The epidemiology of endodontic complexity in general dental practice: a prevalence study

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Key points

This is the first study of its kind to measure the epidemiology of root canal treatment complexity encountered by general dental practitioners in daily practice.

The distribution of endodontic complexity over Classes I, II and III (low, moderate and high) was 40%, 32% and 28%, respectively.

Teeth with existing extra-coronal restorations formed 18% of the cases encountered, while the history of trauma was recorded in 9% of cases.

Abstract

Aim To determine the prevalence and the epidemiology of the factors influencing endodontic complexities in general dental practice.

Method Eligible cases where endodontic treatment was indicated as a treatment option were collected by a total of 30 general dental practitioners based in the UK. Online-based Endodontic Complexity Assessment Tool (E-CAT) was used to determine the perceived complexity of each case. In total, 22 categories, including patient- and tooth-related factors, were recorded.

Results Collectively, 435 non-surgical root canal treatment cases were assessed. Overall, 72% of the root canal treatments encountered in general dental practice were found to be either uncomplicated (Class I) or moderately complicated (Class II) and can be considered within the remit of general dental practitioners. Despite the relatively equal distribution of the assessed teeth, the proportion of extraction as a proposed treatment for posterior teeth was more than double that of anterior teeth.

Conclusion The results obtained in this study provide a good resource and databank for researchers, educators, public health commissioners and academic institutions to access a wide range of information concerning the prevalence and distribution of endodontic complexity.

Introduction

The need for endodontic treatment in general dental care is well established, with several studies reporting a substantial need for non-surgical root canal treatment (NSRCT).[1,2] A systematic review by Pak *et al.*[3] revealed the prevalence of root canal-treated teeth to be around 10% of all teeth.

Endodontic treatments can vary significantly in their complexity. There appears to be a lack of good-quality epidemiological studies reporting the prevalence of complex root canal treatment or the factors behind such complexity. There is an extensive range of factors that are reported to affect the complexity of NSRCT.[4,5,6,7] There are several cross-sectional studies describing the prevalence of periapical radiolucency in the population[3,8] and other studies looking into the prevalence of root canal treatment within the population. Yet, possibly due to 'complexity' being a subjective matter, the literature review revealed no studies reporting the prevalence of complex endodontic cases in general dental practice.

There is currently no data on how endodontic complexities could affect the proposed treatment's decision-making to the case being assessed. Such information may help identify shortfalls within the health system and help guide future research to resolve such areas.

Aims

This study was designed to assess the epidemiology of non-surgical root canal treatment complexity in general dental practice. The aims were as follows:

1. Determine the prevalence and distribution of the factors influencing endodontic complexities in general dental practice
2. Assess the distribution of proposed dental treatment in relation to the complexity levels and factors.

Methods

Ethics approval for the study was sought and granted through the Integrated Research Application System (REC reference: 15/NE/0372).

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Table 1 The participants' demographic data

Demographic data	Distribution (%)
Sex	
Male	60%
Female	40%
Location	
London and South of England	16.5%
Midlands	16.5%
North West	33%
North East	14%
Scotland	10%
Wales	10%
Postgraduate endodontic training	
Yes	25%
No	75%
Practice type	
NHS	67%
Private	33%
Post qualification experience (years)	
0–5	33%
5–10	31%
10+	36%

The participating dentists were recruited through an announcement published on online dental forums and societies. The inclusion criteria were defined as general dental practitioners (GDPs) working solely in general dental practice in the UK. Cases treated by specialist endodontists or dentists with a special interest in endodontics were excluded from the study.

The participating GDPs' General Dental Council number, qualification year and practice address and nature (NHS or private) were recorded on a secure, password-protected database. Each GDP was provided with a personal identification number code to match their details when the data was recorded. Consent to take part in the study and use the data collected for research purposes was obtained from all participants.

The eligibility criteria were as follows: any patient presenting to their GDP with a pulpal/periapical disease in a restorable tooth where non-surgical root canal treatment was a viable treatment option. This included both emergency and routine appointments.

