring that follow-up occurs.

Learning from this feasibility study is useful in ensuring efficiency within larger scale studies. It used specially developed measurement tools to capture outcome-related data and to quantify quality of root canal treatment provided in primary care.³² Data collected can be randomised and blinded to all examiners. Learning from training and calibration in scoring radiographs aids future training and calibration. There was a great reliance on the dentists participating in this course to enrol and to provide data for this study; including collecting data as part of routine treatment provision as well as collecting and forwarding information to the research team in a timely manner. Maintaining complete trust in the participants supplying accurate information also contributed to the development of and sustenance of a good working relationship with the participants. All of the data collected were an already required part of the patient record and could in future be part of electronic contemporaneous record keeping.^{3,7,49-51} Ideally, the data collection should be digital and routine as part of daily clinical record keeping,⁴⁴ as radiographs form part of the clinical record and can therefore be easily included.

Plain film radiographs are not particularly reliable for assessing the quality of root fillings;^{52,53} however, this is current practice, in adherence to ESE guidelines.³⁰ This study used a combination of digital and plain films, both converted to JPEG format for assessment. A problem unique to this study of GDPs in a busy NHS dental practice was the logistical and financial difficulty in administering a standardised approach to taking radiographs. Although the course teaching involved the use of radiographic assessment using film holders as standard to reduce the risk of errors related to film positioning, standardisation of radiographs was difficult to implement and therefore, no attempt was made to standardise the radiographic equipment or clinicians. Larger primary care-based models of research will encounter the same difficulties, however, this feasibility study shows that reasonable interpretations of the radiographs is possible. The quality of the coronal restoration was also assessed in this feasibility study and it was likely that this service had been provided by the referring GDP (who was the same person for approximately 8% of the patients who participated in the study). It was not the responsibility of the DES as per the commissioning arrangements in the service. This may account for the observation that a significant proportion of patients seen at the follow-up was considered to have had an 'unsatisfactory' coronal restoration on the root canal treated tooth. In future, it may be appropriate to consider the coronal restoration as an important part of the service provided by a DES in endodontics, as this is a prognostic factor for outcome of root canal treatment.^{34,54-59}

The development of quality assessment tools was challenging, as the current practices and measurement of outcome may be considered subjective and echo the subjectivity of measuring outcomes and quality in dentistry generally.⁶⁰ At inception it was agreed that measurement tools developed for this study should be based on current clinical practice in order to integrate these into daily practice in any setting, and explore the reliability of these practices. This study revealed the impact of training and calibration on reliability, although maintaining high levels of agreement over time required repeated training and calibration. There is valuable learning in discussion with experts to arrive at opinions about radiographic appearances, which then may feed the decision-making process. Although these quality assessment

scales can be used in routine practice by the clinician providing the treatment, it is recommended that regular training and calibration are used in areas of high subjectivity such as plain film radiography.³²

Key endodontic factors associated with oral health related quality of life, using the OHIP14 questionnaire, have been studied recently, although the study consisted of data collection as part of one episode of endodontic treatment and not change in OHIP-14 scores following treatment.³⁶ The OHIP-14 questionnaire was considered sensitive to endodontic disease on quality of life impact, with higher impact when there was pain and discomfort.³⁶ The OHIP-EOM questionnaire used in this study was developed, validated and tested in a teaching hospital setting.³³ The future use of this tool could be combined with assessment of the dentition and symptom score,³⁶ before completion of the questionnaires at each time point. This would allow better recognition of specifically endodontic factors that may contribute to oral health-related quality of life.

This alternative model was viewed favourably by the DES and can result in maintenance of the skills learned after completion of training with positive patient-related outcomes. It also demonstrated that it was possible to follow-up patients in a primary care setting via questionnaires submitted through their primary care dentists and received at a different academic setting. By this process, it was possible to document and analyse patient views on the quality of service provided, their level of satisfaction (or lack of it), costs and fee payments, issue of referrals and the patient's own health status according to their own judgement. The financial cost of the course was estimated at approximately £83,050 per dentist for both years when 1600 teeth were saved. There is therefore evidence for stakeholders to invest in this design of additional training for general dentists, thereby improving the quality of primary dental care in England. The everyday tools formalised for capturing data and measuring quality have been validated and show reliability in assessing quality of process and outcome, if appropriate training is undertaken regularly. These findings present an insight into an area within dentistry, which is not yet explored within the literature. Accurate estimation of the actual cost incurred in training this cohort of DES was difficult due to significant organisational changes that occurred within the NHS. Therefore, the cost included in this study is estimated. In terms of developing expertise, the number of hours

spent practising a craft is important.^{61,62} In this course it is estimated that delegates spent between 18,072 and 58,096 hours in training. Considering the cost of training specialists and providing this treatment within secondary care, it is likely to be significantly cheaper to train and provide endodontics of moderate complexity within primary care.

It appears possible to integrate service provision and training as part of existing networks or new managed clinical networks (MCNs) for the improvement of skills in primary care.^{18,63,64} Acceptance for treatment within the MCN will depend on the complexity of the case, the strategic importance of the tooth and the priority level of the patient (for example those that have undergone radiotherapy to the jaws, have taken bisphosphonates or have bleeding disorders that require prophylactic cover). There is opportunity to accept a case mix of lower complexity depending on the training needs of the different levels of staff within the MCN. Consultant triaging was seen to be the most efficient pathway,¹¹ and this could be used again. The DES or trainee DES becomes part of the network, able to dip into training on a regular basis as part of a structured course. This does not need to be a bespoke training arrangement such as that assessed in this study, but could include state or self-funded training programmes such as diplomas and Master of Science degrees, but should also include the volume of cases treated in general practice as in this training initiative. Training for DES within MCNs can be aligned with training provided for other post-graduate students and speciality trainees to facilitate efficient use of resources. Similar schemes involving primary and secondary care have been suggested for oral surgery.⁶⁵⁻⁶⁷ The training potential of MCNs has been recognised.⁶⁴ The advantage of incorporating research into this model is that research carried out in universities and hospitals do not need to be extrapolated to different settings as the data can be collected for the different settings in the same way and compared.⁶⁸ The quality assessment tools from this study could be used to assess the outcome of training. It is not clear if the numbers of cases treated by each dentist as part of the training initiative involved in this study, or the method of course delivery and assessment, played a part in the outcome, which may be different for other training programmes.

In order to achieve change in behaviour, Grol and Wensing⁶⁹ recommended five steps: create a proposal for the desired change; analyse current practice as well as barriers

Fig. 4 The implementation of changing behaviour in the provision of root canal treatment in primary dental care



and incentives for change; develop and choose ways to change practice; test the implementation plan; and undertake the implementation plan with continued evolution and adaptation as required.⁶⁹ These steps have been implemented in training other healthcare practitioners such as general medical practitioners.⁷⁰ The first three steps of this approach to behaviour change have been addressed within this feasibility study as shown in Figure 4. Factors impeding behaviour change identified by the respondents of this course were not dissimilar to the theoretical domains framework developed by Michie *et al.*,⁷¹ such as the lack of knowledge and skills (training), beliefs about capabilities and consequences (motivation and incentives) and resources. The next step would be to test the implementation plan against a control group; and where necessary adapt the implementation plan.^{69,70,72} Remuneration as a strong impacting factor on behaviour change has been demonstrated elsewhere.^{8,73} Fee payments should be strongly based on an understanding of actual costs of providing treatment.

In healthcare, there is new emphasis on 'getting it right first time' with the aim of identifying and administering the correct treatment at the appropriate time, to a high standard with minimal complications and therefore reducing the need for expensive revision treatment.⁷⁴ This philosophy is also applicable to dentistry. A series of three recent articles concentrated on the measurement of quality within primary care dentistry in the UK.^{60,75,76} The current study addressed issues of measuring quality of dentistry within primary care and relates to the provision of root canal treatment. As suggested by Campbell & Tickle,⁷⁵ this study developed a multifaceted approach to measuring quality of root canal treatment from patient, clinician and commissioner points of view. As recommended by Tickle and Campbell,⁶⁰ the quality assessment tools developed are conceptually accepted in published literature; the validity and reliability of which has been tested. Moreover, the use of these quality assessment tools as a routine part of dental treatment within primary care has

