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Pain associated with root canal treatment

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Abstract

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Aim To determine the pain experienced by patients during root canal treatment and to correlate with age and gender, pulpal diagnosis, previous periapical status, dental characteristics and length of treatment.

Methodology One hundred and seventy-six patients (68 men and 108 women), with ages ranged from 6 to 83 years, were randomly recruited. Patients completed a 10-cm visual analogue scale (VAS) that ranked the level of pain experienced during root canal treatment.

Results The mean pain level during root canal treatment was 1.2 ± 0.8 in a VAS between 0 and 10. Fifty-four per cent of patients did not experience pain. There were no significant differences in relation to gender or age groups. Mandibular teeth had a significantly ($P < 0.05$) higher percentage incidence of pain in comparison with maxillary teeth. Pain was absent in 63% of anterior teeth compared with 44% in posterior ones ($P < 0.01$). Interventions shorter than 45 min resulted in a significantly higher percentage of pain absence ($P < 0.05$). Root canal treatment was significantly ($P < 0.05$) more painful in teeth with irreversible pulpitis and acute apical periodontitis compared to the group with necrotic pulps and chronic apical periodontitis ($P = 0.049$).

Conclusions Root canal treatment in teeth with irreversible pulpitis and acute apical periodontitis was more painful. Age, tooth type and length of the treatment were factors associated with increased risk for pain experienced during the procedure. Knowledge of pain levels endured by patients will allow dentists to decide when to use supplemental local anaesthesia.

Keywords: endodontic pain, irreversible pulpitis, nonsurgical endodontic therapy, pain, periapical status, pulpal status.

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Introduction

During root canal treatment, many patients become anxious as a result of the pain they expect to endure. This apprehension, together with the effects of inflammation, decreases their pain threshold and diminishes the effect of local analgesic (Walton & Torabinejad 1992). Clinicians report that managing the pain and distress of patients can be frustrating, especially when the treatment itself appears to initiate its onset. Indeed, the result can be distressing to both the patient and the operator (Sathorn *et al.* 2008). On the contrary, the elimination of pain enhances the confidence of patients.

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In the case of the endodontic therapy, the patient is frequently affected by symptomatic pulpitis or periodontitis, undergoing central sensitization (an increase in the excitability of neurons within the central nervous system) and peripheral sensitization (a reduction in threshold and an increase in responsiveness of the peripheral ends of nociceptors) (Woolf & Salter 2000). This pain hypersensitivity represents a challenge for the control of pain, especially when morphogenetic changes produced by neurogenic inflammation causes resistance of the nerve fibres to the anaesthetic (Jeske 2003). For example, in patients with irreversible pulpitis conventional inferior alveolar nerve block is ineffective in up to 80% of cases (Meechan 2002).

Fear of pain during endodontic treatment is usually associated with the procedure itself, not the post-treatment period (Gale & Ayer 1969). Most studies

involving endodontic pain have not involved the pain experienced during the actual treatment (Harrison *et al.* 1983). The purpose of this study was to measure the level of patient discomfort experienced during root canal treatment and its correlation age and gender, dental characteristics, pulpal diagnosis, previous periapical radiographic status and the duration of the procedure.

Materials and methods

One hundred seventy six patients (68 men and 108 women), with ages ranging from 16 to 83 years, were questioned after undergoing root canal treatment in relation to their pain perception. Patients were recruited randomly in two private dental clinics (Seville and Madrid, Spain). Patients ageing <16 years, being under analgesic treatment for a medical condition, taking analgesics in the previous 24 h, or who refused to give written consent, were excluded. Root canal treatment was carried out by two experienced endodontists. The Ethics Committee of the School of Dentistry approved the investigation and all the patients included in the study gave written informed consent.

