

A systematic review of nonsurgical single-visit versus multiple-visit endodontic treatment

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Abstract: Conventional endodontic treatment used to require multiple visits, but some clinicians have suggested that single-visit treatment is superior. Single-visit endodontic treatment and multiple-visit endodontic treatment both have their advantages and disadvantages. This paper is a literature review of the research on nonsurgical single-visit versus multiple-visit endodontic treatment. The PubMed database was searched using the keywords (endodontic treatment OR endodontic therapy OR root canal treatment OR root canal therapy) AND (single-visit OR one-visit OR 1-visit). Review papers, case reports, data studies, and irrelevant reports were excluded, and 47 papers on clinical trials were reviewed. The studies generally had small sample sizes, and the endodontic procedures varied among the studies. Meta-analysis on the selected studies was performed, and the results showed that the postoperative complications of the single-visit and multiple-visit endodontic treatment were similar. Furthermore, neither single-visit endodontic treatment nor multiple-visit treatment had superior results over the other in terms of healing or success rate. Results of limited studies on disinfection of the root canals using low-energy laser photodynamic therapy is inconclusive, and further studies are necessary to show whether laser should be used in endodontic treatment. This review also found that that neither single-visit endodontic treatment nor multiple-visit treatment could guarantee the absence of postoperative pain. