Prevalence of and factors affecting postpreparation pain in patients undergoing two-visit root canal treatment

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Abstract

Glennon JP, Ng Y-L, Setchell DJ, Gulabivala K. Prevalence of and factors affecting postpreparation pain in patients undergoing two-visit root canal treatment. *International Endodontic Journal,* **37**, 29–37, 2004.

Aim This longitudinal, prospective study (i) investigated the prevalence of postpreparation pain during root canal treatment and (ii) evaluated the influence of factors affecting the pain experience.

Methodology Twenty practitioners, comprising general dental practitioners, MSc graduates and endodontists, participated in this study. The patient sample ($n = 272$) was derived from consecutive patients attending the practitioners' surgeries for a two-visit root canal treatment on a single tooth. Demographic, medical history, preoperative and intraoperative data as well as pain experience on days 1 and 2 after root canal preparation were recorded. Intensity of pain experienced was recorded on a visual analogue scale (VAS) of 0–5. The data were analysed using logistic regression models.

Results The prevalence of postpreparation pain within 48 h after treatment was 64.7% ($n = 176$), but less than 10% of patients experienced severe pain (VAS 4 or 5) on either day 1 or day 2. The presence of preoperative pain (OR = 2.841, $P < 0.001$), tooth type (OR = 2.008, $P = 0.009$), systemic steroid therapy for other medical reasons (OR = 0.181, $P = 0.023$) and preoperative swelling (OR = 2.433, $P = 0.040$) were the only factors to significantly influence postpreparation pain experience.

Conclusions The prevalence of postpreparation pain was high, and the important prognostic determinants were presence of preoperative pain, tooth type, systemic steroid therapy and preoperative swelling.

Keywords: pain, root canal treatment.

Received 2 May 2003; accepted 29 August 2003

Introduction

Development of interappointment pain during root canal treatment may undermine patients' confidence in their dentist. The ability to predict its prevalence and forewarn the patient may go some way towards enabling coping strategies. Unfortunately, the aetiological factors in pain manifestation have not been determined precisely. However, several hypothetical mechanisms involving chemical, mechanical or microbial injury to the periradicular tissues as well as psychological influences have been suggested as possible causes of postpreparation pain (Seltzer & Naidorf 1985). This subject has attracted considerable attention by researchers since 1970 (Table 1). The reported prevalence of post-preparation pain ranges widely from 2 to 88% (Table 1). Although most of the studies were either randomized controlled trials (Harrison *et al.* 1981; 1983, Marshall & Walton 1984, Balaban *et al.* 1984, Mata *et al.* 1985, Rimmer 1991) or prospective studies (Clem 1970, O'Keefe 1976, Georgopoulou *et al.* 1986, Torabinejad *et al.* 1994, Kvist & Reit 2000, Mattscheck *et al.* 2001, Siqueira *et al.* 2002), direct comparison between them is complicated by differences in study design, preoperative condition of the root-treated tooth, treatment protocol, timing of recording pain experience, index of pain measurement and severity of

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Table 1 Summary of studies of prevalence of pain experienced by patients after canal preparation