Prior to treatment, each practitioner recorded the tooth type, arch (Table 1), patient gender and age, and provided a pulpal diagnosis for each tooth after evaluating the patient's reaction to mastication, palpation, percussion and thermal stimulation. Pulpal status was classified as normal, irreversible pulpitis and necrotic. In addition, a periapical radiograph was taken and periapical status was assessed and classified as normal, acute apical periodontitis (AAP) and chronic apical periodontitis (CAP) as described previously (Jiménez-Pinzón *et al.* 2004, Segura-Egea *et al.* 2004, Ridao-Sacie *et al.* 2007).

Patients were anaesthetized with the volume of anaesthetic and type of injection being at the discretion of the dentist. After endodontic access cavity preparation, the working lengths of the canals were verified either by radiograph or apex locator. Then, the canals were cleaned and shaped using a crown-down technique with hand and rotary instrumentation. Treatment was completed during the same appointment by filling the canals with gutta-percha and sealer using the lateral compaction technique. When treatment was completed, the length of the procedure was recorded. Immediately, each patient received instruction on how to use a 10-cm visual analogue scale (VAS) (Huskinsson 1974) to assess pain. As soon as each patient self-recorded his/her pain by ranking the level of pain experienced during treatment, he/she was informed verbally about the aim of the study. Then, this score was converted to a numerical value between 0 and 10 and to a verbal scale (none, slight, moderate, intense and unbearable) (Fig. 1).

Raw data were entered into Excel (Microsoft Corporation, Redmond, WA, USA). The analyses were carried out in an SPSS environment (Version 11; SPSS Inc., Chicago, IL, USA). Frequency distributions and contingency table analyses were used to describe and compare demographic and dental variables with patient-reported pain variables (significance level, $\alpha = 0.05$). Experienced pain variables were analysed first as continuous variables and then were dichotomized into high or low categories according to the sample distribution and previous literature reports on VAS (Price *et al.* 1983). Statistical regression modelling techniques were used; linear regression for continuous outcome variables and logistic regression for dichotomous outcome variables to identify important relationships between dental variables and perceived pain, whilst controlling for the behaviour intervention variables that were part of the study design. Age dichotomized as 35 years and younger and older than 35 years was used as a predictor variable in the logistic regression analysis. The factors or independent variables considered in the analyses were patient's age, gender, pulpal diagnosis, previous radiographic periapical status, tooth type and treatment length.

Table 1 Distribution by tooth type and arch of the 176 root filled teeth

Tooth type	Maxilla	Mandible	Total (%)
Incisor	20	12	32 (18)
Canine	10	8	18 (10)
Premolar	27	23	50 (28)
Molar	35	41	76 (43)
Total (%)	92 (52)	84 (48)	176 (100)

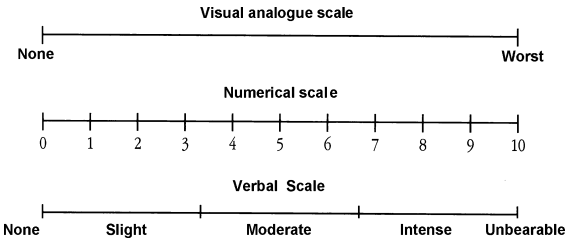

Figure 1 Scales used to assess pain levels.

Results

The mean pain level during root canal treatment was 1.2 ± 0.8 in a VAS scale between 0 and 10. Relative frequencies of the verbal assessment of the pain experienced are shown in Table 2. Pain was absent in 54% of the cases. The pain experienced was slight, moderate and intense in 34%, 9% and 3% of the cases respectively. No intervention resulted in unbearable pain. Mean pain levels did not differ between men (1.1 ± 0.6) and women (1.3 ± 1.1) ($P > 0.05$). Sixty-one per cent of men and 47% of women did not experience pain during the treatment ($P < 0.05$). Women felt a significantly higher percentage of slight pain (42%) in comparison with men (26%) ($P < 0.05$).