Table 2 The overall prevalence of Class I, II and III cases and the surveyed tooth-related categories of endodontic complexities

Factors/categories	Number of entries (N = 435)	Prevalence within general practice
Prevalence of complexity		
Class I – uncomplicated	173	39.8%
Class II – moderately complicated	139	31.9%
Class III – highly complicated	123	28.3%
Tooth position		
Anterior or premolar	207	48.6%
1st or 2nd molar	222	50.2%
3rd molar	6	1.2%
Inclination of tooth (degree of tooth tilt)		
No or small inclination (<10°)	379	87.1%
Moderate inclination (10–35°)	52	12.0%
Extreme inclination (>35°)	4	0.9%
Rotation of tooth		
No or mild rotation (<10°)	413	94.9%
Moderate rotation (10–35°)	21	4.8%
Extreme rotation (>35°)	1	0.3%
Canal radiographic visibility		
Large pulp chamber, clearly visible canals to apex	148	34.3%
Reduced pulp chamber volume, narrow yet visible canal space to apex	182	42.6%
Indistinct pulp chamber or canal space in part or throughout	91	20.9%
Completely invisible canal space in part or throughout	14	3.2%
Root curvature		
Small or no curvature (<30°)	282	64.4%
Moderate curvature (30–40°)	133	30.6%
Severe curvature (>40°)	18	3.5%
Extremely severe curvature (>60°)	2	0.5%
Apical morphology		
Closed (fully formed) apex	424	96.5%
Open apex (>size 60 k-file)	9	2.1%
Open apex with history of failed surgicalretrograde root end fill	2	0.4%
Complex root canal morphology	51	11.7%
Very long tooth (working length>30 mm)	1	0.3%
Anterior tooth or lower premolar with 2 canals	7	1.6%
Premolar with 3 canals	3	0.69%
Molar with ≥4 canals	40	9.2%
Root canal shape and pulp stones	62	14.3%
Pulp stones present	38	8.7%
S shape canal	21	4.7%
C shape or ribbon shape root canal system (confirmed clinically or with cone-beam computed tomography)	3	0.6%
Root resorption	16	3.6%
Apical root resorption	10	2.2%
Internal root resorption	5	1.1%
External root resorption	3	0.7%

Table 3 The surveyed patient-related categories of endodontic complexities

Factors/categories	Number of entries (N = 435)	Prevalence in general practice
Radiographic difficulties		
Normal conditions	413	94.9%
Severe gag reflex	6	1.4%
Narrow palatal vault/high floor of mouth	12	2.8%
Superimposed anatomical structure	4	0.9%
Mouth opening		
Normal mouth opening (>35 mm)	406	93.4%
Reduced mouth opening (25–35 mm)	26	5.9%
Extremely reduced mouth opening (<25 mm)	3	0.7%
Medical history, anaesthesia and patient management		
Fit and well or well-controlled medical history – American Society of Anesthesiologists Classification I, II	412	94.7%
Diabetes (poorly controlled)	7	1.6%
Complex medical history (American Society of Anesthesiologists Classification III or IV) or vasoconstrictor intolerance including haemophilia	6	1.3%
Vasoconstrictor intolerance	1	0.3%
IV bisphosphonate or history of head and neck radiotherapy	9	2.0%
Allergy to anaesthesia	0	0%
Diagnosis		
Uncomplicated clear diagnosis	386	88.9%
Requires simple further investigation	40	9.1%
Confusing and complex signs of symptoms: difficult or unable to achieve clear diagnosis	9	2.0%
Physical and psychological limitations	64	14.7%
Lack of cooperation/significantly anxious patient	47	10.9%
Sedation required	4	0.9%
Moderately limited reclination	9	2.3%
Unable to recline	4	0.9%

With a 95% confidence interval (CI = 95%), the sample size required was calculated to be 385 cases.

This study was incorporated within the Endodontic Complexity Assessment Tool (E-CAT).[9] E-CAT is an interactive, online, digital tool that utilises an evidence-based approach to enable clinicians to assess the endodontic complexity of any non-surgical root canal therapy case. The criteria assessed include 22 categories analysing both patient and tooth-related factors. The tool is free to use and can be found online at www.e-cat.uk.

Each participating dentist was requested to record 10–15 consecutive cases using the E-CAT tool. All data was stored on an encrypted database with all responses anonymised; no patient data was required. The dentists had up to four months to complete their data collection.

Schneider, Weine, Lutein and Cunningham's methods of evaluating root curvature as summarised in Balani *et al.*[10] were all considered for the study. As the Schneider technique was found to be the most commonly familiar and easiest to follow,[11] it was selected for this research, despite the limitations associated with it.

Before starting the study, every participant was calibrated through a series of anonymised endodontic cases provided to them until 100% calibration was achieved. All eligible cases were included, regardless of whether patients chose to receive treatment or not. The participants were also asked to report on the outcome of the cases assessed.

Results

A total of three adverts were sent out. Overall, 44 dentists responded to the adverts, of which 30 were successfully enrolled onto the study. A total of three dentists were excluded due to working in a hospital environment, a further two were only accepting endodontic referrals, five did not complete the calibration exercise and the remaining four did not contribute with cases following their enrolment. The demographic distribution of the participants can be found in Table 1.

