Pain Prevalence and Severity before, during, and after Root Canal Treatment: A Systematic Review

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Abstract

Introduction: Anticipation and experience of root canal associated pain is a major source of fear for patients and a very important concern of dentists. Pretreatment, treatment, and posttreatment pain is anticipated, experienced, remembered, and shared by patients. The purpose was to determine the influence of root canal treatment on pain prevalence and severity and estimate the prevalence and severity of pretreatment, treatment, and posttreatment pain in patients receiving root canal treatment. **Methods:** Defined searching of MEDLINE, Embase, Cochrane, and PsycINFO databases identified 5,517 articles. Systematic review, including title scanning, abstract scanning, full-text review, and quality rating, provided 72 studies for meta-analysis. L'Abbe plots were used to evaluate the influence of root canal treatment on pain prevalence and severity. Pretreatment, treatment, and posttreatment pain prevalence and severity data were analyzed. **Results:** L'Abbe plots revealed that pain prevalence and severity decreased substantially after treatment. Mean pretreatment, 24-hour posttreatment, and 1-week posttreatment pain prevalences with associated standard deviations were 81 (28%), 40 (24%), and 11 (14%), respectively. Pretreatment, 24-hour posttreatment, and 1-week posttreatment pain severities, on a 100-point scale, were 54 (24%), 24 (12%), and 5 (5%), respectively. Supplemental injections were frequently required (60 [24%]). **Conclusions:** Pretreatment root canal–associated pain prevalence was high but dropped moderately within 1 day and substantially to minimal levels in 7 days. Pretreatment root canal–associated pain severity was moderate, dropped substantially within 1 day of treatment, and continued to drop to minimal levels in 7 days. Supplemental anesthesia was often required. *(J Endod 2011;37:429–438)*

Key Words

Endodontic, L'Abbe plot, meta-analysis, pain, prevalence, root canal, severity

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Pain of endodontic origin is widely feared by the public (1–3). Root canal procedures are commonly believed to be the most painful dental treatment, but only 17% of subjects experiencing root canal treatment described it as their most painful dental experience (4). Indeed, the provision of over 15 million elective root canal treatments annually in the United States suggests that the public values root canal treatment (5). Rigorous systematic reviews have shown that root canal treatment facilitates the long-term retention of teeth with pulpal or periradicular disease that would otherwise likely be extracted (6, 7). Root canal treatment obviously alleviates pain of endodontic origin, but this important benefit has not yet been subjected to systematic review or meta-analysis.

Accurate knowledge of pain prevalence and severity associated with pulpal or periradicular disease and its diminution by root canal treatment has the potential to change the attitudes of the public, dentists, and other health care professionals, thus allowing more natural teeth to be retained. Dentists could be better guided by the best evidence in making anesthesia and pain management treatment decisions. In addition, more accurate evidence-based advice could be given to individual patients by individual dentists. This would improve the basis upon which individual patients make their own informed treatment decisions. Furthermore, data on expected pain could be used to reassure patients during treatment and healing or to identify those who fall beyond the norms, so that additional care could be appropriately provided. However, the extant literature containing data on endodontic pain is rather disparate and primarily includes articles focusing on other topics, typically prognostic variables, treatment variables, or medications (8, 9). Direct comparisons of pretreatment, treatment, and posttreatment pain are extremely rare (10–12). Thus, it is difficult for the dentist to identify, assimilate, or synthesize data on root canal treatment–associated pain in a clinically applicable manner.

Systematic review uses defined methods to search, critically appraise, and synthesize the available literature pertaining to a clinical question. Systematic review is a fundamental scientific activity that methodically digests large quantities of information to find an answer to a research question. It is an efficient and reproducible scientific technique that produces generalizable findings. It also allows the researcher to assess consistency of relationships and to explain inconsistencies and conflicts in data. Furthermore, it increases power and precision of estimations. Hence, systematic review and meta-analysis are widely regarded as providing the highest level of clinical evidence (8, 13–16). The purpose of this study was to determine the influence of nonsurgical root canal treatment on pain prevalence and severity in adult patients and to estimate the prevalences and severities of pain experienced before, during, and after root canal treatment through systematic review and meta-analysis.

Materials and Methods

A systematic review was developed following established guidelines (9). Methodology included the following: formulating review questions using a PICO (patient population, intervention, comparison, and outcome) framework, constructing a search strategy, defining inclusion and exclusion criteria, locating studies, selecting studies, assessing study quality, extracting data, and interpretation.

The following review questions were formulated to determine the influence of nonsurgical root canal treatment in adult patients on pain prevalence and severity estimations and allow the comparison of pretreatment, treatment, and posttreatment pain in patients requiring and receiving root canal treatment: (1) In adult patients receiving