been demonstrated. The overall project took into account structure (training, equipment, remuneration), process (the provision of high quality root canal treatment) and outcome (healing and patient-centred outcomes) as described by Donabedian.⁷⁷⁻⁷⁹ The ability to improve and maintain skills of general dental practitioners using educational incentives that improve access to care was demonstrated, with insight into impact of additional training on individual clinicians, their organisation and the wider NHS.⁷⁶ This training initiative was developed by the London Deanery before the establishment of HEE and the new policy and framework for educating the workforce.^{80,81} Yet, it is central, not only to the key themes outlined by HEE, but also those by NHS England, PHE, and is essential for the future plans for NHS dentistry nationally.^{16,82,83} This includes improving outcomes across health-care and the population with inclusion of research, as the NHS constitution states that all patients should be offered the opportunity to take part in research.⁸⁴ Quality-based primary care research in other dental specialities is already taking place.⁶⁸ The NHS has developed, and the current direction of change is to move towards a tiered system of care, whereby the complexity of the treatment needs is matched with the skills of the practitioner. Therefore, there is a place for tools to score complexity of cases and tools to measure quality in terms of treatment outcome, in order to also measure skills of clinicians in a comparative manner.

The most appropriate analytical strategy for a larger scale study would be a regression analysis predicting quality of root filling with predictor variables of operator, stage of training, score for the clinical treatment process of providing root canal treatment, score for the appearance of the root filling as seen radiographically, score for healing as seen radiographically and score for healing as seen clinically, as well as patient-related outcome scores. The sample size of dentists participating in this course was limited to eight (and cannot be changed according to a power calculation), due to the course arrangements, which are beyond the scope of this study. The number of cases treated by each dentist is limited by the referral pattern to each area although the PCT and training course recommend that each trainee DES treat a minimum of 100 cases per year. In line with the data derived from this feasibility study, we would expect a medium effect size and therefore would aim to recruit approximately 64 dentists per group.⁸⁵

Analysis of the patient-based data in a future trial should be analysed using multi-level modelling to account for clustering within the data.⁸⁶ In order to recruit 375 patients to each arm for multilevel modelling, it is likely that 2–3 years of recruitment and 4–6 years of data collection will be required; however, this would depend on the commissioning arrangements and number of cases commissioned from each of the dentists (Table 1). It would be feasible to conduct a larger scale study to measure the outcome of root canal treatment provided in primary care, if the measurement of outcome is closely related to remuneration of treatment or future securing of commissioning. Recruitment rates can be improved if submission of such data is mandatory. Honest completion of treatment process data is possible if the data capture form is integrated into the patient's dental record and misinformation is considered an issue of probity.⁵⁰

Conclusion

It is possible to engage dentists in primary care settings in primary care research and feasible to collect data for measuring the outcome of root canal treatment. This feasibility study provides robust measurement tools and discusses the methodology to measure the quality of root canal treatment provided in primary care. It has highlighted issues with practitioner compliance and patient involvement, which need to be addressed in the future if primary care research is to develop into the important resource it deserves to be in dentistry. The costs of such initiatives should be collected as they occur including recruitment, equipment, material and teaching costs. Feasibility to carry out mixed-methods research in primary care was demonstrated with important learning for future studies.

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Conflict of Interest Declaration

S. Eliyas taught on the DES course described above. P. Briggs was the educational lead for the London DES in Endodontics Programme, taught on the DES course and was responsible for patient triage for three of the DES participants. J.E. Gallagher was part of the Senior Dental Leadership Team in the Department of Health and a Dental Public Health representative in the working group for setting up DES in endodontics and reports grants from London Deanery (now Health Education England) during the conduct of the study. The other authors have stated explicitly that there are no conflicts of interest in connection with this article.

