

Factors influencing the diagnosis and management of teeth with pulpal and periradicular disease by general dental practitioners. Part 2

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Objective To identify techniques commonly used in the management of periradicular disease by general dental practitioners and to ascertain views on continuing professional education in endodontics.

Design Data was collected via a postal questionnaire distributed to 617 general dental practitioners in Scotland (33% of practitioners registered with the Dental Practice Board).

Results 417 (69%) questionnaires were completed and returned. Only 24.9% of respondents used rubber dam routinely. The majority of respondents used hand instruments for preparation with either sodium hypochlorite or local anaesthetic being used most frequently for irrigation. The mean time for treatment of a single rooted tooth was 71 minutes. The demand for continuing education courses was high with 340 and 197 respondents requesting endodontic and rubber dam courses, respectively.

Conclusions Traditional methods for preparing the root canal using hand instruments were favoured by most dentists. The major disincentive to the use of rotary instruments and new techniques for obturating with thermally softened gutta-percha was expense. The importance of rubber dam isolation requires reiteration and more continuing education courses are required to update clinical skills.

It has been shown in a previous paper¹ that general dental practitioners consider that they have a good grasp of the concepts of diagnosis and management of periradicular disease. However despite this assertion, longitudinal studies suggest that the quality of root canal treatment in the developed world is not very high.²⁻⁶ There are some disincentives to performing root canal treatment that include poor remuneration and lack of patient interest. There have been a number of fundamental changes in the philosophy of non-surgical root canal treatment that has led to the development of new techniques and instruments. These have been developed in an effort to simplify the clinical procedures, speed up treatment and make a successful outcome more predictable. It is recognised that these techniques require considerable practice to be mastered and that continuing education courses are necessary to allow formal instruction.⁷

There have been no previous studies on the techniques and

materials employed by general dental practitioners for root canal treatment, or their interest in continuing education in the subject. The aims of this study were as follows:

- Ascertain the treatment regimes used to treat periradicular disease non-surgically in general dental practice
- Investigate the requirements and opportunities for continuing education on periradicular disease management

Materials and Methods

Questionnaire

This aspect of the investigation was conducted using a self-administered postal questionnaire, as described in a previous paper,¹ using the same 617 general dental practitioner participants and the same methods both for gathering the data and subsequent analysis of the results.

Results

Analysis of the Questionnaire

The response and the respondents

Of the 604 questionnaires mailed 417 (69%) were returned. The time since graduation covered 41 years with a mean of 16.2 years and a mode of 15 years. With regard to the sphere of practice, the majority of respondents 215 (51.6%) reported their practice as mixed NHS and independent, 173 (41.5%) worked exclusively in the National Health Service and 17 (4.1%) were mainly independent practitioners.

Treatment of the acute apical abscess

Table 1 indicates the distribution of the options that respondents would undertake for the treatment of an acute apical abscess in a maxillary central incisor. Those who graduated most recently were less likely to leave the tooth on open drainage ($P=0.008$). Treatment that included opening and preparing the root canal plus the prescription of an antibiotic was advocated most commonly by those respondents who had graduated most recently, after 1983 ($P<0.001$).

A number of written comments ($n=116$) were annotated to the section on the treatment of the acute abscess. The treatment provided to the patient was often affected by time constraints of the busy dentist (37 [31.9%]). There were 33 (28.4%) comments relating to provision of antibiotics. Several comments suggested that antibiotics were used as a last resort or where the patient had systemic signs and symptoms. Other factors influencing the provision of antibiotics were the presence of a fluctuant swelling, inability to gain anaesthesia or to achieve drainage through the tooth. Several respondents were keen to emphasise the need to keep open drainage for as short a time as is reasonable; 'if left open, 24-48h only'. Six

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REFEREED PAPER

Received 18.05.99; accepted 20.07.99

© British Dental Journal 1999; 187: 548-554

Table 1 Opinions regarding the treatment of an acute apical abscess

	Yes, most definitely 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Open canal for drainage	140 (37.9%)	76 (20.6%)	78 (21.1%)	53 (14.4%)	22 (6%)
Open canal for drainage plus antibiotics	26 (7.1%)	59 (16.1%)	191 (52.2%)	63 (17.2%)	27 (7.4%)
Open and prepare canal and dress	73 (19.6%)	139 (37.3%)	107 (28.7%)	40 (10.7%)	14 (3.8%)
Open and prepare canal and dress plus antibiotics	23 (6.2%)	44 (11.8%)	204 (54.8%)	79 (21.2%)	22 (5.9%)
Antibiotics only	2 (0.6%)	12 (3.3%)	103 (28.5%)	151 (41.7%)	94 (26%)

respondents considered patient attitude an important factor; 'patients with severe pain do not want active treatment and are thus given antibiotics'.

Use of rubber dam

Rubber dam was used routinely by only 104 (24.9%) respondents. The disincentives included taking too long (168 [40.3%]), patients unable to tolerate it (149 [35.7%]), expense (63 [15.1%]), and other reasons (56 [13.4%]). The latter included lack of practice and habit. Some expressed a lack of confidence in the use of rubber dam and several felt that it was not cost effective to use it. Several respondents suggested that patients did not like rubber dam being used. There was no significant interaction between the use of rubber dam and time since qualification (P=0.722).

Techniques for root canal treatment

Preparation

Instruments used to prepare the root canal. The frequencies of use of various instruments in the preparation of the root canal are shown in Table 2. The use of hand reamers was statistically significantly related to time since graduation (p=0.002), those longest qualified

being most likely to use these instruments. Engine driven files were more often used by practitioners who qualified before 1983 (P=0.007).

Method of preparation. Table 3 shows the distribution of the scores for the method of preparation. Twenty nine percent (94) used a crown down approach for all cases whilst 57 (17.9%) use a step-back method for all cases. Those respondents graduating after 1983 used a crown-down approach more frequently (P=0.009).

Movement of hand instruments. Details of the way in which the instruments are used in the root canal are shown in Table 4. The more recently graduated respondents used the balanced force technique more than the older group (P=0.009). There were no other significant interactions in relation to time of qualification.

Irrigation of the root canal. The distribution of frequencies of the use of various irrigants in root canal treatment is shown in Table 5. Unfortunately there appeared to be a number of respondents who were confused about the irrigant they used. Milton solution, used by 98 respondents in all or most cases, is either a 1% or 2% solution

Table 2 Instrument types used

	Yes, most definitely 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Hand K files	77 (25.2%)	60 (19.7%)	28 (9.2%)	63 (20.7%)	77 (25.2%)
Hand K files (flexible)	122 (36.4%)	87 (26.0%)	41 (12.2%)	41 (12.2%)	44 (13.1%)
Hand reamers	43 (13.4%)	38 (11.9%)	38 (11.9%)	74 (23.1%)	127 (39.7%)
Hand hedstrom files	44 (13.6%)	39 (12.1%)	40 (12.4%)	95 (29.4%)	105 (32.5%)
Engine-driven files	22 (7.1%)	32 (10.3%)	27 (8.7%)	72 (23.2%)	158 (50.8%)
Gates Glidden burs	127 (35.6%)	73 (20.4%)	59 (16.5%)	60 (16.8%)	38 (10.6%)
Peeso reamers	9 (2.9%)	4 (1.3%)	10 (3.3%)	35 (11.4%)	249 (81.1%)
Ultrasonic instruments	11 (3.7%)	12 (4.0%)	13 (4.3%)	22 (7.3%)	243 (80.7%)
Sonic instruments	9 (2.9%)	2 (0.7%)	5 (1.6%)	21 (6.8%)	270 (87.9%)
Nickel titanium hand files	11 (3.7%)	5 (1.7%)	12 (4.0%)	37 (12.4%)	234 (78.3%)
Nickel titanium engine-driven files	12 (4.4%)	4 (1.5%)	9 (3.3%)	20 (7.3%)	229 (83.6%)

Table 3 Frequency of use of specific methods of preparation

	Yes, most definitely 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Instrumentation from crown to apex	94 (29.0%)	79 (24.4%)	31 (9.6%)	91 (28.1%)	29 (9.0%)
Instrumentation from apex to crown	57 (17.9%)	99 (31.1%)	24 (7.5%)	87 (27.4%)	51 (16.0%)