TABLE 1. Search Strategy for Root Canal Treatment–associated Pain

I	((exp Endodontics/or exp Dental Pulp Diseases/or exp Periapical Diseases/or exp "Root Canal Filling Materials"/or Dental Pulp Test/or Dental Pulp/or Dental Pulp Cavity/) or (("root canal".mp. or apicectom:.mp. or apicoectom:.mp. or (dead adj3 (teeth or tooth)).mp. or (dental adj3 pulp:).mp. or endodont:.mp. or endont:.mp. or endosonic.mp. or ((lateral or vertical) adj condensation).mp. or ((non-vital or nonvital) adj3 (teeth or tooth)).mp. or obtura.mp. or obturation.mp. or obturate.mp. or (pulp adj3 (capping or therap: or extirpation:)).mp. or (pulp adj (canal$1 or chamber$1)).mp. or pulpectomy.mp. or pulpotomy.mp. or replantation.mp. or ("root" adj end adj5 fill:).mp. or ((silver or gutta) adj3 (percha or balata)).mp. or (silver adj (cone$1 or point$1)).mp. or thermafil.mp. or trans-polyisoprene.mp. or transpolyisoprene.mp. or ultrafil.mp.) or ((periradicular or radicular or periapical or apical).mp. and (exp tooth/or exp tooth components/))) not (*Apicoectomy/or *Dental Implantation, Endosseous, Endodontic/or *Retrograde Obturation/or *Tooth Replantation/)) and (Clinical Protocols/or exp Clinical trials/or exp Patient Care Management/or Patient Selection/or Practice Guidelines/or clinic:.mp. or (recall adj3 appointment$1).mp. or ((patient or research) adj3 (recruitment or selection)).mp. or (selection adj3 (criteria or treatment or subject$1)).mp. or (treatment adj protocol$1).mp. or ra.fs. or radiograph:.mp. or ah.fs. or histolog:.mp. or (nonsurg: or non-surg:).mp.) and (exp Disease progression/ or exp Morbidity/ or exp Mortality/ or exp "Outcome assessment (health care)"/ or exp Patient satisfaction/ or exp Prognosis/ or exp Survival analysis/ or exp Time factors/ or exp Treatment outcome/ or ((beneficial or harmful) adj3 effect$).mp. or co.fs. or course.mp. or (inception adj cohort$1).mp. or (natural adj history).mp. or outcome$1.mp. or predict$.mp. or prognos$.mp. or surviv$3.mp. or fail$5.mp. or longevity.mp. or durability.mp. or succes:.mp. or random$.ti,ab. or predispos$.ti,ab. or causa$.ti,ab. or exp Case-control studies/ or (case$1 adj control$).ti,ab. or exp Cohort studies/ or exp "Comparative study"/ or exp Epidemiological Studies/ or odds ratio/ or (odds adj ratio$1).ti,ab. or exp Risk/ or risk$.ti,ab. or Meta-analysis/ or Meta-analysis.pt. or practice guideline.pt. or exp Clinical Trials/ or (randomized controlled trial or controlled clinical trial).pt. or random$.ti,ab. or (systematic adj review$1).mp. or Retreatment/ or Recurrence/ or (retreat: or revis:).mp.)
II	(Dental anxiety/ or odontophobia.mp. or ((dental or dentist:) adj5 (pain or anxi: or phob: or fear)).mp. or ((Pain/ or Fear/ or Anxiety/) and (exp Dentistry/ or exp Stomatognathic System/ or exp Stomatognathic diseases/)) or ("Quality of Life"/ or exp Consumer Satisfaction/ or Attitude/ or ((consumer$1 or patient$1) adj5 (satisf: or preference$1 or accept:)).mp.))
III	((Dentition, Primary/ or (immatur: adj3 (teeth or tooth)).mp. or (open adj3 (apex or apices or apexes)).mp. or blunderbuss.mp. or limit to (preschool child <2 to 5 years> or child <6 to 12 years>)) not (Dentition, Mixed/ or Dentition, Permanent/ or Adolescent/ or (mature adj3 (teeth or tooth)).mp. or (closed adj3 (apex or apices or apexes)).mp. or limit to all adult <19 plus years>)) not (Animal/ not Human/)) limit to English language

I lists MeSH keywords and search terms for non-surgical root canal treatment. II lists the MeSH keywords and search terms for psychosocial data. III lists the MeSH keywords and search term limits.

nonsurgical root canal treatment, does root canal treatment decrease pain prevalence? (2) In adult patients requiring nonsurgical root canal treatment, what is the prevalence of pretreatment pain? (3) In adult patients receiving nonsurgical root canal treatment, what is the prevalence of treatment pain? (4) In adult patients receiving nonsurgical root canal treatment, what is the prevalence of posttreatment pain? (5) In adult patients receiving nonsurgical root canal treatment, does root canal treatment decrease pain severity? (6) In adult patients requiring nonsurgical root canal treatment, what is the severity of pretreatment pain? (7) In adult patients receiving nonsurgical root canal treatment, what is the severity of treatment pain? and (8) In adult patients receiving nonsurgical root canal treatment, what is the severity of posttreatment pain?

Inclusion and Exclusion Criteria

Inclusion criteria further refined the review questions; these included comparative or noncomparative, prospective or retrospective, longitudinal data including prevalence and severity of pretreatment and posttreatment pain; incidence of treatment pain; anesthetic efficacy; and incidence of flare-ups, swelling, and emergencies. Inclusion criteria for article included the following: articles published in English from January 1966 to December 2009, adult subjects, secondary teeth, and a quality rating of 19 or more in the Wong Scale–Revised. (17) Exclusion criteria consisted of literature that failed to meet these inclusion criteria; root canal treatment caused by trauma; treatment modalities not currently being used, such as the blanket prescription of antibiotics without specific indication, the use of paraformaldehyde containing sealers, and so on; gray literature (literature not listed in MEDLINE, Cochrane, PsycINFO, or EMBASE databases); and studies without pain measurement outcomes.

Search Methodology

Electronic searches were performed in MEDLINE, Cochrane, EMBASE, and PsycINFO databases. The search strategies for MEDLINE, Cochrane, and EMBASE databases were as follows: "endodontic studies" and for "psychosocial outcomes" in a prior investigation but with the addition of the term "pain" (Table 1) (6). The search strategy for PsycINFO was simply keyword (periapical disease OR endodontics OR root canal). The results were supplemented by hand searches, citation mining, and expert recommendation. Hand searching involved reviewing the table of contents of every issue of the most recent 2 years of the following journal titles: *American Journal of Dentistry*, *International Endodontic Journal*, *Journal of Dentistry*, *Journal of Endodontics*, *Journal of Oral Rehabilitation*, *Oral Surgery Oral Medicine Oral Pathology and Oral Radiology*, and *Endodontics, Pain, and Quintessence International*. The citation mining and expert recommendation processes incorporated relevant materials that did not appear in database searches, such as book chapters or review articles. Experts were consulted to recommend additional articles or books for review. Two investigators screened the titles and abstracts of all articles identified in the electronic and hand searches. Articles that did not meet the search criteria were excluded. All remaining articles were full-text reviewed in the second stage of the process.

Study Quality Rating

The quality of study methodology, design, and data analysis was assessed using the Wong Scale–Revised. Studies were assessed by reviewer responses to nine questions; a score of 1 (inappropriate), 2 (mediocre), or 3 (appropriate) was assigned to each question. Out of a comprehensive total score of 9 to 27, a score under 19 indicated that the methodology, design, and analysis of the study failed to support the reliability of the authors' conclusions, necessitating exclusion from the meta-analysis (17).

Data Analysis

L'Abbe plots were used to depict the effect of root canal treatment intervention on the prevalence and severity of pain. Studies that reported

both pre- and post-treatment pain were included in the L'Abbe plots. These plots are very useful in assessing changes due to treatment, especially among heterogenous studies when pretreatment values may vary widely. Pretreatment data serve as a baseline measure to which analagous posttreatment data can be validly compared. Points plotted to the upper left of the diagonal plot line denote an increase in pain after treatment, whereas points plotted to the lower right of the diagonal line denote a decrease in pain after treatment.

Where possible, data from like studies were analyzed by meta-analysis. Descriptive statistics, weighted means, and standard deviations were calculated. Pain prevalence and severity trends over the 7 days after treatment were plotted.

Results

Description of the Existing Literature

Initial electronic and manual searches identified 5,517 studies. MEDLINE supplied 4,858 studies, EMBASE supplied 107 additional studies, PsycINFO supplied 25 additional studies, the Cochrane Library supplied 517 additional studies, and hand searching supplied 10 additional studies. After title and abstract screening, full texts for 183 were obtained. After full-text review, 72 articles pertaining to pretreatment, treatment, or posttreatment endodontic pain were identified (1, 10, 18–87). Of these, MEDLINE supplied 58, the Cochrane Library provided 12 additional articles, and hand searching provided 2 additional articles. Major sources of heterogeneity included reporting of results from differing areas of the mouth, comparison of differing materials and techniques within studies, differing follow-up times, differing outcomes measures, differing methods of measurement, differences in operator type, and variations in patient selection or sample size. The overall mean study quality rating of the 72 included studies was 23 (standard deviation = 2) on the 27-point scale. All studies had quality ratings of 19 or above, so none were excluded for reasons of quality. Evidence for the following analyses of pain prevalence, pain severity, and anesthetic efficacy are summarized in Tables 2 through 4.

Effect of Root Canal Treatment on Pain Prevalence

An L'Abbe plot was made to include data limited to the 7 studies that included both pre- and posttreatment pain prevalence data (Fig. 1 and Table 2) (10, 36,40, 48, 61, 81, 87). Posttreatment pain prevalence was substantially lower than pretreatment prevalence in all cases. Pain prevalence substantially decreased over the days immediately after root canal treatment in all cases. Root canal treatment unequivocally reduced pain prevalence.

Pretreatment Pain Prevalence

Pretreatment pain prevalence was high. The mean pain prevalence for all 30 studies with pretreatment pain prevalence data was 81% (standard deviation = 28%) (10, 22–28, 35, 36, 40, 45, 48, 51, 53, 54, 58, 61, 63, 68, 71–74, 76, 81, 82, 85–87). However, most studies using visual analog scales (VASs) reported 100% prevalence because even the tiniest discomfort registered a pain score of more than zero. The mean pain prevalence for all 14 categoric studies, non-VAS studies, was 68% (standard deviation = 28%) (10, 27, 35, 36, 40, 54, 61, 63, 68, 72, 74, 76, 86, 87). Likewise, it is important to note that 3- and 4-point scales still registered pain that had substantially diminished in severity as being extant pain for prevalence calculations. Study purposes and designs likely selected for patients with pain. For all of these reasons, the pain prevalence data reported in this article may be overestimated.

Posttreatment Pain Prevalence

Posttreatment pain prevalence was moderate. The mean pain prevalence for all 11 studies reporting prevalence results at 24 hours was 40% (standard deviation = 24%) (10, 19, 20, 38–40, 61, 64, 67, 84, 87). The mean pain prevalence for all 12 studies reporting prevalence results at 1 week was 11% (standard deviation = 14%) (18, 19, 31–34, 36, 39, 40, 44, 61, 64).