- World Health Organisation. Models and tools for health workforce planning and projections. Human Resources for Health Observer. 2010. Available at http://apps.who.int/iris/bitstream/handle/10665/44263/9789241599016_eng.pdf;jsessionid=356F941C1162C0E48C9A32018A7A01FF?sequence=1 (accessed August 2016).
- House Of Commons Health Committee. Dental services – fifth report of session 2007–08. Vol. 1. London: The Stationery Office Ltd, 2008. Available: <https://publications.parliament.uk/pa/cm200708/cmselect/cmhealth/289/289i.pdf> (accessed May 2016).
- Steele J. NHS dental services in England: An independent review led by Professor Jimmy Steele. 2009. Available at http://www.sigwales.org/wp-content/uploads/dh_101180.pdf (accessed July 2016).
- Centre for Workforce Intelligence. Securing the future workforce supply: dental care professionals stocktake. 2014. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/507376/CfWI_Dental_care_professionals_stocktake.pdf (accessed July 2016).
- Health And Social Care Information Centre. Dental treatment band analysis England 2007 preliminary results. April to July 2007 and comparisons with 2003–04. 2007. Available: <https://digital.nhs.uk/data-and-information/publications/statistical/nhs-dental-statistics/dental-treatment-band-analysis-england-2007-preliminary-results> (accessed August 2018).
- House Of Commons Health Committee. Dental services – fifth report of session 2007–08 Vol 2. London: The Stationery Office Ltd, 2008. Available at <http://www.publications.parliament.uk/pa/cm200708/cmselect/cmhealth/289/289ii.pdf> (accessed May 2016).
- McDonald R, Cheraghi-sohi S, Tickle M, Roland M, Doran T, Campbell S. The impact of incentives on the behaviour and performance of primary care professionals. Queen's Printer and Controller of HMSO, 2010. Available at <http://www.netscc.ac.uk/hsdr/files/adhoc/158-final-report.pdf> (accessed August 2016).
- Tickle M, McDonald R, Franklin J, Aggarwal V R, Milsom K, Reeves D. Paying for the wrong kind of performance? Financial incentives and behaviour changes in NHS dentistry 1992–2009. *Community Dent Oral Epidemiol* 2011; **39**: 465–473.
- Tanalp J, Güven E P, Oktay I. Evaluation of dental students' perception and self-confidence levels regarding endodontic treatment. *Eur J Dent* 2013; **7**: 218–224.
- Davey J, Bryant S T, Dummer P M H. The confidence of undergraduate dental students when performing root canal treatment and their perception of the quality of endodontic education. *Eur J Dent Educ* 2015; **19**: 229–234.
- Al-Haboubi M, Eliyas S, Briggs P F A, Jones E, Rayan R R, Gallagher J E. Dentists with extended skills: the challenge of innovation. *Br Dent J* 2014; **217**: E6.
- Department of Health/Faculty of General Dental Practitioners United Kingdom. Implementing a Scheme for Dentists with Special Interests (DwSIs). 2004. Available: http://web.archive.nationalarchives.gov.uk/20120503230817/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4083120.pdf (accessed August 2016).
- Department Of Health/FGDP UK. Guidelines for the appointment of Dentists with Special Interests (DwSIs) in Endodontics, London. 2006. Available at http://web.archive.nationalarchives.gov.uk/20130124072759/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4133752.pdf (accessed August 2018).
- Department Of Health/FGDP UK. Primary Care Contracting. Dentists with Special Interests: a step by step guide to setting up a DwSI service – London. 2006. Available at https://www.pcc-cic.org.uk/sites/default/files/articles/attachments/step_by_step_guidance_dwsis.pdf (accessed June 2016).
- Pawson R, Greenhalgh J, Brennan C. Chapter 5 Role change: general practitioners with a special interest – can they control and shape demand? In *Demand management for planned care: a realist synthesis*. No. 4.2. Southampton (UK): NIHR Journals Library, 2016. Available at <http://www.ncbi.nlm.nih.gov/books/NBK38669/> (accessed August 2016).