Study	Sample size	Study design[b]	Preoperative status of teeth controlled	Variables recorded[c]	Timing of recording pain after preparation	Prevalence of postpreparation pain, %	Prognostic factors identified	Statistical method
Clem (1970)	318 teeth	P	None	1, 2, 6, 7, 9, 15, 16	Immediate to next appointment	25 (moderate pain)	Presence of sinus, tooth type	Chi-square tests (χ^2)
O'Keefe (1976)	147 patients	P	None	1, 2, 3, 6, 8, 9 12, 16	Same as above	61	Age, medical problem, tooth type, preoperative pain	χ^2
Maddox *et al.* (1977)	101 treatment sessions	P	None	9, 16	Immediate to 2 days	37.6	None	χ^2
Harrison *et al.* (1983)	229 cases	RCT	No preoperative pain No pulpal exposure	6, 9, 15, 16	Immediate to next appointment	44.5 (mild 28.8, moderate-severe 15.7)	None	χ^2
Harrison *et al.* (1981)	245 patients	RCT	No preoperative pain No pulpal exposure	15, 16	2–14 days	13.3	None	χ^2
Marshall & Walton (1984)	50 patients	RCT	No medicament	5, 6, 7, 9, 13	4, 24, 48 h	9–29 (moderate -severe pain)	Use of intramuscular injection of steroid postop	Multiple regression
Balaban *et al.* (1984)	157 patients	RCT	Nonvital pulp, Presence of lesion, no previous RCT, no preoperative pain	1, 2, 12	Immediate to next appointment	10–14	Age, tooth type	χ^2
Torabinejad *et al.* (1988)	2000 patients	R	None	1, 2, 3, 4, 8, 9, 10, 12, 13, 16, 17	Immediate to next appointment	No data	Age, gender, tooth type, history of allergy, size of periapical lesion, sinus, previous RCT, preoperative pain, preop medication	χ^2
Trope (1990)	474 teeth	R	None	6, 7, 8, 9	Immediate to next appointment	2.53 (severe pain)	None	χ^2
Walton & Fouad (1992)	946 patient visits	P	None	6, 7, 8, 9, 11,	Immediate to next appointment	3.17 (severe pain)	Preop medication, pain, swelling, pulpal vitality	χ^2
Mata *et al.* (1985)	100 patients	RCT	No systemic disease or medication, no history or allergy to penicillin, nonvital pulp, no preoperative pain, no previous RCT, no medicament	8, 15, 17	Immediate, 2 days	88 (pain/swelling)	Postoperative penicillin V	χ^2
Georgopoulou *et al.* (1986)	245 patients	P	None	1, 2, 6, 7, 8, 12, 13, 15, 16	2–4 days or 7–14 days	4.3	Over-instrumentation	χ^2
Rimmer (1991)	356 patients	RCT	None	6, 8, 10, 14, 15, 16, 17	7–12 days	Not reported	Use of medicament with antibacterial, anti-inflammatory or anaesthetic properties	No information
Mor et al. (1992)[a]	334 patients	R	None	1, 2, 6, 8, 12, 15, 16	Immediate to next appointment	4.2 (pain requiring emergency appointment)	Pulp vitality	χ^2
Torabinejad *et al.* (1994)	588 patients	RCT	None	1, 2, 4, 5, 6, 8, 9, 15, 17	Immediate to 72 h	Not reported	Preoperative pain and intensity, apprehension, postoperative intraoral medication	χ^2 and multiple regression

Walton & Chiappinette (1993)[a]	80 patients	P	Nonvital pulp, presence of periapical lesion, no preoperative pain	15, 16, 17	4–48 h postoperative	69–79	None		χ^2
Eleazer & Eleazer (1998)	201 patients	R	Nonvital pulp, no sinus tract, 1st and 2nd molars	15, 16	Immediate to next appointment	8	None		χ^2
Kvist & Reit (2000)	46 patients	P	Presence of periapical lesion, had root canal treatment	14, 15, 16	Immediate to 6 days	20	Not studied		χ^2
Mattscheck *et al.* (2001)[a]	71 patients	P	None	6, 7, 8, 15, 16	4–120 h	Not reported	Preoperative pain		ANOVA
Siqueira *et al.* (2002)	627 teeth, 602 patients	P	All nonvital	7, 8, 14, 15, 16	Immediate to 1 week	15.2	Preoperative pain		χ^2
DiRenzo *et al.* (2002)	72 patients	P	Adult (18+), healthy, no preoperative medicati	6, 9, 12, 14, 15, 16	6–48 h	20	None		Independent-samples *t*-test

[a]Data contaminated with postobturation pain.
[b]P = prospective; R = retrospective; RCT = randomized controlled trial.
[c]1 = Age; 2 = gender; 3 = medical history; 4 = history of allergy; 5 = preoperative medication; 6 = pulpal vitality; 7 = previous root canal treatment; 8 = periapical lesion; 9 = preoperative pain; 10 = preoperative sinus; 11 = preoperative swelling; 12 = tooth type/location; 13 = extent of instrumentation; 14 = size of apical preparation; 15 = irrigant; 16 = medicament; 17 = postoperative medication.