Posttreatment pain prevalence trends over the 7 days after treatment were described by 16 categoric studies plotted in Figure 2 (10, 18–20, 31–34, 38–40, 61, 64, 67). Prevalence decreased substantially after treatment, especially during the first 2 days. By 7 days, pain prevalence had generally dropped to levels of 10% or less.

Effect of Root Canal Treatment on Pain Severity

An L'Abbe plot was made to include data limited to the 12 studies that included both pre- and posttreatment pain severity data (Fig. 3 and Table 3) (10, 21, 25, 26, 28, 36, 40, 45, 51, 53, 58, 82). At 1 day posttreatment, pain severity was substantially lower than pretreatment severity. Change in pain severity over time after treatment was described by 10 of these studies (10, 21, 25, 26, 28, 40, 45, 51, 75, 82). In all cases, pain severity substantially decreased over the days immediately after root canal treatment. Root canal treatment unequivocally reduced pain severity.

Pretreatment Pain Severity

Pretreatment pain severity was moderate. The mean pain severity for all 22 studies with pretreatment pain severity data was 54% (standard deviation = 24%) normalized to a 100-point scale (10, 21, 22, 24–26, 28, 35, 36, 40, 45, 48, 51, 53, 58, 63, 71, 73, 75, 77, 80, 82). However, study designs likely selected for patients motivated to address extant pain.

Posttreatment Pain Severity

Posttreatment pain severity was moderate. Studies reported posttreatment pain severity at differing intervals. The crude mean pain severity for all 18 studies with posttreatment pain severity data at 24 hours was 24% (standard deviation = 12%) (10, 19–21, 25, 26, 28, 38–40, 45, 51, 61, 67, 74, 75, 82, 87).

Posttreatment pain severity over the 7 days after treatment was described by 18 studies (Fig. 4) (10, 19–21, 25, 26, 28, 32, 34, 38, 40, 45, 51, 61, 67, 74, 82, 87). This graph showed that severity decreased substantially after treatment, especially during the first 2 days. By 7 days, pain severity had generally dropped to levels of 10% or less. The crude mean pain severity at 7 days was 5% (standard deviation = 5%), as described by six studies (19, 32, 34, 39, 40, 61).

Treatment Pain Prevalence and Severity

Data on pain prevalence and severity experienced during treatment were extremely limited, thus precluding meta-analysis. Three VAS studies showed 100% prevalence of treatment pain (21, 25, 73). Again, because any tiny discomfort registers a pain score of more than zero, this resulted in very high prevalences with VAS studies. Notably, these three VAS studies indicated that the severity of treatment associated pain was very low (ie, 4%, 6%, and 8%, respectively, on 100-point VAS scales). Three other non-VAS studies reported prevalence of treatment pain ranging from 11% to 22% (37, 41, 85). It is important to note that the prevalence and severity of treatment pain were in comparison to those of pretreatment pain as described earlier.

TABLE 2. Evidence Table Summary for Prevalence of Root Canal Treatment–associated Pain

Reference	Year	Study focus	Patients (teeth)	Pre Tx pain (%)	Tx pain (%)	Post Tx pain	Quality score
Genet (10)	1986	Prognosis	803 (1204)	37		1 d, 24%; 2 d, 19%; 3 d, 13%; 4 d, 7%	21
Alacam (18)	1985	Prognosis	(212)			3 d, 14%; 7 d, 1%	20
Albashaireh (19)	1998	Prognosis	300			1 d, 33%; 2 d, 22%; 3 d, 12%; 7 d, 3%	24
Aqrabawi (20)	2006	Prognosis	146			8 h, 74%; 1 d, 69%; 2 d, 46%	23
Bigby (22)	2007	Anes eff	48	100 VAS			21
Brennan (23)	2006	Prognosis	195	100 VAS			23
Claffey (24)	2004	Anes eff	72	100 VAS			24
Creech (25)	1984	Prognosis	49	100 VAS	100 VAS	4 h, 8 h, 1 d, 36 h, 2 d, all time points 100% VAS	21
DiRenzo (26)	2002	Prognosis	72	100 VAS		6 h, 12 h, 1 d, 2 d, all time points, 100% VAS	24
Dugas (27)	2002	Endo vs GP	119 (238)	98			26
Ehrmann (28)	2003	Intracanal meds	221 (223)	100 VAS		4 h, 1 d, 2 d, 3 d, 4 d, all time points, 100% VAS	21
Fava (31)	1991	Prognosis	52 (60)			2 d, 5%; 7 d, 5%	24
Fava (32)	1994	Prognosis	52 (60)			2 d, 5%; 7 d, 5%	24
Fava (33)	1995	Prognosis	78			2 d, 100%; 7 d, 6%	24
Fava (34)	1998	Prognosis	48 (60)			2 d, 7%; 7 d, 0%	22
Gallatin (35)	2000	Meds (abx)	40	100		Time unknown, 76%	20
Gesi (36)	2006	Prognosis	256	97		7 d, 10%	23
Glassman (38)	1989	Interappt pain	40			8 h, 83%; 1 d, 55%; 2 d, 11%	24
Harrison (39)	1983	Prognosis	236			1 d, 30%; 7 d, 8%; 30 d, 2%; 60 d, 1%	23
Henry (40)	2001	Medications	41	100		1 d, 93%; 2 d, 68%; 3 d, 59%; 5 d, 41%, 6 d, 27%; 7 d, 32%	23
Krasner (45)	1986	Meds (abx)	50	100 VAS		8 h, 1 d, all time points, 100% VAS	22
Marshall (48)	1993	Medications	106	100		81%	24
Mattscheck (51)	2001	Prognosis	30	100 VAS		4 h, 8 h, 12 h, 1 d, 3 d, 4 d, 5 d, all time points, 100% VAS	25
Menhinick (53)	2004	Medications	57	100 VAS		Time unknown, 100% VAS	25
Michaelson (54)	2002	Prognosis	497	60			20
Negm (58)	1994	Intracanal meds	760	100 VAS		Time unknown, 100% VAS	23
Oginni (61)	2004	Flare-ups	227	64		1 d, 49%; 7 d, 14%	22
O'Keefe (63)	1976	Prognosis	147	81			22
Pekruhn (64)	1981	Prognosis	102			1 d, 16%; 2 d, 16%; 3 d, 11%; 7 d, 5%	26
Pisano (67)	1985	Prognosis	74			immed, 40%; 1 d, 30%; 2 d, 18%	21
Polycarpou (68)	2005	Prognosis	175	62			22
Rosenberg (71)	2007	Anes eff	48	100 VAS			22
Ross (72)	2009	Recall	7105	21			23
Rousseau (73)	2002	Prognosis	250	100 VAS	100 VAS		26
Rowe (74)	1980	Medications	149	49		Every 2 h (6 h-36 h), all time points, 100%	24
Shedletsky (76)	1984	Alternative meds	75	100			21
Torabinejad (81)	1994	Medications	411			6%	25
Torabinejad (82)	2005	EDTA/MTAD	73	100 VAS		12 h, 1 d, 2 d, 7 d, all time points, 100% VAS	22
Walton (84)	2003	Intracanal meds	140			74%	19
Watkins (85)	2002	Pain	333	20	22		24
Weiger (86)	2000	Intracanal meds	67	42			23
Yesilsoy (87)	1988	Prognosis	186	44		1 d, 25%; 4 d, 9%	26