Table 4 The surveyed coronal tooth-related categories of endodontic complexities

Factors/categories	Number of entries (N = 435)	Prevalence in general practice	Prevalence within category
Pre-treatment prior to commencement	143	32.9%	
Simple pre-treatment required for isolation (eg restoration replacement)	73	16.7%	51%
Extensive pre-treatment required for isolation (eg sub-gingival caries)	37	8.5%	25%
Removal of crown or bridge prior to treatment	33	7.5%	24%
Obstructed access to root canal system with direct restorations	282	64.8%	
Direct restoration with clear crown morphology	119	27.3%	42%
Direct restoration affecting crown morphology	142	32.6%	50%
Amalgam core build-up in pulp chamber without post/crown	10	2.3%	4%
Composite core build-up in pulp chamber without post/crown	11	2.5%	4%
Extra-coronal restoration	80	18%	
Crown, bridge or onlay present but planned to be removed prior to commencing treatment	35	8.0%	43%
Access required through crown or onlay	37	8.5%	46%
Poorly adapted post	4	0.9%	5%
Well-adapted and firmly cemented post/cast post and core	4	0.9%	5%
Crown morphology abnormality	4	0.9%	
Dens invaginatus or fusion	3	0.7%	75%
Dentinogenesis imperfecta	1	0.3%	25%

On average, the GDPs required 6.25 weeks (pro-rata; adjusted for annual leave or part-time work) to complete collecting ten cases; the range was as low as four weeks and up to eleven weeks. As a crude assumption, this study estimates that a full-time GDP working in the UK comes across an average of 1.6 (range = 0.9–2.5) potential root canal treatment cases a week, or 70.4 (39.6–100) annually.

Prevalence and distribution of complexity factors

Collectively, 437 non-surgical root canal treatment cases were assessed and recorded. Two dentists reported two separate erroneous entries. These were deleted, leaving a total of 435 cases.

Tables 2, 3, 4 and 5 show the distribution of the data recorded in endodontic cases in general dental practice.

The distribution of proposed treatment in relation to the complexity levels

To further analyse the results and enable more meaningful interpretation, the study also investigated proposed treatment destination of each case encountered. The results are shown in Figure 1. Figure 2 shows the distribution of proposed treating clinicians in relation to the type of tooth (anterior or posterior) assessed for treatment. This includes cases with failed endodontic treatment (previously obturated cases).

Discussion

This cross-sectional epidemiological study was designed to explore the prevalence of the factors influencing the complexity of non-surgical root canal treatments in general dental practice.

An ideal epidemiological study would include a very large sample with as much detail of each category recorded as possible. Ideally, the data collection would be standardised through a series of examiners cross-checking the records to ensure minimal bias in recording the data. This is relatively easily achieved in the case of single item prevalence study (for example, periapical pathology). In contrast, the current study required a comprehensive root canal treatment complexity assessment consisting of numerous interdependent factors. Therefore, determining the prevalence of the root canal treatment complexity was found to be challenging and demanded that all relevant categories be recorded or accounted for in as much detail as possible. A thorough literature search to identify the factors affecting endodontic complexity was carried out to ensure most of the key categories are included in the surveying questions.[9]

To ensure an appropriate methodology is followed, only qualified dentists who passed the calibration process (including the Schneider technique tutorial for assessment of root curvature) were selected. However, it must be acknowledged that there are areas where clinicians' subjective opinion and recorded results still may vary (for example, radiographic canal visibility). To dilute the effect of the subjective variations, the number of dentists participating and the cases collected was aimed to be as high as possible. This is in line with the prevalence studies conducted in this field;[3,12] a sample size of around 300–400 endodontic cases would be required. The nature of the study did not allow for cross-examination of the