pain included in the statistical analysis. Subjective synthesis of the data suggests that the presence and severity of preoperative pain (O'Keefe 1976, Torabinejad *et al.* 1988; 1994, Mattscheck *et al.* 2001, Siqueira *et al.* 2002) appear to have a strong influence on the development of pain after initial root canal preparation. Other factors such as gender (Torabinejad *et al.* 1988), age (O'Keefe 1976, Torabinejad *et al.* 1988), history of allergies (Torabinejad *et al.* 1988), tooth type (Torabinejad *et al.* 1988), location (O'Keefe 1976), pulpal status (Mor *et al.* 1992), presence and size of periapical lesion (Torabinejad *et al.* 1988), presence of sinus tract (Clem 1970, Torabinejad *et al.* 1988), history of root canal treatment failure (Torabinejad *et al.* 1988), over-instrumentation (Georgopoulou *et al.* 1986), intracanal medicament (Rimmer 1991) and postoperative intraoral medications such as antibiotics (Mata *et al.* 1985, Torabinejad *et al.* 1988, Rimmer 1991) have also been reported to have significant effects on postpreparation pain. The majority of previous studies (Table 1) have analysed the potential associations with individual factors separately, using the Chi-square test which does not allow several independent variables to be considered simultaneously, a more realistic clinical scenario.

The aim of this study was to determine the prevalence of postpreparation pain during root canal treatment and to evaluate its association with various clinical factors using multiple logistic regression models.

Materials and methods

Consecutive patients attending the participating dental practitioners ($n = 20$) for root canal treatment on only one tooth were invited to participate in this prospective study. The dental practitioners included endodontists ($n = 5$), MSc postgraduates in the Departments of Conservative Dentistry and Periodontology ($n = 6$) and general dental practitioners ($n = 9$) with a special interest in Endodontics but with no formal postgraduate training. A total of 415 patients consented to participate but only those receiving root canal treatment over two visits ($n = 272$) were included for analyses in this study. Preoperative (Table 2) and intraoperative (Table 2) data were collected by the operators. All the teeth were associated with a periapical lesion. The root canal preparation was completed in the first visit for all cases. The presence and severity of postoperative pain over the first 2 days (Table 2) following root canal preparation were recorded by the patient in a questionnaire and returned to the operator on the second visit. The severity of pain was recorded on a visual analogue scale of 0–5.

Table 2 Data recorded for each case

Preoperative data
Patient identification, date of birth and gender
Relevant medical history
Chronic debilitating disease[a]
Diet diabetics
Insulin diabetics
Topical steroid therapy
Systemic steroid therapy
Chemotherapy
Radiotherapy
Asthmatic
Drug allergy
Food allergy
Hay fever
Eczema
Tooth type
Preoperative clinical signs and symptoms associated with the tooth studied
History of pain (before and within 24 h)
History of swelling (before and within 24 h)
Presence of sinus (at the time of treatment)
Presence of periapical radiolucent area
History of previous root canal treatment
Intraoperative data
Operator qualification
Size of apical preparation (=25 or <25)
Irrigant used (NaOCl, local anaesthesia, EDTA + NaOCl, others)
Medicament used ($Ca(OH)_2$, Ledermix, Ledermix + $Ca(OH)_2$, formocresol, others)
Postpreparation pain
Presence and intensity of pain in the first 12–24 and 24–48 h
Characteristics (temperature sensitivity, tenderness to biting on the tooth, throbbing)

[a]Chronic debilitating disease = respiratory disease, Crohn's disease, sarcoidosis, cardiac disease, myalgic encephalomyelitis, gout, thyroid disease, kidney disease, rheumatoid disease, ocular disease, depression.

Furthermore, they were asked to select a descriptor best defining the pain experienced. The participating dentists and patients were supplied written instructions on how to assess and record the experience, severity and characteristics (Table 2) of pain at 1 and 2 days postinstrumentation. The written instructions were followed by a telephone call to the operators to establish if there were any difficulties in understanding or using the data collection forms.

The relationship between possible factors influencing the pain experienced by patients after root canal preparation was analysed using logistic regression models with a statistical package (SPSS version 11, SPSS Inc., Chicago, IL, USA).

Results

Of the 272 patients studied, 176 (64.7%) experienced some level of pain on either day 1 or day 2 postpreparation. The level of reported pain on a VAS is presented in Table 3. Of the 176 patients who experienced postpre-

Table 4 Frequency distribution of presentation of postpreparation pain reported by the patients

Presentation of pain	No. (%) of patients with pain at 1 day postpreparation ($n = 174$)	No. (%) of patients with pain at 2 days postpreparation ($n = 102$)
Temperature sensitivity	23 (13.2)	11 (10.8)
Tenderness to biting on the tooth	104 (59.8)	63 (61.8)
Throbbing	69 (39.7)	33 (32.4)

	Intensity of pain presented on Day 2						
VAS	0	1	2	3	4	5	Total
Intensity of pain presented on Day 1							
0	96	4	1	3	0	0	105
1	43	18	5	3	0	1	69
2	21	10	5	2	0	2	40
3	5	5	10	7	4	0	31
4	3	4	1	3	4	1	16
5	2	0	1	3	2	3	11
Total	170	41	23	21	10	7	272

Shaded cells represent number of patients with the same pain intensity on days 1 and 2.
Cells *above* the shaded cells represent number of patients with higher pain intensity on day 2 than on day 1.
Cells *below* the shaded cells represent number of patients with lower pain intensity on day 2 than on day 1.