Tx, treatment; Anes eff, anesthetic efficacy; Endo, endodontist; GP, general dentist; Meds, medications; abx, antibiotics; EDTA, ethylenediaminetetraacetic acid; MTAD, mixture tetracycline acid detergent; immed, immediately after treatment; VAS, Visual Analog Scale.
References include the first author, reference number, and year. Relevant pain data from these articles are represented in Figures 1 and 2; meta-analyses are presented in the results section.

TABLE 3. Evidence Table Summary for Severity of Root Canal Treatment–associated Pain

Reference	Year	Study focus	Patients (teeth)	Pre Tx pain (%)	Tx pain (%)	Post Tx pain	Quality score
Genet (10)	1986	Prognosis	803 (1,204)	26		1 d, 15%; 2 d, 12%; 3 d, 9%; 4 d, 5%	21
Albashaireh (19)	1998	Prognosis	300			1 d, 15%; 2 d, 14%; 3 d, 8%; 7 d, 8%	24
Aqrabawi (20)	2006	Prognosis	146			8 h, 49%; 1 d, 43%; 2 d, 24%	23
Attar (21)	2008	Meds	39	66	4	6 h, 18%; 12 h, 21%; 18 h, 19%; 1 d, 11%	23
Bigby (22)	2007	Anes eff	48	61			21
Claffey (24)	2004	Anes eff	72	56			24
Creech (25)	1984	Prognosis	49	16	6	4 h, 14%; 8 h, 18%; 1 d, 16%; 36 h, 10%; 2 d, 2%	21
DiRenzo (26)	2002	Prognosis	72	41		6 h, 26%; 12 h, 19%; 1 d, 17%; 2 d, 11%	24
Ehrmann (28)	2003	Intracanal meds	221 (223)	43		4 h, 37%; 1 d, 23%; 2 d, 38%; 3 d, 11%; 4 d, 9%	21
Fava (32)	1994	Prognosis	52 (60)			2 d, 4%; 7 d, 0%	24
Fava (34)	1998	Prognosis	48 (60)			2 d, 2%; 7 d, 0%	22
Gallatin (35)	2000	Meds (abx)	40	86		7 d, 34%	20
Gesi (36)	2006	Prognosis	256	28		2%	23
Glassman (38)	1989	Interappt pain	40			8 h, 44%; 1 d, 24%; 2 d, 6%	24
Harrison (39)	1983	Prognosis	236			1 d, 19%; 7 d, 5%; 30 d, 1%; 60 d, 0.5%	23
Henry (40)	2001	Medications	41	69		1 d, 56%; 2 d, 33%; 3 d, 27%; 4 d, 27%; 5 d, 16%; 6 d, 10%; 7 d, 11%	25
Krasner (45)	1986	Medications	50	33		8 h, 39%; 1 d, 28%	22
Marshall (48)	1993	Meds	106	86			24
Mattscheck (51)	2001	Prognosis	84 (30)	9		4 h, 12%; 8 h, 11%; 12 h, 10%; 1 d, 11%; 2 d, 8%; 3 d, 6%; 4 d, 3%; 5 d, 4%	25
Menhinick (53)	2004	Meds	57	76		14%	25
Negm (58)	1994	Meds	760	71		62%	23
Oginni (61)	2004	Flare-ups	227			1 d, 33%; 7 d, 7%	22
O'Keefe (63)	1976	Prognosis	147	64			22
Pisano (67)	1985	Prognosis	74			Immed, 21%; 1 d, 14%; 2 d, 8%	21
Rosenberg (71)	2007	Anes eff	48	69			22
Rousseau (73)	2002	Prognosis	250		8		26
Rowe (74)	1980	Meds	149			6 h, 38%; 8 h, 47%; 12 h, 46%; 18 h, 38%; 1 d, 40%; 36 h, 34%	24
Ryan (75)	2008	Anes eff	43	70		Immed, 11%; 6 h, 50%; 12 h, 49%; 18 h, 32%; 1 d, 28%	25
Sherman (77)	2008	Anes eff	40	91			23
Srinivasan (80)	2009	Anes eff	40	66			22
Torabinejad (82)	2005	Prognosis	73	24		12 h, 16%; 1 d, 15%; 2 d, 15%; 7 d, 6%	22
Yesilsoy (87)	1988	Prognosis	186			1 d, 16%; 4 d, 6%	26