Age was not correlated with mean pain levels (Table 3). There were no significant differences between the six groups of age ($P > 0.05$). Patients older than 65 years were those that most frequently did not feel any pain (72%) and those of age between 26 and 35 years felt pain most frequently (63%). Nevertheless, when the patients where dichotomized in two groups, 35 years and younger and older than 35 years (Fig. 2), significant differences were observed in pain levels. Sixty per cent of patients ageing 35 years and younger experienced some type of pain, whereas only 39% of patients older than 35 years felt pain ($P < 0.05$).

Tooth type did not influence significantly the pain level (Table 4). However, pain was absent in 63% of treatments carried out in anterior teeth (incisors and canines) compared with 44% in the posterior quadrant (premolars and molars) ($P < 0.01$). Classifying the treatments according to the jaw, there were no significant differences in pain levels (Fig. 3), although the percentage of patients who did not feel pain was greater in the maxilla (60%) than in the mandible (48%) ($P > 0.05$). However, mandibular teeth had a significantly higher percentage of slight pain (42%) in comparison with maxillary teeth (26%) ($P < 0.05$).

The influence of treatment length on the pain experienced is outlined in Fig. 4. The percentage of patients who did not feel pain diminished as the length of the procedure increased, becoming stabilized at 60 min. In the same way, the percentage of patients who felt some type of pain increased progressively reaching a steady state at 60 min. Interventions

Table 2 Pain experienced with root canal treatment by gender

Pain level	Men (%)	Women (%)	Total (%)	*P*
None	61	47	54	<0.05
Slight	26	42	34	<0.05
Moderate	9	9	9	>0.05
Intense	4	2	3	>0.05

Table 3 Age distribution of the pain experienced (percentage) associated with root canal treatment

Pain level	<25	26–35	36–45	46–55	56–65	>65	Total
None	41	39	63	49	59	72	54
Slight	40	42	28	44	33	18	34
Moderate	13	12	7	6	7	9	9
Intense	6	7	2	0	1	1	3
Total	100	100	100	100	100	100	100

$P > 0.05$.

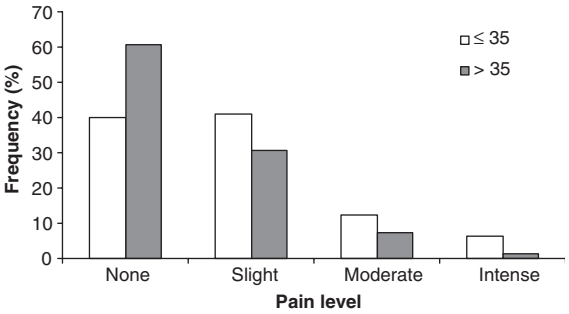

Figure 2 Age distribution of the pain experienced with root canal treatment when age dichotomized as 35 years and younger and older than 35 years. *$P < 0.05$.

Table 4 Pain experienced (percentage) associated with root canal treatment by tooth type

Pain level	Incisor	Canine	Premolar	Molar	Total
None	58	68	46	42	54
Slight	34	30	36	37	34
Moderate	7	1	15	14	9
Intense	1	1	3	7	3

Dotted squares: Anterior teeth versus posterior teeth; $P < 0.05$.

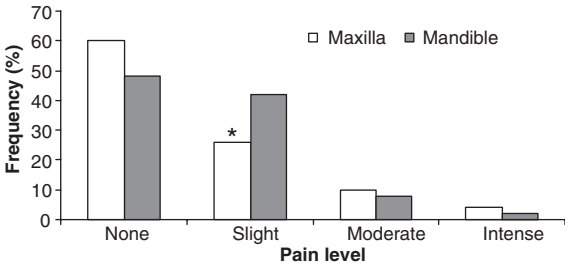

Figure 3 Pain experienced with root canal treatment by arch.*$P < 0.05$.