Table 3 Cross-tabulation representing the frequency of combination of pain (intensity) presenting on days 1 and 2. ($n = 272$)

Table 5 Frequency distribution of key explanatory variables and postpreparation pain in the first 48 h

Variables	Categories	Total		Postpreparation pain	
		Number	%	Number	%
Gender	Female	148	54.4	103	70
	Male	124	45.6	73	59
Age	<20	7	2.6	4	57
	=20 and <30	25	9.2	16	64
	=30 and <40	54	19.9	38	70
	=40 and <50	87	32.0	54	62
	=50 and <60	40	14.7	27	68
	=60 and <70	39	14.3	23	59
	=70 and <80	13	4.8	8	62
	=80	7	2.6	6	86
Tooth type	Incisors or canines	58	21.3	33	57
	Premolars	66	24.3	36	55
	Molars	148	54.4	107	72
History of allergy	Yes	100	36.8	66	66
	No	172	63.2	110	64
Topical steroid treatment	Yes	2	0.79	1	50
	No	270	99.3	175	65
Systemic steroid treatment	Yes	9	3.3	3	33
	No	263	96.7	173	66
Diet controlled diabetic	Yes	7	2.6	3	43
	No	265	97.4	173	65
Insulin controlled diabetic	Yes	1	99.6	1	100
	No	271	0.4	175	65
Chronic debilitating disease	Yes	14	5.1	10	71
	No	258	94.9	166	64
Preoperative pain within 24 h before treatment	Yes	144	52.9	109	76
	No	128	47.1	67	52
Preoperative pain >24 h before treatment	Yes	188	69.1	130	69
	No	84	30.9	46	55
Preoperative swelling within 24 h	Yes	38	14.0	30	79
	No	234	86.0	146	62
Preoperative swelling >24 h before treatment	Yes	55	20.2	38	69
	No	217	79.8	138	64
Preoperative sinus	Yes	29	10.7	17	59
	No	243	89.3	159	65
Periapical lesion >3 mm	Yes	75	27.6	44	59
	No	197	72.4	132	67
Previous root canal treatments	Yes	47	17.3	35	74
	No	225	82.7	141	63
Operator qualification	Endodontists	133	48.9	92	69
	MSc postgraduates	31	11.4	21	68
	GDPs	108	39.7	63	58
MAF size = 25	Yes	269	98.9	176	65
	No	3	1.1	0	0
Irrigant used	NaOCl	232	85.3	154	66
	LA	2	0.7	2	100
	EDTA + NaOCl	27	9.9	17	63
	Unknown	2	0.7	1	50
	Others	9	3.3	2	22
Medicament used	None	99	36.4	67	68
	$Ca(OH)_2$	118	43.4	77	65
	Ledermix	13	4.8	8	62
	Ledermix + $Ca(OH)_2$	20	7.4	13	62
	Formocresol	14	5.1	6	43
	Unknown	5	1.8	2	40
	Others	3	1.1	3	100

Table 6 Logistic regression models for each explanatory variable given separately