Table 4 Movement of hand instruments

	Yes, most definitely 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Reaming	36 (11.9%)	43 (14.2%)	44 (14.5%)	81 (26.7%)	99 (32.7%)
Stem winding	29 (9.9%)	54 (18.5%)	49 (16.8%)	73 (25.0%)	87 (29.8%)
Quarter turn-pull	38 (12.5%)	66 (21.6%)	52 (17.1%)	79 (25.9%)	70 (23.0%)
Filing (push-pull)	46 (15.9%)	82 (28.3%)	60 (20.7%)	62 (21.4%)	40 (13.8%)
Balanced force	23 (9.2%)	56 (22.5%)	31 (12.4%)	51 (20.5%)	88 (35.3%)

Table 5 Use of irrigants

	Yes, all the time 1	In most cases 2	Occasionally 3	Almost never 4	Not at all 5
Sodium hypochlorite	56 (19.5%)	17 (5.9%)	11 (3.8%)	31 (10.8%)	172 (59.9%)
0.1% NaOCl	8 (3.0%)	2 (0.7%)	6 (5.9%)	32 (11.9%)	221 (82.2%)
0.5% NaOCl	9 (3.4%)	2 (0.7%)	4 (1.5%)	27 (10.1%)	225 (84.3%)
1% NaOCl	17 (6.2%)	12 (4.4%)	4 (1.5%)	29 (10.5%)	213 (77.5%)
2% NaOCl	35 (12.2%)	14 (4.9%)	4 (1.4%)	30 (10.5%)	203 (71.0%)
4% NaOCl	13 (4.8%)	4 (1.5%)	4 (1.5%)	29 (10.7%)	222 (81.6%)
Milton	62 (20.4%)	36 (11.8%)	19 (6.3%)	37 (12.2%)	150 (49.3%)
NaOCl Conc unknown	20 (8.1%)	11 (4.5%)	7 (2.8%)	22 (8.9%)	186 (75.6%)
Sterile saline	4 (1.4%)	6 (2.0%)	13 (4.4%)	33 (11.3%)	237 (80.9%)
Water	16 (5.3%)	20 (6.6%)	12 (4.0%)	45 (14.9%)	210 (69.3%)
Local anaesthetic	86 (23.6%)	62 (17.0%)	56 (15.3%)	110 (30.1%)	51 (14.0%)
Chlorhexidine	19 (6.1%)	21 (6.7%)	29 (9.2%)	50 (15.9%)	195 (62.1%)
EDTA	16 (5.4%)	3 (1.0%)	22 (7.4%)	45 (15.2%)	211 (71.0%)

Table 6 Use of intracanal medication

	Yes, all the time 1	In most cases 2	Occasionally 3	Almost never 4	Not at all 5
None used	8 (3.0%)	34 (12.9%)	23 (8.7%)	54 (20.5%)	144 (54.8%)
Camphorated monochlorophenol	17 (6.2%)	41 (14.9%)	25 (6.0%)	34 (12.3%)	159 (57.6%)
Ledermix paste	32 (9.8%)	59 (18.0%)	91 (27.7%)	98 (29.9%)	48 (14.6%)
Ca(OH)	52 (15.5%)	77 (23.0%)	81 (24.2%)	87 (26.0%)	38 (11.3%)
Others	14 (8.0%)	12 (6.9%)	16 (9.1%)	10 (5.7%)	123 (71.3%)

Table 7 Obturation of the canal. Numbers who would obturate when various signs and symptoms present

	Yes, all the time 1	In most cases 2	Occasionally 3	Almost never 4	Not at all 5
No symptoms present	220 (55.8%)	137 (34.8%)	24 (6.1%)	11 (2.8%)	2 (0.5%)
Symptoms during previous 48h	13 (3.3%)	69 (17.7%)	161 (41.3%)	104 (26.7%)	43 (11%)
Root canal can be dried	143 (36.8%)	178 (45.8%)	50 (12.9%)	13 (3.3%)	5 (1.3%)
Sinus is present	47 (12.0%)	80 (20.4%)	102 (26.0%)	99 (25.3%)	64 (16.3%)
Tooth is slightly tender to percussion	11 (2.8%)	40 (10.2%)	121 (30.9%)	135 (34.4%)	85 (21.7%)
Root canal has bad odour	10 (2.6%)	21 (5.4%)	52 (13.4%)	136 (35.1%)	169 (43.6%)

of sodium hypochlorite (NaOCl), with 16% sodium chloride (NaCl). There was no statistical correlation between the irrigant used and the time after qualification. There was, however, an interaction between the use of rubber dam and the irrigant used. Those respondents using NaOCl, especially in higher concentrations (2% solution, $P < 0.001$, 4% solution, $P < 0.01$) were more likely to use rubber dam. This was also the case for those using EDTA ($P < 0.001$) and ultrasonics ($P = 0.016$). However, the converse was true for the use of local anaesthetic. Those not using rubber dam were more likely to use local anaesthetic ($P < 0.001$).

Intracanal medication. The frequency of use of intracanal medication is shown in Table 6. Statistical analysis showed that camphorated monochlorophenol was used more regularly by dentists who had qualified before 1983 ($P = 0.047$). In contrast, the dentists who had qualified after 1983 used calcium hydroxide as the dressing most frequently used ($P = 0.038$). Finally the respondents who qualified prior to 1983 used other medication statistically more often than the more recently qualified group ($P < 0.001$). These medications included Cresophene ($n = 30$), beechwood creosote ($n = 4$), Septomyxine ($n = 3$), Endomethasone ($n = 2$), chlorhexidine solution, Pulpomixine, and Savlon ($n = 1$).

Obturation

The respondents were asked to give up to four factors that they considered important when deciding to obturate the root canal. The majority considered factors relating to preparation of the root canal were important ($n = 428$). These included adequate preparation,

adequate shaping and cleaning, removal of all pulp debris and all the root canals found. A large number of dentists ($n = 169$) considered a dry root canal was necessary and 191 felt that the tooth should be symptomless before obturation. Thirty-seven of the respondents considered that the canal should have no foul smell before obturation. Minority responses included 'I always obturate', '35–40 diameter at apex', 'dry dentine chips in file', 'patient not going on holiday for 2–3 weeks'.

Questions relating to various specific factors regarding obturation were posed. The results are shown in Table 7. There were no statistically significant interactions among any of the factors and the year of qualification of the dentist.

Techniques for obturation

The most popular technique for obturation was cold lateral condensation of gutta-percha which was used all the time by 159 (42.4%) and in most cases by 127 (33.9%) of the respondents. Sixteen percent ($n = 54$) used a single gutta-percha cone for most of their cases whilst 80 (23.9%) used a single cone occasionally. Heated gutta-percha techniques were used relatively infrequently and the reason for this was the expense of much of the equipment used in these techniques. Table 8 summarises the frequency of responses.

Sealer used

Table 9 shows the frequency with which various types of sealer are used. Most practitioners were using a 'biocompatible' sealer and a minority (33 [9.7%]) were using a sealer containing paraformaldehyde.

Radiographs

Radiography is an important aspect of root canal treatment both for diagnosis, assessment of the working length and after completion of the root filling. Table 10 shows at which particular time during treatment radiographs are taken and Table 11 the techniques applied. Film holders were used more frequently by the respondents who qualified after 1983 ($P = 0.043$). The average number of radiographs taken by dentists during root canal treatment was usually three (221 [56.7%]), whereas 92 (23.6%) took two radiographs and 65 (16.7%) took four. Only four (1.0%) of the respondents took one film and 8 (2.1%) took five.

Electronic apex locators

Thirty (7.7%) respondents used an electronic apex locator at least most of the time. Over 80% (310) of respondents did not use one at all. The most popular type was the Analytic Technology AFA ($n = 10$). At least six other types were used.

Time for treatment

The mean time to complete root canal treatment in a single rooted tooth was 70.8 minutes with a minimum of 15 minutes and a maximum of 200 minutes. The mode was 60 minutes. Most respondents completed the treatment in two visits ($n = 263$), 88 completed the treatment in a single visit and 83 required three visits. Eleven dentists required four visits and two required more than four visits.

The number of appointments required for a molar root canal treatment was greater: 167 required 2 appointments; 168, three appointments; 56, four appointments and 22, more than four appointments. Thirty four respondents indicated that they did the treatment in one appointment. Statistical analysis indicates there is a statistically significant increase in appointments required for molar root canal treatment than for a single-rooted tooth. The practitioners who qualified before 1983 were more likely to require more appointments to complete the root canal treatment of both the single rooted ($P=0.022$) and the molar ($P=0.027$).

Table 8 Methods used for obturation of the root canal

	All the time 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Cold lateral condensation of gutta-percha	159 (42.4%)	127 (33.9%)	44 (11.7%)	14 (3.7%)	31 (8.3%)
Single gutta-percha cone	7 (2.1%)	47 (14.0%)	80 (23.9%)	70 (20.9%)	131 (39.1%)
Warm lateral condensation of gutta-percha	18 (5.4%)	8 (2.4%)	58 (17.3%)	48 (14.3%)	203 (60.6%)
Thermomechanical compaction	5 (1.5%)	12 (3.7%)	17 (5.2%)	32 (9.8%)	261 (79.8%)
Vertical condensation of warm gutta-percha	10 (3.1%)	8 (2.5%)	10 (3.1%)	24 (7.5%)	268 (83.8%)
System B	4 (1.3%)	3 (1.0%)	2 (0.6%)	10 (6.1%)	294 (93.9%)
Injectable warm gutta-percha	1 (0.3%)	1 (0.3%)	3 (0.9%)	11 (3.4%)	305 (95%)
Low heat (Ultrafil)	0	1 (0.3%)	1 (0.3%)	9 (2.8%)	309 (96.6%)
High heat (Obtura)	1 (0.3%)	0	1 (0.3%)	10 (3.1%)	308 (96.3%)
Thermafil	6 (1.8%)	8 (2.4%)	38 (15.9%)	24 (7.3%)	252 (76.8%)
Sealer only	3 (0.9%)	4 (1.2%)	11 (3.4%)	31 (9.6%)	275 (84.9%)
Silver cones	0	1 (0.3%)	23 (7.2%)	41 (12.8%)	255 (79.7%)

Table 9 Sealers used

	All the time 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
No sealer	2 (0.6%)	1 (0.3%)	2 (0.6%)	6 (1.9%)	302 (96.5%)
ZnO/Eugenol	146 (41.2%)	76 (21.5%)	48 (13.6%)	26 (7.3%)	58 (16.4%)
Calcium hydroxide containing sealer	97 (26.9%)	68 (18.8%)	78 (21.6%)	26 (7.2%)	92 (25.5%)
Epoxy resin	5 (1.6%)	2 (0.6%)	4 (1.3%)	17 (5.5%)	280 (90.9%)
Paraformaldehyde-containing sealers	17 (5.0%)	16 (4.7%)	19 (5.6%)	15 (4.4%)	273 (80.3%)
Others	1 (0.5%)	0	0	1 (0.5%)	174 (98.9%)

Table 10 Radiographs taken during root canal treatment

	All the time 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Pre-operative	207 (52.5%)	135 (34.3%)	50 (12.7%)	1 (0.3%)	1 (0.3%)
Working length	233 (61.5%)	74 (19.5%)	46 (12.1%)	17 (4.5%)	9 (2.4%)
Master files in place	49 (14.9%)	33 (10.0%)	87 (26.4%)	100 (30.4%)	60 (18.2%)
Master cones in place	35 (10.5%)	26 (7.8%)	85 (25.4%)	105 (31.4%)	83 (24.9%)
Final obturation	319 (81.6%)	44 (11.3%)	23 (5.9%)	4 (1.0%)	1 (0.3%)

Table 11 Radiographic techniques used

	All the time 1	In most cases 2	Occasionally 3	Almost never 4	No, definitely not 5
Long cone paralleling	149 (41.7%)	58 (16.2%)	40 (11.2%)	36 (10.1%)	74 (20.7%)
Bisecting angle	113 (32.6%)	69 (19.9%)	63 (18.2%)	30 (8.6%)	72 (20.7%)
Film holders	72 (21.6%)	56 (16.8%)	58 (17.4%)	29 (8.7%)	119 (35.6%)
Digital imaging machine	5 (1.6%)	1 (0.3%)	6 (2.0%)	3 (1.0%)	290 (95.1%)