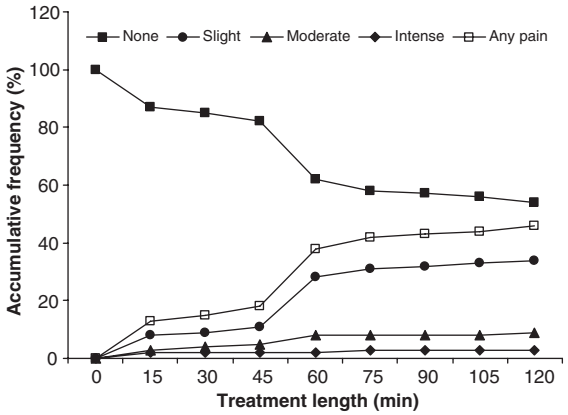

Figure 4 Pain experienced with root canal treatment by length of treatment.

shorter than 45 min showed a significantly higher percentage of pain absence compared to those that were longer ($P < 0.05$).

Table 5 shows pulpal diagnoses and previous periapical states, assessed radiographically. Fifty-three per cent of the treated teeth were diagnosed as necrotic, 40% with irreversible pulpitis, and 7% as 'normal'. Thirty-nine per cent of the teeth had widening of the periodontal ligament space and were diagnosed as acute apical periodontitis, 52% had a periapical radiolucency and were diagnosed as chronic apical periodontitis, and 10% showed a normal periapical status.

Table 5 Pulpal diagnoses and previous radiographic periapical status of the 176 root filled teeth

Periapical/Pulpal	Normal	IP	Necrotic	Total
Normal (%)	13 (7)	4 (2)	0	17 (10)
AAP (%)	0	56 (32)	12 (7)	68 (39)
CAP (%)	0	10 (6)	81 (46)	91 (52)
Total (%)	13 (7)	70 (40)	93 (53)	176 (100)

AAP, acute apical periodontitis; CAP, chronic apical periodontitis; IP, irreversible pulpitis.

Pain levels during root canal treatment were analysed in relation to the pulpal diagnosis and the periapical status (Table 6). When comparing all the groups, there were no significant differences in relation to pulpal diagnosis ($P > 0.05$) or to periapical status ($P > 0.05$). However, there was a significant difference between two groups: the root canal treatment was significantly more painful in the group of teeth with irreversible pulpitis and apical acute periodontitis compared to the group of teeth with necrotic pulps and chronic apical periodontitis ($P = 0.049$) (Table 6, dotted squares).

Multivariate logistic regressions were run with age (<35/>35 years), gender (male/female), tooth type (posterior teeth/anterior teeth), pulpal status (irreversible pulpitis/other), periapical status (acute apical periodontis/other), and length of the treatment as independent variables and pain experienced as the dependent variable (Table 7). The analysis suggested that age (OR = 2.4; 95% CI 1.2–3.6; $P < 0.01$), tooth type (OR = 3.4; 95% CI 1.6–7.3; $P < 0.01$) and length of the treatment (OR = 1.5; 95% CI 1.0–2.2; $P < 0.05$) were factors associated with increased risk for pain experienced during the procedure.

Discussion

Few studies have been published analysing the pain experienced during root canal treatment (Harrison *et al.* 1983, Rousseau *et al.* 2002, Watkins *et al.* 2002). The results from this study revealed that more than 50% of patients did not feel pain during root canal treatment, but about 12% of patients experienced moderate-to-intense pain. Assessment of the intraoperative pain experienced were carried out using a visual analogue scale (VAS), a valid and reliable method

Table 6 Pain experienced with root canal treatment in relation to pulpal diagnosis and previous radiographic periapical status

	Normal pulp				Irreversible pulpitis				Necrotic pulp			
Pain level	N	S	M	I	N	S	M	I	N	S	M	I
NPA	7	4	1	0	2	1	0	0	0	0	0	0
AAP	0	0	0	0	28	19	7	4	7	4	1	1
CAP	0	0	0	0	5	3	1	0	49	27	5	0
Total	7	4	1	0	35	23	8	4	56	31	6	1

NPA, normal periapex; AAP, acute apical periodontitis; CAP, chronic apical periodontitis.
Pain level: N, none; S, slight; M, moderate; I, intense.
Dotted squares: AAP/Irreversible pulpitis versus CAP/Necrotic pulp; $P = 0.049$.
Irreversible pulpitis versus necrotic pulp; $P > 0.05$.
AAP versus CAP; $P > 0.05$.