Explanatory variables (reference category)	Single logistic regression analyses		
	P-value	OR	95% CI for OR
MAF size = 25	–	–	–
Preoperative pain within 24 h before treatment (no)	<0.001*	2.835	1.694, 4.746
Preoperative pain >24 h before treatment (no)	0.023*	1.852	1.090, 3.144
Molar tooth (no)	0.004*	2.080	1.255, 3.447
Preoperative swelling within 24 h before treatment (no)	0.052**	2.660	0.992, 5.150
Use of NaOCl as irrigant (no)	0.053**	3.109	0.988, 9.784
Systemic steroid therapy (no)	0.061**	0.260	0.064, 1.065
Gender (female)	0.066**	0.625	0.379, 1.032
Operator (GDP vs. MSc)	0.082**	0.624	0.367, 1.064
Previous root canal treatments (no)	0.127	1.738	0.855, 3.531
Periapical lesion >3 mm (no)	0.200	0.699	0.404, 1.208
Diet diabetic (no)	0.235	0.399	0.087, 1.820
Medicament [$Ca(OH)_2$]	0.439	0.814	0.483, 1.371
Preoperative swelling >24 h before treatment (no)	0.447	1.279	0.678, 2.414
Preoperative sinus (no)	0.469	0.748	0.341, 1.641
Chronic debilitating disease (no)	0.591	1.385	0.422, 4.538
Topical steroid therapy (no)	0.667	0.543	0.034, 8.777
History of any form of allergy (no)	0.734	1.094	0.652, 1.836
Insulin diabetic (no)	0.734	98.859	0.000, 3.1E+13
Operator (GDP vs. endodontist)	0.877	0.936	0.405, 2.164
Medicament (Ledermix)	0.891	0.948	0.445, 2.023
Age	0.988	1.000	0.984, 1.017

Variable 'MAF size = 25' was not analysed because of absence of sample with MAF size <25 and no postpreparation pain.
P-values with * are significant at 5% level.
P-values with ** are significant at 10% level.

paration pain, the majority ($n = 94$, 53.5%) had pain on both day 1 and day 2, whilst 74 (42.0%) and 8 (4.5%) patients presented with pain only on day 1 or day 2 postpreparation, respectively. Most of the patients reported either lower ($n = 113$, 64.2%) or the same ($n = 37$, 21.0%) level of pain on day 2 compared with day 1. Only 26 (14.8%) patients complained of more severe pain on day 2 compared with day 1. Severe pain (VAS 4 and 5) was reported by 27 (9.9%) and 17 (6.3%) patients on days 1 and 2, respectively. The presenting characteristics of postpreparation pain reported by the patients are given in Table 4.

The frequency distribution of the key explanatory variables and the prevalence of postpreparation pain within 48 h after the preparation visit are presented in Table 5.

The results were analysed using logistic regression models with the odds of 'postpreparation pain on day 1 or day 2' as the dependant variable. When each explanatory variable was analysed separately in single logistic regression models (Table 6), the odds of prevalence of postpreparation pain significantly increased by 2.8- or 1.8-fold if there was preoperative pain within 24 h (OR 2.835, 95% CI 1.694–4.746, $P \leq 0.001$) or preoperative pain more than 24 h (OR 1.852, 95% CI 1.090–3.144, $P = 0.023$) before treatment, respectively. Treatment of a molar significantly doubled the odds of postpreparation pain (OR 2.080, 95% CI 1.255–3.447, $P = 0.004$) when compared with other tooth types. Other variables such as preoperative swelling within 24 h before treatment (OR 2.66, 95% CI 0.99–5.15, $P = 0.052$), use of NaOCl as irrigant (OR 3.11, 95% CI 0.99–9.78, $P = 0.053$), systemic steroid therapy for general medical condition (OR 0.26, 95% CI 0.06–1.07, $P = 0.061$), gender (OR 0.63, 95% CI 0.38–1.03, $P = 0.066$) and qualification of operator (GDP vs. MSc postgraduates) (OR 0.62, 95% CI 0.37–1.06, $P = 0.082$) also appear to have a marginally significant influence on the postpreparation pain at the 10% level.

Some of these potential predictive factors were highly correlated ($P < 0.05$) (Table 7) and therefore could not be included in a multiple regression model simultaneously.

Table 8, model 1, illustrates the effect of attempting to simultaneously enter 'preoperative pain within 24 h', 'molar tooth type', 'systemic steroid therapy', 'use of sodium hypochlorite as irrigant' and 'gender' into a

Table 7 *P*-values of correlation tests between potential prognostic factors

Variable code	Variable	2	3	4	5	6	7	8
1	Preoperative pain within 24 h	<0.001*	0.025*	0.013*	0.618	0.721	0.155	0.864
2	Preoperative pain >24 h		1.000	0.058	0.207	0.758	0.118	0.276
3	Preoperative swelling within 24 h			0.680	0.100	0.883	0.130	0.281
4	Gender				0.787	0.071	<0.001*	0.406
5	Systemic steroid therapy					0.043*	0.930	0.840
6	Operator						0.013*	0.605
7	Molar tooth							1.000
8	Use of NaOCl as irrigant							

P-values with * indicates significance at 5% level.

statistical model; 'use of sodium hypochlorite as irrigant' and 'gender' failed to reach statistical significance at the 5% level.