Single visit root canal treatment

Three hundred and seventy one respondents made comments about the circumstances in which they would carry out root canal treatment in a single visit. The most common reasons were cases with a vital pulp (n=120), traumatic pulpal exposure (n=68) or elective root canal treatment (n=43). Twenty respondents stated that most of their cases were done in a single visit whilst 26 confirmed that they never completed root canal treatment in a single visit. Patient related factors, including the patient leaving the area or unable to re-attend accounted for 24 responses and 38 responses indicated that single visit root canal treatment would be undertaken if time permitted. Several respondents stated that they would perform single-visit root canal treatment on patients receiving antimicrobial prophylaxis. The majority of the respondents who undertake single visit root canal treatment in non-vital cases would do so only if the tooth was symptomless or where the anatomy of the tooth was straightforward; for example, a single rooted tooth.

Continuing professional education

Three hundred and fifty two respondents regularly attended post-graduate refresher courses, of which 264 had attended a course on endodontics and 340 wished to attend other endodontic courses. The most popular format for these courses was 'hands on' in a clinical techniques laboratory although there was an almost 50-50 split for those who wished a course where patients were treated. One hundred and ninety seven out of 284 respondents also requested rubber dam courses.

Journals

Journals were read by 95.7% of respondents. The most popular were, in order, *Dental Practice* (318/88.1%), *British Dental Journal* (277/79.8%) and *Dental Update* (270/77.4%). The specialist endodontic academic journals were less popular with a readership of 23 (8.4%) for the *International Endodontic Journal*, 17 (6.8%) for *Oral Surgery*, 16 (5.9%) for the *Journal of Endodontics* and 7 (2.6%) for *Endodontics and Dental Traumatology*. Several respondents had just subscribed to the new endodontic journal, *Endodontic Practice*.

Meetings

Informal meetings with colleagues were cited by 280 (80.2%) dentists in the survey, 235 (68.7%) attended formal lectures and 212 (63.1%) participated in 'hands on' courses. Only 95 (33.8%) attended meetings of the specialist societies.

Textbooks

One hundred and three (29.6%) practitioners stated that they had read a textbook on some aspect of endodontics in the last two years. The most popular textbook was *Endodontics in Practice*, a BDJ publication by Stock and Nehammer. The undergraduate text by Saunders and Harty, *Endodontics in Clinical Practice*, was also popular. Other books that had been perused were *Pathways of the Pulp* by Burns and Cohen, *Endodontic Quizbook* by Walker, *Colour Atlas of Endodontics* by Stock, Gulibavala and Walker and *Surgical Endodontics* by Gutmann and Harrison. Finally two respondents had read *Root Canal Cover up* by Meinig.

Discussion

A response rate of 69% was considered good and sufficiently high to make the findings credible. It could be argued that participants completing a questionnaire may give answers that they consider to be correct rather than those based on their own practice. However, in the present study the honesty shown in the answer to 'do you routinely use rubber dam for root canal treatment?', only 24.9%, would refute this. No general dental practitioner, irrespective of their time of qualification, was taught other than the use of rubber dam isolation was mandatory for root canal treatment. If this question was

answered truthfully then there is every reason to presume that this was the case with all answers.

The results of this study indicate that there had been a shift in treatment of the acute apical abscess among those practitioners who graduated after 1983. Leaving the tooth on open drainage is avoided in favour of establishing drainage and then closing the tooth after placement of an intracanal dressing. This treatment regime is logical; once the root canal system has been cleaned of toxins it would be counterproductive to allow recontamination from the oral cavity. This trend of closing the root canal system after initial drainage and cleaning has been confirmed amongst endodontists in the United States.⁸ It was clear from the written comments that treatment was adapted by time constraints and that optimal treatment could not always be performed on the first visit. It is now accepted that treatment of the acute abscess should involve drainage and cleaning of the root canal system but it was evident that antibiotics were prescribed in some cases by respondents in this study without drainage being instituted. The unnecessary prescription of antibiotics is an important issue and further emphasis should be placed on the criteria for their use by dental surgeons. Patient factors also influenced the treatment of the acute abscess when severe pain precluded active treatment at the first visit.