Tx, treatment; Anes eff, anesthetic efficacy; Meds, medications; abx, antibiotics; immed, immediately after treatment.

Relevant pain data from these articles are represented in Figures 3 and 4; meta-analyses are presented in the results section.

TABLE 4. Evidence Table Summary for Anesthetic Efficacy for Root Canal Treatment–associated Pain

Reference	Year	Study focus	Patients (teeth)	% Requiring supplementary injection	Quality score
Bigby (22)	2007	Anes eff	48	74	21
Claffey (24)	2004	Anes eff	72	77	24
Elsharrawy (30)	2007	Anes eff	40	90	20
Ianiro (41)	2007	Anes eff	40	29	23
Matthews (50)	2009	Anes eff	82	67	22
Nusstein (60)	1998	Anes eff	51	51	26
Reisman (69)	1997	Anes eff	48	75	22
Srinivasan (80)	2009	Anes eff	40	22	22

anes eff, anesthetic efficacy.
Meta-analyses are presented in the results section.

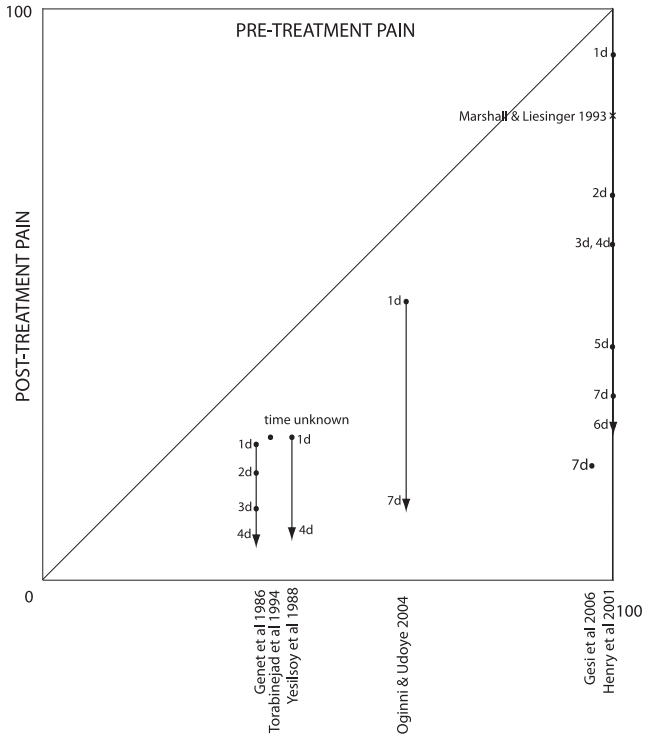

Figure 1. L'Abbe plot of effect of root canal treatment on pain prevalence.

Anesthetic Efficacy

Eight studies on anesthetic efficacy studies measured the need for or the effects of various types of supplemental injection (Table 4) (22, 24, 30, 41, 50, 60, 69, 80). These studies suggested that supplemental injections were frequently required (23%-90%). The calculation of a crude mean indicated that supplemental anesthesia was necessary 60% (24) of the time. Supplemental anesthesia was generally successful in reducing pain and in achieving anesthesia. Two studies reported on pain experienced during injection; pain was commonly experienced during needle insertion, needle placement, and solution deposition (50, 52). These data suggest the need for care in communication and in anesthetic injection technique.

Discussion

Pain research has steadily gained prominence throughout all health care disciplines. Many prior endodontic studies have attempted to relate posttreatment pain to the following predictive factors: single versus multivisit treatment, different types of intracanal dressings, different treatment procedures, patient factors, analgesics, anesthetic, use of antibiotics, and pretreatment pain (1, 10, 18–87). However, relatively few articles have been directly focused on the patient experience.

Although systematic review is a useful form of research, differences in study design or patient experience can make comparison problematic. However, dental procedures including third molar extraction and root canal treatment are often used as general pain models in studies evaluating analgesic efficacy. Interestingly, a recent study investigating the use of nonsteroidal anti-inflammatory drugs for posttreatment pain pooled the results of surgical extraction of third molars, episiotomy, gynecologic, urologic, and other procedures (88). It has been suggested that posttreatment pain in different areas of the body may be pooled because similar pain mechanisms are involved (89).