- Department of Health. Five-Year Forward View. 2014. Available at <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf> (accessed August 2016).
- Rooney E. The evolution of dentists with enhanced skills. *Fac Dent J* 2015; **6**: 66–69.
- NHS England, Introductory Guide for Commissioning Dental Specialties. 2015. Available: <https://www.england.nhs.uk/commissioning/wp-content/uploads/sites/12/2015/09/intro-guide-comms-dent-spec1.pdf> (accessed May 2016).
- Burke F J, McCord J F. Research in general dental practice problems and solutions. *Br Dent J* 1993; **175**: 396–398.
- Rajarayan R K. Dental Science – Reality of the evidence. *Prim Dent Care* 2000; **7**: 134–139.
- Wilson M A, Cowan A J, Randall R C. A practice based randomised controlled clinical trial of a new resin composite restorative: one year results. *Oper Dent* 2002; **27**: 423–429.
- Crawford F. Clinical trials in dental primary care: what research methods have been used to produce reliable evidence? *Br Dent J* 2005; **199**: 155–160.
- Koch M. On implementation of an Endodontic Programme. *Swed Dent J Suppl* 2013; **5230**: 9–97.
- Dahlström L, Molander A, Reit C. The impact of a continuing education programme on the adoption of nickel-titanium rotary instrumentation and root-filling quality among a group of Swedish general dental practitioners. *Eur J Dent Educ* 2015; **19**: 23–30.
- Reit C, Bergenholtz G, Caplan D, Molander A. The effect of educational intervention on the adoption of nickel-titanium rotary instrumentation in a public dental service. *Int Endod J* 2007; **40**: 268–274.
- Molander A, Caplan D, Bergenholtz G, Reit C. Improved quality of root fillings provided by general dental practitioners educated in nickel–titanium rotary instrumentation. *Int Endod J* 2007; **40**: 254–260.
- Koch M, Eriksson H G, Axelsson S, Tegelberg A. Effect of educational intervention on adoption of new endodontic technology by general dental practitioners: a questionnaire survey. *Int Endod J* 2009; **42**: 313–321.
- Koch M, Wolf E, Tegelberg A, Petersson K. Effect of education intervention on the quality and long-term outcomes of root canal treatment in general practice. *Int Endod J* 2015; **48**: 680–689.
- Dahlström L, Molander A, Reit C. Introducing nickel-titanium rotary instrumentation in a public dental service: the long-term effect on root filling quality. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011; **112**: 814–819.
- European Society Of Endodontology. Quality Guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006; **39**: 921–930.
- Eliyas S, Briggs P, Gallagher J E. The experience of dentists who gained enhanced skills in endodontics within a novel pilot training programme. *Br Dent J* 2017; **222**: 269–275.
- Helminen S E, Vehkalahti M, Murtomaa H. Dentists' perception of their treatment practices versus documented evidence. *Int Dent J* 2002; **52**: 71–74.
- Eliyas S, Briggs P F A, Harris I R, Newton J T, Gallagher J E. Development of quality measurement instruments for root canal treatment. *Int Endod J* 2017; **50**: 652–666.
- Rasheed T. Outcome measure for Endodontic Treatment: PhD research at King's College London. 2012. Available at https://kclpure.kcl.ac.uk/portal/files/13552179/StudentthesisTahir_Rasheed_2012.pdf (accessed August 2016).
- Farzaneh M, Abitbol S, Friedman S. Treatment outcomes in endodontics: The Toronto Study. Phases I and II: orthograde re-treatment. *J Endod* 2004; **30**: 627–633.
- Liu P, Mcgrath C, Cheung G. What are the key endodontic factors associated with oral health-related quality of life? *Int Endod J* 2014; **47**: 238–245.
- Ghotane S G, Al-Haboubi M, Kendall N, Robertson C, Gallagher J E. Dentists with enhanced skills (Special Interest) in Endodontics: gatekeepers views in London. *BMC Oral Health* 2015; **15**: 110.
- Department Of Health. NHS dental contract pilots – Early findings. 2012. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/212999/NHS-dental-contract-pilots-early-findings.pdf (accessed August 2016).