The low numbers of respondents who used rubber dam routinely was disappointing. Rubber dam is recognised as the best way of achieving asepsis during root canal treatment and its use is mandatory in undergraduate teaching of root canal treatment in the United Kingdom. In addition it provides a barrier against accidental swallowing or inhalation of instruments and irrigating fluids.⁹ Abbott¹⁰ when examining the factors associated with continuing pain after the start of endodontic treatment by general dental practitioners, found that lack of use of rubber dam was the most commonly occurring factor. Written comments suggested that some dentists had begun their practising lives using rubber dam but had used it less and less until confidence in its application had been lost. The results showed that there was no relationship between time since qualification and rubber dam use indicating that this method of tooth isolation is abandoned quickly. Cost also played a part in the decision not to use rubber dam.

Use of rubber dam in non-surgical root canal treatment is considered mandatory¹¹ and failure to use it could be considered to be below the standard of care.¹²

There are variations in the designs of hand instruments used in preparation of the root canal. Hand reamers were used more often by practitioners who had graduated before 1983. It has been shown that the more flexible instruments with modified tips show better shaping attributes than reamers¹³ but it would appear that this information is not reaching some general dental practitioners. Almost half the respondents undertook instrumentation from apex to crown in most cases. However, more recently qualified respondents favoured a crown down approach to preparation. This method has many advantages, including the removal of micro-organisms coronally, better penetration of irrigant, better access to the apical part of the root canal and reduced incidence of changes in working length.¹⁴ Twenty six per cent of respondents used reaming, or clockwise rotation, for preparation of the root canal for most cases. Reaming produces a round, tapered preparation but is unsatisfactory in curved root canals where iatrogenic damage occurs. The balanced force technique was used by 31.7% of respondents and was used more often by those who had graduated more recently which is understandable as the technique was first described in 1985.¹⁵ This technique has been shown to be superior in shaping the root canal than other hand preparation methods.¹⁶⁻¹⁸

Despite the small numbers of practitioners who were using nickel-titanium rotary instruments there was considerable interest in their use. This was evidenced by written comments indicating that practitioners were keen to include them in their armamentarium but some

were concerned about the cost-effectiveness of their use. Recent evidence suggests that rotary instruments made from nickel titanium produce root canal preparations of adequate shape with little tendency to create iatrogenic damage.^{19–22} However, there is a need for 'hands on' instruction and practice with these techniques.

Irrigation of the root canal is an important part of cleaning and shaping of the root canal system. Sodium hypochlorite is commonly recommended for irrigation, combining potent antibacterial activity with tissue dissolving properties. It is used in combination with other agents including chelating agents such as EDTA that remove inorganic debris and smear layer. Some authorities have recommended full strength household bleach,^{23,24} which, in the UK corresponds approximately to a 4% solution. Forty percent of respondents use local anaesthetic for irrigation and although the flushing effect of the solution helps cleaning there are no other active properties to facilitate cleaning. The positive correlation between non-use of rubber dam and use of local anaesthetic solution indicates the more diligent isolation requirements for irrigation with sodium hypochlorite.

Camphorated monochlorophenol and proprietary phenol-related compounds were used routinely as intracanal medicaments by 36% of respondents. These materials are no longer recommended as intracanal medicaments because they have powerful tissue toxicity, combined with allergenicity and mutagenicity. In addition, bacteria are not eliminated fully from the root canal system using these medicaments.²⁵ Calcium hydroxide was used by a further 21.1% of dentists. This material is most commonly recommended for use as an intracanal medicament and has been shown to work well in this role.^{25,26} Ledermix paste was used by 27.8% of respondents. This paste consists of a tetracycline, demeclocycline, and a corticosteroid, triamcinolone and has been advocated as an intracanal medicament despite the fact that its antimicrobial spectrum is narrow. Abbott *et al.*²⁷ have suggested mixing Ledermix with calcium hydroxide to enhance its effectiveness. A small proportion of respondents (15.9%) did not use intracanal medication. It is now known that despite thorough cleaning and shaping of the root canal system the environment is not rendered sterile. If an intracanal medicament is not used then bacterial levels increase and at the time of obturation there may be considerable numbers of bacteria present in the root canal system. These can influence the prognosis of treatment adversely.