When 'preoperative pain >24 h' (model 2) or 'preoperative swelling within 24 h' (model 3) replacing 'preoperative pain within 24 h' were entered separately in a similar model, 'preoperative pain >24 h' lost its statistical significance at the 5% level.

Subsequently, 'preoperative pain within 24 h' or 'preoperative swelling within 24 h' were analysed separately in models 4 and 5, respectively, with 'molar tooth' and 'systemic steroid': all four factors remained significant at the 5% level.

'Preoperative pain within 24 h' appears to be the single best predictor ($P < 0.001$) of the odds of postpreparation pain during root canal treatment. A 'nonmolar' tooth ($P = 0.009$) or systemic steroid therapy ($P = 0.023$) was, on the other hand, significantly associated with lower prevalence of postpreparation pain. There was a marginally significant ($P = 0.040$) association between preoperative swelling within 24 h and a higher prevalence of postpreparation pain.

Table 8 Multiple logistic regression models incorporating preoperative pain within 24 h before treatment, preoperative pain more than 24 h before treatment, preoperative swelling within 24 h, molar tooth, systemic steroid therapy, NaOCl irrigant and gender as predictors

	Multiple logistic regression analyses		
Explanatory variables (reference category)	*P*-value	OR	95% CI for OR
Model 1			
Preoperative pain within 24 h before treatment (no)	<0.001*	2.820	1.638, 4.854
Molar (no)	0.015*	1.942	1.139, 3.309
Systemic steroid (no)	0.031*	0.192	0.043, 0.860
Use of NaOCl as irrigant (no)	0.056	3.294	0.968, 11.211
Gender (female)	0.263	0.737	0.432, 1.258
Model 2			
Preoperative pain >24 h before treatment (no)	0.146	1.509	0.867, 2.627
Molar (no)	0.009*	2.001	1.186, 3.376
Systemic steroid (no)	0.072	0.260	0.060, 1.125
Use of NaOCl as irrigant (no)	0.101	2.744	0.820, 9.183
Gender (female)	0.120	0.662	0.393, 1.114
Model 3			
Preoperative swelling within 24 h before treatment (no)	0.038*	2.481	1.054, 5.841
Molar (no)	0.004*	2.177	1.289, 3.677
Systemic steroid (no)	0.052*	0.233	0.054, 1.011
Use of NaOCl as irrigant (no)	0.100	2.717	0.825, 8.945
Gender (female)	0.070	0.618	0.367, 1.040
Model 4			
Preoperative pain within 24 h before treatment (no)	<0.001*	2.841	1.671, 4.831
Molar (no)	0.009*	2.008	1.186, 3.401
Systemic steroid (no)	0.023*	0.181	0.041, 0.787
Model 5			
Preoperative swelling within 24 h before treatment (no)	0.040*	2.433	1.043, 5.678
Molar (no)	0.002*	2.236	1.333, 3.750
Systemic steroid (no)	0.042*	0.227	0.054, 0.947

P-values with * are significant at 5% level.

Discussion

Consecutive patients attending the participating dentists for root canal treatment on a single tooth requiring two-visit root canal treatment during the study period were selected for analysis in this prospective study. More than one tooth receiving root canal treatment in the same patient cannot all be assumed to behave independently from each other, for the purpose of this analysis; therefore, such cases were excluded. Postpreparation pain during root canal treatment was the focus of interest in this study: as the root filling procedures for those cases completed in one visit may have a confounding effect on the postpreparation pain, they were also excluded from the analyses. The cases with root canal preparation procedures carried out over more than two visits may present with postpreparation pain on more than one occasion; as each occasion cannot be treated as independent from the other, these cases too were excluded from the analysis. Previous studies have not considered the confounding effect of such data characteristics (Clem 1970, Maddox *et al.* 1977, Harrison *et al.* 1981, 1983, Balaban *et al.* 1984, Mata *et al.* 1985, Torabinejad *et al.* 1988, 1994, Trope 1990, Rimmer 1991, Mor *et al.* 1992, Walton & Fouad 1992, Walton & Chiappinette 1993, Siqueira *et al.* 2002).