39. Health Research Authority, Ethics Guidance: Payments and Incentives in Research. 2014. Available at <http://www.hra.nhs.uk/documents/2014/05/hra-guidance-payments-incentivesresearch-v1-0-final-2014-05-21.pdf> (accessed May 2016).
40. Grant R W, Sugarman J. Ethics in Human Subjects Research: Do Incentives Matter? *J Med Phil* 2004; **29**: 717–738.
41. Singer E, Couper M P. Do Incentives Exert Undue Influence on Survey Participation? Experimental Evidence. *J Empir Res Hum Res Ethics* 2008; **3**: 49–56.
42. Cheung A, Weir M, Mayhew A, Kozloff N, Brown K, Grimshaw J. Overview of systematic reviews of the effectiveness of reminders in improving healthcare professional behaviour. *Syst Rev* 2012; **1**: 36.
43. NHS. National Institute for Health Research Clinical Research Network Portfolio. Available at <https://www.nihr.ac.uk/research-and-impact/nihr-clinical-research-network-portfolio/> (accessed March 2018).
44. Mjör IA. Review Article: Practice-based dental research. *J Oral Rehab* 2007; **34**: 913–920.
45. Draper H, Wilson S, Flanagan S, Ives J. Offering payments, reimbursement and incentives to patients and family doctors to encourage participation in research. *Fam Pract* 2009; **26**: 231–238.
46. Newington L, Metcalfe A. Factors influencing recruitment to research: qualitative study of the experiences and perceptions of research teams. *BMC Med Res Methodol* 2014; **14**: 10.
47. Moorcraft S Y, Marriott C, Peckitt C *et al*. Patients' willingness to participate in clinical trials and their views on aspects of cancer research: results of a prospective patient survey. *Trials* 2016; **17**: 17.
48. Department Of Health. NHS dental contract pilots – Learning after first two years of piloting. 2014. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/282760/Dental_contract_pilots_evidence_and_learning_report.pdf (accessed August 2016).
49. General Dental Council. Maintaining Standards – Guidance to Dentists on Professional and Personal Conduct. Revised May 1999.
50. General Dental Council, Standards for Dental Professionals. 2005. Available at <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKewil49DRz-DcAhXj4UKH-QTRDpoQFjAegQIAxAc&url=https%3A%2F%2Fwww.gdc-uk.org%2Fapi%2Ffiles%2FOLD%2520Standards%2520for%2520Dental%2520Professionals.pdf&usq=AOvVaw2b5gWd7gdHGfxxl2kjsfch> (accessed August 2018).
51. National Health Service Commissioning Board. Securing Excellence in Commissioning NHS Dental Services. 2013. Available at <https://www.england.nhs.uk/wp-content/uploads/2013/02/commissioning-dental.pdf> (accessed August 2016).
52. Eckerbom M, Magnusson T. Evaluation of technical quality of endodontic treatment-reliability of intraoral radiographs. *Endod Dent Traumatol* 1997; **13**: 259–264.
53. Van Der Sluis L W M, Wu MK, Wesseling R P. An evaluation of the quality of root fillings in mandibular incisors and maxillary and mandibular canines using different methodologies. *J Dent* 2005; **33**: 683–688.
54. Aquilino S A, Caplan D J. Relationship between crown placement and the survival of endodontically treated teeth. *J Prosthet Dent* 2002; **87**: 256–263.
55. Salehrabi R, Rotstein I. Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study. *J Endod* 2004; **30**: 846–850.
56. Ng YL, Mann V, Gulabivala K. Outcome of primary root canal treatment: a systematic review of the literature – part 2. Influence of clinical factors. *Int Endod J* 2008; **41**: 6–31.
57. Ng YL, Mann V, Gulabivala K. Outcome of secondary root canal treatment: a systematic review of the literature. *Int Endod J* 2008; **41**: 1026–1046.
58. Tickle M, Millsom K, Qualtrough A, Blinkhorn F, Aggarwal V R. The failure rate of HNS funded molar endodontic treatment delivered in general dental practice. *Br Dent J* 2008; **204**: E8.
59. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of non-surgical root canal treatment: part 1: periapical health. *Int Endod J* 2011; **44**: 583–609.
60. Tickle M, Campbell S. How do we measure quality in primary dental care? *Br Dent J* 2013; **215**: 183–187.
61. Ericsson K A, Krampe R T, Tesch-Romer C. The Role of Deliberate Practice in the Acquisition of Expert Performance. *Psychol Rev* 1993; **100**: 363–406.