The timing and quality of obturation of the root canal is affected by several factors which are highlighted in this study. Most of the respondents would not obturate if the tooth had symptoms at the obturation visit. The symptoms were not cited in many cases but it is not considered judicious to obturate a tooth that has an acute periradicular periodontitis. However, it is recognised that teeth with signs and symptoms of an acute pulpitis can be obturated after cleaning and shaping of the root canal system. Over 82% of respondents regarded a dry root canal as essential for obturation. The presence of fluid in the root canal may affect the properties of the sealer adversely, preventing adequate flow into the intricacies of the system and causing the material to set prematurely. Many of the other, minority responses concerning obturation were anecdotal and based on no scientific rationale.

Cold lateral condensation of gutta-percha was the most popular technique for obturation. This method is predictable and is the primary method taught in most UK dental schools. A small number of respondents were using heated gutta-percha techniques although considerable interest was expressed in experiencing these methods. Unfortunately, the use of the vast majority of these heated techniques requires relatively expensive equipment and the development of new clinical skills.

Few of the respondents were using paraformaldehyde-containing sealers. These are known to cause tissue damage if extruded into the periradicular tissues or surrounding anatomical structures and have

been shown to be very toxic.^{28,29}

Radiographic monitoring for treatment planning and progress of the treatment was undertaken by a large majority of the respondents. The most common views taken were of the pre-operative status, establishment of working length and final obturation. These are considered to be essential for root canal treatment. Fifty one per cent of respondents were using a bisecting angle technique. This technique is not recommended for root canal treatment because of the distortion that occurs to the image.¹¹ Film holders provide a method of achieving more consistent and accurate images but these were used routinely by only 38.4% of respondents. Digital imaging produces images rapidly with a lower radiation dose. The images can be stored in a computer and manipulated subsequently to allow assessments of periradicular healing to be made. The technology is relatively new and expensive and only six dentists used such a system for most of their root canal treatments. Electrical apex locators are now more dependable^{30–32} and can be used in the presence of fluid within the root canal although only 30 respondents used such a device most of the time.

The time taken to complete root canal treatment is governed by a number of factors, including the difficulty of the case, the techniques employed for preparation and obturation and the level of remuneration. The mean time for treatment of a single rooted tooth was 70.8 minutes which suggests that the level of remuneration does not make this item of treatment viable under National Health Service regulations. Most of the respondents completed the treatment of a single rooted tooth in two visits, the first to clean and shape and the second to obturate. The increased complexity of treatment for a molar was evidenced by the increased number of visits required. Many respondents carried out single visit root canal treatment on cases with a vital pulp but there was rather less enthusiasm for such treatment of non-vital cases. This concurs with recent research which demonstrated that success rates were reduced if infected cases were completed in a single visit.³³

There was considerable enthusiasm for continuing education courses in endodontics, including 'hands on' practical courses. It is important that, with the advent of compulsory continuing professional education, adequate resource is made available to provide these courses and steps are made to ensure that courses are of good quality. Saunders⁷ has alluded to the difficulties in organising these courses. Other ways in which general dental practitioners can keep up to date with clinical matters is by attending meetings and perusing journals and textbooks. As expected, journals covering general topics were most widely read although a number of endodontic textbooks had been studied.

Conclusions

The choice of materials and methods for the treatment of periradicular disease was linked to the time of qualification with those qualifying after 1983 using a crown-down approach to preparation and the balanced force technique more frequently than those who had qualified before 1983. Hand reamers and camphorated monochlorophenol intra-canal dressing were preferred by the cohort of respondents who had been qualified longer.

Rubber dam was used routinely by only 25% of respondents and its lack of use was related to the irrigant used. There was no correlation between rubber dam use and time of qualification.

Practitioners were keen to attend courses on root canal treatment and rubber dam, the most popular being with a 'hands on' component.

There is a need to increase awareness of changes to endodontic practice especially amongst those practitioners who have been qualified for longer than 16 years.

The authors wish to express their sincere thanks to all that completed the questionnaire. The secretarial assistance of Mrs A Kerr is acknowledged gratefully.

Chief Scientist Office, Scottish Home and Health Department funded the study,

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