The high prevalence (64.7%) of pain experience after root canal preparation was consistent with some (O'Keefe 1976, Mata *et al.* 1985) but much higher than that reported by most other previous studies (Clem 1970, Maddox *et al.* 1977, Harrison *et al.* 1981; 1983, Balaban *et al.* 1984, Marshall & Walton 1984, Georgopoulou *et al.* 1986, Trope 1990, Mor *et al.* 1992, Eleazer & Eleazer 1998, Siqueira *et al.* 2002). This discrepancy could be attributed to differences in the preoperative status of the teeth, treatment procedures used and the severity of pain included for analysis. Some studies only included asymptomatic teeth (Harrison *et al.* 1981; 1983, Balaban *et al.* 1984, Mata *et al.* 1985) and could account for the lower prevalence of pain reported, as preoperative pain was found in this study to be a significant influencing factor. Those studies that defined postpreparation pain as moderate or severe (Clem *et al.* 1970, Marshall & Walton 1984, Trope *et al.* 1990), pain that required treatment (Mor *et al.* 1992) or pain that could not be controlled by over-the-counter analgesics (Eleazer & Eleazer 1998) reported a much lower prevalence of postpreparation pain.

When all the explanatory variables were considered separately to explore the potential influence that each might have on the prevalence of postpreparation pain (Table 6), eight independent variables (preoperative pain within 24 h before treatment, preoperative pain >24 h before treatment, tooth type, preoperative swelling within 24 h before treatment, systemic steroid therapy, type of irrigant, gender and operator) were identified as potentially important prognostic factors. However, only four variables (preoperative pain within 24 h before treatment, preoperative swelling within 24 h before treatment, tooth type, systemic steroid therapy) remained significantly associated with postpreparation pain when all eight variables were considered in further regression models (Table 8).

Amongst the four variables, the most significant factor was 'preoperative pain within 24 h before treatment' ($P < 0.001$). When there was preoperative pain, the odds of occurrence of postpreparation pain was increased 2.8-fold. This finding is in agreement with others (O'Keefe 1976, Torabinejad *et al.* 1988; 1994, Mattscheck *et al.* 2000, Siqueira *et al.* 2002). Preoperative swelling within 24 h before treatment also had a significant effect on postpreparation pain; however, it was confounded by the 'preoperative pain within 24 h before treatment'.

There are conflicting results with regards to the influence of tooth type on the prevalence of postpreparation pain (Clem 1970, Balaban *et al.* 1984, Torabinejad *et al.* 1988, Georgopoulou *et al.* 1986, Mor *et al.* 1992). This study found that molar teeth were associated with greater susceptibility to postpreparation pain, consistent with the finding by Clem (1970). This may be a function either of the canal system complexity rendering debridement more difficult or simply of the higher number of roots and canal exits, increasing the risk of postpreparation complications.

Patients receiving systemic steroid therapy for other medical conditions appeared to have significantly ($P = 0.023$) less postpreparation pain than those not receiving such therapy. This finding is consistent with those of Liesinger *et al.* (1983) and Marshall & Walton (1984) who showed that postoperative injection of steroid significantly reduced both prevalence and severity of post-treatment pain. Steroid may suppress the acute inflammatory response (Smith *et al.* 1976) that develops in the periradicular tissue as a result of additional mechanical, chemical or microbial insults during root canal preparation and may explain its effect on the prevalence of postpreparation pain.

Other factors such as age, gender, history of allergies, presence of sinus tract, size of lesion and history of root canal treatment were found to have no significant influence on postpreparation pain, in contrast to the findings of Torabinejad *et al.* (1988): they did however collect their

data retrospectively and only analysed the factors separately using the Chi-square test.

The lack of significant influence on postpreparation pain by type of irrigant or medicament is in agreement with others (Maddox *et al.* 1977, Harrison *et al.* 1981; 1983, Torabinejad *et al.* 1988; 1994, Trope 1990) but contradicts Rimmer (1991) who found that intracanal medicaments with antibacterial, anti-inflammatory or anaesthetic property were associated with less postoperative pain.

Conclusions

The prevalence of some level of postpreparation pain during root canal treatment was high and significantly affected by preoperative pain or swelling, tooth type and systemic steroid therapy for other medical conditions.

Acknowledgements

The authors would like to acknowledge Mr D. R. Moles for his advice regarding the statistical analyses.

References

Balaban FS, Skidmore AE, Griffin JA (1984) Acute exacerbations following initial treatment of necrotic pulps. *Journal of Endodontics* **10**, 78–81.