62. Hambrick D Z, Altmann E M, Oswald F L, Meinz E J, Gobet F, Campitelli G. Accounting for expert performance: The devil is in the details. *Intelligence* 2014; **45**: 112–114.
63. Skipper M. Managed Clinical Networks. *Br Dent J* 2010; **209**: 241–242.
64. Guthrie B, Davies H, Greig G. SDO Project (08/1518/103). Delivering health care through managed clinical networks (MCNs): lessons from the North. 2010. Available at http://www.netscc.ac.uk/hedr/files/project/SDO_FR_08-1518-103_V01.pdf (accessed August 2016).
65. Renton T, Balmer C. Primary care training for oral surgery: challenges and possibilities. *Fac Dent J* 2013; **4**: 65–73.
66. Renton T. Workforce in oral surgery: current and potential challenges and opportunities. *Fac Dent J* 2013; **4**: 80–87.
67. Renton T. Level 3 service delivery: implementation of the oral surgery review. *Fac Dent J* 2013; **4**: 88–93.
68. Heasman P A, Macpherson L E, Haining S A, Breckons M. Clinical research in primary dental care. *Br Dent J* 2015; **219**: 159–163.
69. Grol R, Wensing M. What drives change? Barriers to and incentives for achieving evidence-based practice. *Med J Aust* 2004; **180**: S57–S60.
70. Porcheret M, Main C, Croft P, Mckinley R, Hassell A, Dziedzic K. Development of a behaviour change intervention: a case study on the practical application of theory. *Implement Sci* 2014; **9**: 42.
71. Michie S, Johnston M, Abraham C, Lawton R, Parker D, Walker D on behalf of the 'Psychological Theory' Group. Making psychological theory useful for implementing evidence based practice: a consensus approach. *Qual Saf Health Care* 2005; **14**: 26–33.
72. Baker R, Camosso-Stefinovic J, Gillies C *et al*. Tailored interventions to address determinants of practice. *Cochrane Database Syst Rev* 2015; DOI: 10.1002/14651858.CD005470.pub3.
73. Chaix-Couturier C, Durand-Zaleski I, Jolly D, Durlieux P. Effects of financial incentives on medical practice: results from a systematic review of the literature and methodological issues. *Int J Qual Health Care* 2000; **12**: 133–142.
74. Briggs T. A national review of adult elective orthopaedic services in England. Getting It Right First Time. 2015. Available at <https://www.boa.ac.uk/wp-content/uploads/2015/03/GIRFT-National-Report-Mar15..pdf> (accessed August 2018).
75. Campbell S, Tickle M. What is quality primary dental care? *Br Dent J* 2013; **215**: 135–139.
76. Campbell S, Tickle M. How do we improve quality in primary dental care? *Br Dent J* 2013; **215**: 239–243.
77. Donabedian A. The definition of quality and approaches to its management, Vol 1: Explorations in quality assessment and monitoring. Ann Arbor, Mich, Health Administration Press, 1980.
78. Donabedian A. Evaluating the quality of medical care. *Milbank Q* 1966; **44**: 166–203.
79. Donabedian A. The Quality of Care – How can it be assessed? *JAMA* 1988; **260**: 1743–1748.
80. Health Education England. Workforce planning guidance 2014/15. Available at <https://hee.nhs.uk/sites/default/files/documents/Workforce-planning-guidance-2014-15.pdf> (accessed August 2018).
81. Health Education England Framework 15. Health Education England Strategic Framework 2014–2029. Available at https://www.nhs.uk/sites/default/files/documents/HEE%20strategic%20framework%202017_1.pdf (accessed July 2016).
82. Department Of Health. NHS Outcomes Framework 2015/16 at a glance. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/417894/At_a_glance_acc.pdf (accessed June 2016).
83. Department Of Health. Improving outcomes and supporting transparency Part 1A: A public health outcomes framework for England, 2013–2016. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/263658/2901502_PHOF_Improving_Outcomes_PT1A_v1_1.pdf (accessed August 2018).
84. Department Of Health. NHS Constitution: Guide to the Healthcare System in England Including the Statement of NHS Accountability. 2013. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/194002/9421-2900878-TSO-NHS_Guide_to_Healthcare_WEB.PDF (accessed July 2016).
85. Norman G, Monteiro S, Salama S. Sample size calculations: should the emperor's clothes be off the peg or made to measure? *Br Med J* 2012; **345**: e5278.
86. Masood M, Masood Y, Newton J T. Accounting for the clustering effects of surfaces within the tooth and teeth within individuals. *J Dent Res* 2015; **94**: 281–288.