Table 7 Multivariate logistic regression analyse of the influence of the independent variables age (>35/<35 years), gender (male/female), tooth type (posterior teeth/anterior teeth), pulpal status (irreversible pulpitis/other), periapical status (acute apical periodontitis/other) and length of the treatment, on the dependent variable 'pain experienced during root canal treatment' (absent/present)

Independent variables	B	*P*	Odds Ratio	CI 95% Inf. Limit	CI 95% Sup. Limit
Age	−4.9123	0.0066	2.4174	1.1874	3.6474
Gender	−1.1181	0.3571	0.3269	0.0303	3.5309
Tooth type	1.2214	0.0018	3.3920	1.5743	7.3084
Pulpal status	−0.2967	0.6062	0.7433	0.2406	2.2962
Periapical status	0.5496	0.3391	1.7325	0.5614	5.3464
Length of the treatment	0.4060	0.0412	1.5008	1.0163	2.2163

widely used in the endodontic literature (Hargreaves & Keiser 2002, Polycarpou *et al.* 2005, Sathorn *et al.* 2008). Patients were told the aim of the study after self-recorded their pain. Thus, the so-called Hawthorne effect (De Amici *et al.* 2000), i.e. the mere awareness of participants in an investigation can alter the way in which a person behaves, was minimized.

The mean pain level during root canal treatment found in the present report was 1.2 ± 0.8 in a VAS between 0 and 10. Moderate or intense pain only was felt by 12% of patients. Previous investigations using VAS between 0 and 100 reported comparable results. Thus, in the study developed by Rousseau *et al.* (2002) the mean pain experienced during root canal treatment was 7.7; Watkins *et al.* (2002) reported the mean pain level during root canal treatment was 22.7 ± 19.9, meaning that 22.6% of patients felt high pain levels.

The mean levels of experienced pain did not differ by gender. Comparable results have been reported by Watkins *et al.* (2002) who found similar intraoperative pain levels in both sexes, although women anticipated higher pain levels than men. However, in this study a higher percentage of men (61%) did not experience pain during treatment compared with women (47%) ($P < 0.05$), who felt a significantly higher percentage of slight pain. Gender differences in pain reports with women reporting more pain than men (Unruh *et al.* 1999) and the reduction of pain thresholds in women (Liddell & Locker 1997) have been reported previously. Moreover, Polycarpou *et al.* (2005) determined the prevalence of persistent dento-alveolar pain following nonsurgical and/or surgical endodontic treatment, concluding that female gender was an important risk factor associated with persistent pain after successful endodontic treatment. Recently, Khan *et al.* (2007) found significantly higher levels of mechanical allodynia, defined as reduced mechanical pain thresholds, in women with irreversible pulpitis and acute periradicular periodontitis, compared to men.

The findings of this study show that age did not influence mean pain levels. However, 39% of patients older than 35 years felt pain, whereas 60% of patients ageing 35 years and younger experienced it (OR = 2.4; 95% CI 1.2–3.6; $P < 0.01$). Moreover, Watkins *et al.* (2002) found that anticipated and experienced outcome levels significantly decreased with increasing age. Clinicians should be aware that there are no conclusive data that progressive loss of sensitivity to nociceptive stimuli occurs with age (Walco & Harkins 1999). Thus, the age-related decrease in pain is not thought to be attributable to changes in the physiological pain system.