Clem WH (1970) Posttreatment endodontic pain. *Journal of American Dental Association* **81**, 1166–70.

DiRenzo A, Gresla T, Johnson BR, Rogers M, Tucker D, Begole EA (2002) Postoperative pain after 1- and 2-visits root canal therapy. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **93**, 605–10.

Eleazer PD, Eleazer KR (1998) Flare-up rate in pulpally necrotic molars in one-visit versus two-visit endodontic treatment. *Journal of Endodontics* **2**, 614–6.

Georgopoulou M, Anastassiadis P, Sykaras S (1986) Pain after chemomechanical preparation. *International Endodontic Journal* **19**, 309–14.

Harrison JW, Baumgartner JC, Zielke DR (1981) Analysis of inter-appointment pain associated with the combined use of endodontic irrigants and medicaments. *Journal of Endodontics* **7**, 272–6.

Harrison JW, Baumgartner JC, Svec TA (1983) Prevalence of pain associated with clinical factors during and after root canal therapy. Part 1. Inter-appointment pain. *Journal of Endodontics* **9**, 384–7.

Kvist T, Reit C (2000) Post-operative discomfort associated with surgical and non-surgical endodontic retreatment. *Endodontics and Dental Traumatology* **16**, 71–4.

Liesinger A, Marshall FJ, Marshall JG (1993) Effect of variable doses of dexamethasone on post treatment endodontic pain. *Journal of Endodontics* **19**, 35–8.

Maddox DL, Walton RE, Davis CO (1977) Incidence of post-treatment endodontic pain related to medicaments and other factors. *Journal of Endodontics* **3**, 447–52.

Marshall JG, Walton RE (1984) The effect of intramuscular injection of steroid on post-treatment endodontic pain. *Journal of Endodontics* **10**, 584–8.

Mata E, Koren LZ, Morse DR, Sinai IH (1985) Prophylactic use of penicillin V in teeth with necrotic pulps and asymptomatic periapical radiolucencies. *Oral Surgery, Oral Medicine and Oral Pathology* **60**, 201–7.

Mattscheck DJ, Law AS, Noblett WC (2001) Retreatment versus initial root canal treatment: factors affecting post-treatment pain. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **92**, 321–4.

Mor C, Rotstein I, Friedman S (1992) Incidence of inter-appointment emergency associated with endodontic therapy. *Journal of Endodontics* **18**, 509–11.

O'Keefe EM (1976) Pain in endodontic therapy: preliminary study. *Journal of Endodontics* **2**, 315–9.

Rimmer A (1991) Intracanal medications and antibiotics in the control of inter-appointment flare-ups. *Quintessence International* **22**, 997–1005.

Seltzer S, Naidorf IJ (1985) Flare-ups in endodontics. Part I. Etiological factors. *Journal of Endodontics* **11**, 472–8.

Seltzer S, Naidorf IJ (1985) Flare-ups in endodontics. Part II. Therapeutic measures. *Journal of Endodontics* **11**, 559–67.

Siqueira JF, Rôças IN, Favieri A *et al.* (2002) Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. *Journal of Endodontics* **28**, 457–60.

Smith RG, Patterson SS, El-Kafrawy AH (1976) Histological study of the effects of hydrocortisone on the apical peridodontium of dogs. *Journal of Endodontics* **12**, 376–80.

Torabinejad M, Kettering JD, McGraw JC, Cummings RR, Dwyer TG, Tobias TS (1988) Factors associated with endodontic inter-appointment emergencies of teeth with necrotic pulps. *Journal of Endodontics* **14**, 261–6.

Torabinejad M, Cymerman JJ, Frankson N, Lemon RR, Maggio JD, Schilder H (1994) Effectiveness of various medications on postoperative pain following complete instrumentation. *Journal of Endodontics* **20**, 345–54.

Trope M (1990) Relationship of intracanal medicaments to endodontic flare-ups. *Endodontics and Dental Traumatology* **6**, 226–9.

Walton RE, Chiappinelli J (1993) Prophylactic penicillin: effect on posttreatment symptoms following root canal treatment of a asymptomatic periapical pathosis. *Journal of Endodontics* **19**, 466–70.

Walton RE, Fouad A (1992) Endodontic interappointment flare ups: a prospective study of incidence and related factors. *Journal of Endodontics* **18**, 172–6.