Table 5 The surveyed miscellaneous categories of endodontic complexities

Factors/categories	Number of entries (N = 435)	Prevalence in general practice	Prevalence within category
Iatrogenic incidents	26	5.9%	
Supra-osseous perforations	3	0.6%	11%
Sub-osseous perforations	2	0.4%	7%
Separated instrument: clinically visible	3	0.6%	11%
Separated instrument: clinically not visible	5	1.1%	19%
Overt ledge or apical transportation	10	2.2%	38%
Significantly misaligned previous endodontic access	3	0.6%	11%
History of trauma	39	9.0%	
Unknown type of trauma in the past	17	3.9%	43.3%
Uncomplicated crown fracture	4	0.9%	10.0%
Root fracture	1	0.3%	2.5%
Concussion	7	1.5%	17.9%
Complicated crown fracture of mature teeth	6	1.3%	13.8%
Subluxation	1	0.3%	2.5%
Complicated crown fracture of immature teeth	1	0.3%	2.5%
Severe luxation or avulsion	2	0.5%	5.0%
Previous endodontic treatment	101	22.9%	
Previously initiated but not obturated	33	7.5%	32%
Canal(s) sub-optimally obturated with gutta-percha	58	13.3%	58%
Canal(s) well-obturated with gutta-percha or obturation is >2 mm overfilled	5	1.1%	5.0%
Canal(s) obturated with other materials (eg silver cones, resin-based filling, bioceramic material)	5	1.1%	5.0%
(Periodontic-endodontic) lesion involvement	34	7.8%	
Perio-endo lesion	19	4.3%	56%
Furcation involvement	7	1.6%	21%
Mobility, fenestrations or dehiscence	7	1.6%	21%
Root resection/hemi-section expected or completed	1	0.3%	3%

data to double-check the accuracy of the records, leading to a higher possibility of human error or bias during the data collection phase. Considering that this study exceeded the required sample size number for statistical significance (95% CI), this issue is less probable, but the data should still be analysed bearing this limitation in mind. On the other hand, the majority of the factors reported (for example, medical history or presence of previous endodontic treatment) were less subjective. The reliability of these results can be expected to be very good.

Although the results can provide us with an insight of the prevalence of reduced radiographic canal space and curved roots, the true prevalence of those values can vary due to the use of two-dimensional radiographs in the assessment of the endodontic cases. The observer variation in the assessment of root curvature, the angle of the radiograph and the method used to measure the curvature may also result in deviation from the true prevalence of anatomically curved canals to the results recorded here. It might be more accurate to state that the results concerning the prevalence of canal visibility and root curvature recorded in this study reflect their perceived prevalence by GDPs rather than the true value.

Overall, the majority (72%) of the root canal treatments encountered in general dental practice were found to be either uncomplicated (Class I) or moderately complicated (Class II) and can be considered within the remit of GDPs. This is based on the assumption that Class II complexity cases carry a moderate risk of complication but may still be within the remit of an experienced general dentist or dentists with further non-specialist training in endodontics. However, a relatively high proportion (28%) of the cases was found to be of higher complexity and carry a higher risk of complications and therefore ideally

Fig. 1 The trends of proposed dental treatments in relation to the complexity levels. An upwards trend can be seen for tooth extraction with regard to the complexity, as well as an upwards trend for the referral