Tooth type was not significantly associated with anticipated or experienced pain during dental procedure. Similar results have been found by others investigators (Harrison *et al.* 1983, Yesilsoy *et al.* 1988, Watkins *et al.* 2002). This aspect was investigated by individual tooth type and by comparing maxillary to mandibular and anterior to posterior teeth. Even though patients felt pain more frequently in the mandibular arch, and mandibular teeth had a significantly higher percentage of slight pain (42%) in comparison with maxillary teeth (26%) ($P < 0.05$), the arch in which the treatment was carried out did not influence significantly mean pain levels ($P > 0.05$). Watkins *et al.* (2002) found similar results. However, pain was absent in 63% of treatments carried out in anterior teeth compared to 44% in the posterior quadrant (OR = 3.4; 95% CI 1.6–7.3; $P < 0.01$). Previously, posterior teeth located in the mandibular arch have been reported to be associated significantly with higher levels of post-endodontic pain (Yesilsoy *et al.* 1988). This difference may be related biologically to a greater number of canals and high frequency of bifurcated root canals in mandibular posterior teeth

(Cohen & Burns 1994, Watkins *et al.* 2002). The significantly higher percentage of slight pain in the mandible found in this study could also be explained because nerve-block injections are more technically difficult compared to infiltration injections. Clinical studies have reported that a single inferior alveolar nerve block injection of local anaesthetic is ineffective in 30–80% of patients with a diagnosis of irreversible pulpitis (Hargreaves & Keiser 2002). Bigby *et al.* (2006) has proposed that, when the inferior alveolar nerve block fails to provide profound pulpal anaesthesia, the intraosseous injection of 4% articaine with 1 : 100 000 epinephrine would be successful 86% of the time in achieving pulpal anaesthesia in mandibular posterior teeth of patients presenting with irreversible pulpitis. This technique could be used regularly in root canal treatment of mandibular molar teeth in patients with irreversible pulpitis.

The length of treatment correlated significantly with the painful perception of the patients (OR = 1.5; 95% CI 1.0–2.2; $P < 0.05$). The percentage of patients who did not feel pain decreased as the length of the procedure increased. Interventions shorter than 45 min were significantly less painful than that exceeding this time ($P < 0.05$). This could be explained by the progressive decrease of the anaesthetic effect (Claffey *et al.* 2004, Mikessel *et al.* 2005), together with the increase of the anxiety of the patient as the intervention extended. However, it must be taken into account that root canal treatment in anterior teeth was shorter than in posteriors, and that anterior teeth had less pain compared to posterior. Therefore, the differences found between short and long treatments could be confounded by tooth type.

Harrison *et al.* (1983) reported no association with inter appointment or post-root canal treatment obturation pain and tooth diagnosis. However, this study demonstrated that root canal treatment in teeth with irreversible pulpitis and AAP was significantly more painful than that in teeth with necrotic pulps and CAP ($P = 0.049$). Pain is a major complaint in both irreversible pulpitis and AAP. Dummer *et al.* (1980) found that 87% of patients who suffered from acute pulpitis reported severe pain, and that all patients who presented with AAP complained of severe pain. Recently, Owatz *et al.* (2007) reported that the incidence of mechanical-allodynia in patients presenting with irreversible pulpitis was 57.2%, suggesting that periradicular mechanical-allodynia contributes to early stages of odontogenic pain because of inflammation of vital pulpal tissue. Thus, the reduced mechanical pain thresholds associated with mechanical-allodynia could explain that root canal treatment in teeth with irreversible pulpitis and AAP was significantly more painful than that in teeth with necrotic pulp and CAP.

Conclusions

Root canal treatment in teeth with irreversible pulpitis and acute apical periodontitis was more painful. Age, tooth type and the length of the treatment were factors associated with increased risk for pain experienced during the endodontic procedure. Knowledge of pain levels endured by patients, as well as modifying variables, will allow dentists to decide when to use supplemental local anaesthesia.

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