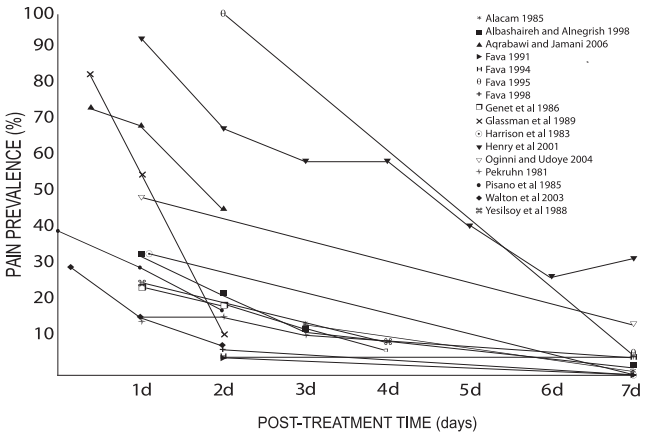

Figure 2. Posttreatment pain prevalence trends over the 7 days after treatment.

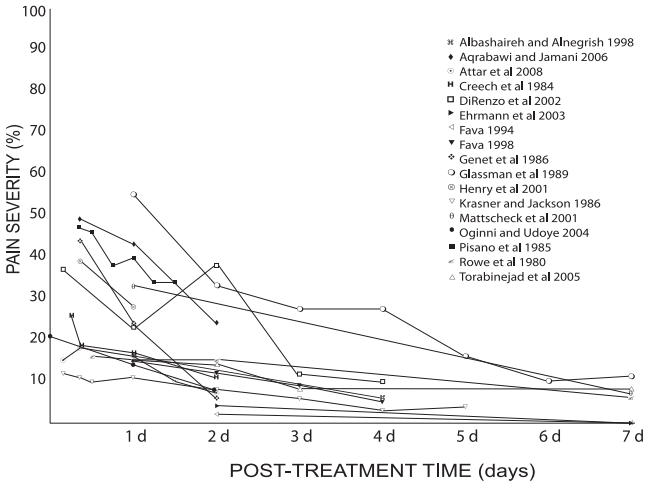

Figure 4. Posttreatment pain severity over the 7 days after treatment.

In this article, all included data were from patients experiencing pain ascribed to endodontic origin. Of course, endodontic pain may differ in severity and source, pulpal, or periradicular. In this article, data generated from different pain measurement methods, including five-point scales, four-point scales, and VASs, was normalized and pooled, wherever possible. Fortunately, endodontic pain evaluations using different types of pain scale are known to be highly correlated (21).

The return rate for articles that met inclusion and exclusion criteria from total hits returned through detailed searching was low, ~1%, but this is not unusual for dental systematic reviews (6). Endodontic pain studies may have been inadequately or improperly tagged in the databases searched, maybe because this was generally not the primary study focus. Careful selection of title words and appropriate keywords is strongly recommended to authors. The 72 studies that met the inclusion criteria had a mean score of 23 out of a possible 27 on the Wong Scale–Revised, but only 13 of the 72 studies had scores at the upper end, 25 or more.

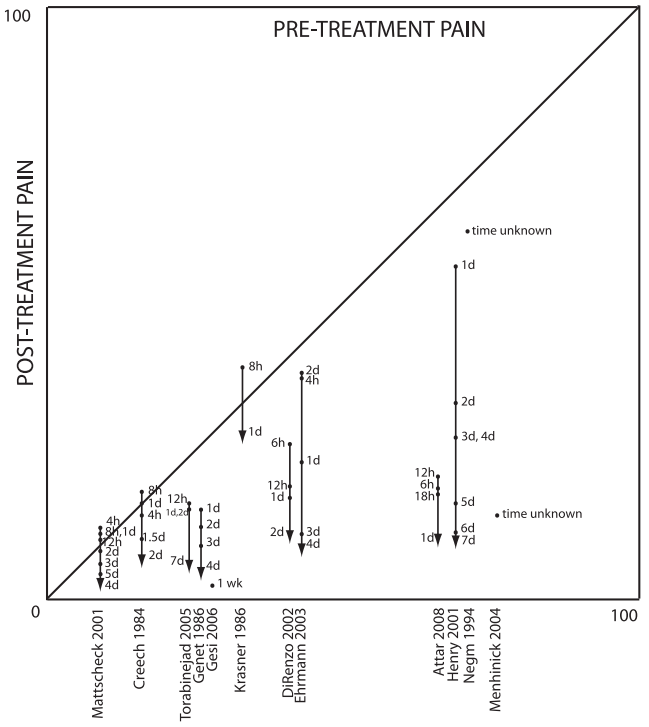

Figure 3. L'Abbe plot of effect of root canal treatment on pain severity.

Despite the favorable quality ratings, this current study was limited by the disposition and heterogeneity of the existing literature. For example, pretreatment pulpal and periradicular diagnoses were rarely provided, nonsurgical root canal treatment methods may have varied considerably, and patient populations likely differed. The heterogeneity of the data in the included studies is reflected by the relatively high standard deviations reported in the results section. However, the included studies represent the reality of the breadth of nonsurgical root canal treatment as practiced across a wide variety of different communities. Furthermore, L'Abbe plots are appropriate to the analysis of heterogenous data.

The articles included in this meta-analysis varied in terms of experimental design and in data reporting. Some studies reported pain prevalence and pain severity for pretreatment and posttreatment conditions. Most studies provided several values at a variety of posttreatment time periods. For this reason, the number of studies included for meta-analysis of the various outcome measures differed with time period.

The influence of root canal treatment on pain prevalence was clearly elucidated by plotting data from studies that reported both pre- and posttreatment pain in the L'Abbe plot in Figure 1. The pretreatment pain prevalences in these studies served as baseline measures to which analagous posttreatment pain prevalences were validly compared. Although the pretreatment prevalences varied among the studies, all studies reported a steady and substantial decline in pain prevalence over time after treatment. Root canal treatment unequivocally and substantially reduced pain prevalence.

Pretreatment pain prevalence was high, likely inflated for both VAS and categoric studies. Additionally, many patients reporting to dental clinics may be episodic patients seeking treatment only because they are in pain. However, valid comparisons of pre- and posttreatment prevalence can still be made.

Posttreatment pain prevalence was moderate or low. All studies except for those performed by Henry et al (40) and Oginni and Udoye (61) reported 7-day pain prevalence as being less than 10%. The Henry et al study specifically selected patients with spontaneous pain from symptomatic, necrotic teeth (ie, those with acute periradicular periodontitis, a notoriously painful condition). It is also important to note that all of the patients who experienced posttreatment pain in the Henry et al study only experienced mild pain. The high posttreatment pain

prevalence in the Oginni and Udoye article likely occurred because their scale grouped "no pain" with "mild pain." Several articles that met the inclusion criteria were not included in the meta-analyses because specific posttreatment time intervals were not reported (37, 46, 47, 55, 90). Recent systematic reviews have shown that 6 months after root canal treatment the frequency of persistent tooth pain of all causes was low, approximately 5%, and the frequency of nonodontogenic pain was approximately 3% (11, 12). These data were consistent with the findings of this current study insofar as they overlap. It also suggests that some of the pain experienced by the patients included in this current study may not have been of endodontic origin.

The effect of root canal treatment on pain severity was depicted by the L'Abbe plot in Figure 3. Root canal treatment unequivocally reduced pain severity. Four of the 12 studies included in the plot show immediate posttreatment severity levels that slightly exceeded the pretreatment severity levels. This may be caused by ongoing inflammatory processes; apical instrumentation, especially when preexisting periradicular inflammation was present; injection of local anesthetic; pressure from a rubber dam clamp; or discomfort because of prolonged opening. Although pain levels fluctuated during the hours immediately after treatment in two studies, an overall decrease in severity was observed. Low levels of pain severity were generally reached within a few days. These findings underscore the need for early posttreatment pain control through nonsteroidal anti-inflammatory drugs.

Pretreatment pain severity for all included studies was moderate. Some studies specifically selected subjects with moderate to severe pretreatment pain, whereas others were conducted at dental clinics that likely attracted patients experiencing and presenting in pain. Thus, a high variance was to be expected. Even so, few patients presented with severe pain.

Posttreatment pain severity showed a steady decrease over time in posttreatment pain prevalence. At 1 day, the mean pain severity had dropped in half. By 7 days, the pain severity had generally decreased to less than 10%. Again, the study by Henry et al (40) reported the highest posttreatment pain severity. The reasons for the higher pain severity are probably akin to the reasons for the higher prevalence level discussed previously.

Of the 72 studies that included pretreatment or posttreatment pain data, only five directly reported data on pain experienced during treatment (21, 25, 41, 73, 85). Three studies reported 100% pain prevalence on VAS, likely for the reasons explained previously. However, very low severity levels were reported of 4% to 8% (21, 25, 73). Two non-VAS studies reported treatment pain prevalences of 11% and 22% (41, 85). These results might be somewhat alarming because complete anesthetization would be desired for patients undergoing root canal treatment. However, one of these studies measured treatment pain after a single inferior alveolar nerve block (41), whereas in routine clinical practice a dentist would administer supplemental anesthesia as needed. The other study carefully investigated anticipated and experienced sensory and affective pain (85); perhaps, the instruction of study subjects to pay more attention to their state of pain resulted in more felt pain during treatment.

Supplemental anesthesia was needed very frequently. However, these studies only included patients with extant pretreatment pain. The subjects were patients reporting to emergency departments, patients reporting to clinics in spontaneous or severe pain, or patients diagnosed with irreversible pulpitis. Routine anesthetic infiltrations or blocks may be insufficient to produce anesthesia with pretreatment pain. Dentists must routinely anticipate the need for supplemental anesthesia when performing root canal treatment.

This systematic review followed guidelines appropriate for addressing our purpose (9). This included appropriate background and question formulation; reporting of search strategy, methods, and results including graphical summaries and L'Abbe plots of study estimates and an indication of statistical uncertainty of findings; discussion of possible bias and study quality along with consideration of alternative explanations for observed results, explanations for inconsistency, and conflict in data; and the inclusion of generalizable conclusions.

Conclusions

Pretreatment root canal associated pain prevalence was high but dropped moderately within 1 day and substantially to minimal levels in 7 days. Pretreatment root canal–associated pain severity was moderate, dropped substantially within 1 day of treatment, and continued to drop to minimal levels in 7 days. Supplemental anesthesia was often required during root canal treatment.

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