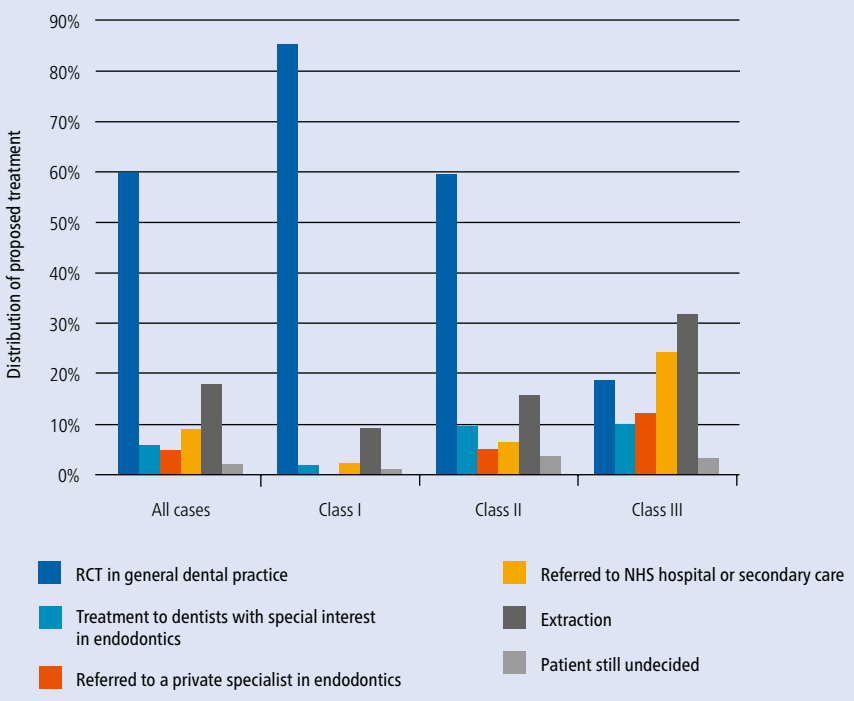
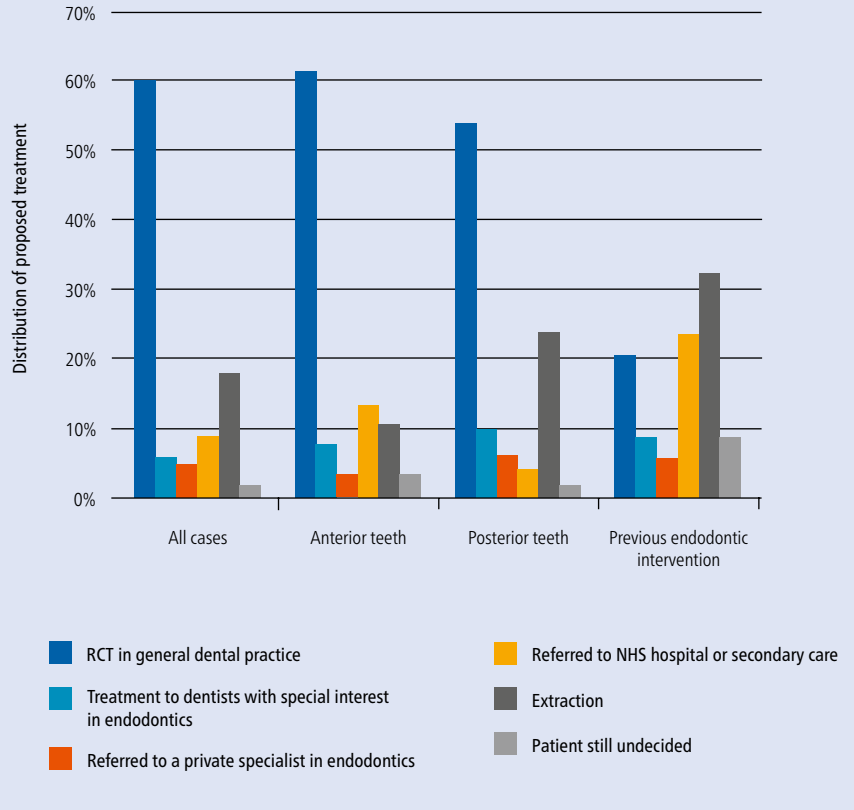


Fig. 2 A higher proportion of teeth planned for extraction observed with posterior teeth and teeth with previous endodontic intervention



require specialist input. The boundary between what specialists and dentists with enhanced skills are expected to treat is a topic that was beyond the remit of this study.

Despite a relatively equal distribution of cases encountered with potential root canal treatment across anterior and posterior teeth, the proportion of extraction as a proposed treatment for posterior teeth is more than double that of anterior teeth. A relatively high percentage of previously root canal-treated teeth are either referred to secondary care or extracted in general practice. The proportion of teeth with Class III complexity and those with previous endodontic intervention being extracted was significantly higher than those previously unfilled. These can be due to patients' wishes, financial limitations, shortage of referral service, wish to accept a shortened dental arch[13] or other factors.

Additionally, the results obtained in this research highlighted some public health queries. According to the latest registration report published by the General Dental Council in October 2021,[14] the total number of registered specialists in endodontics was 322, which forms 0.75% of the dental workforce. Aside from the service provided by teaching hospitals, there is a large shortage of specialist endodontists to refer to within the NHS. This may explain the relatively high proportion (6%) of proposed referrals to dentists with special interest (DWSI) rather than to NHS secondary care or private specialists (5%) in endodontics. Many DWSI are now found in the UK and may indeed be helping to reduce the pressure on GDPs. With around 28% of the cases encountered requiring specialist input, it becomes immediately apparent that further research is required to utilise the results obtained here to assess the level of shortage of endodontic specialists within the UK health system. Further research is also needed to identify a more tangible system to recognise those dentists with a special interest in the field and the level of endodontic complexity that could be referred to them.

Conclusion

The results obtained in this study provide a good resource and databank for researchers, public health commissioners and academic institutions to access a wide range of information concerning the prevalence and distribution of endodontic complexity.

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Ethics declaration

The authors declare that they have no conflicts of interest.

Author contributions

Obyda Essam: conception and development of idea, data analysis, interpretation of results and editing of manuscript. Dariusz Kasperek: data analysis, interpretation of results and editing of manuscript. Edward L. Boyle and Fadi Jarad: conception and development of idea, editing of manuscript and supervision.

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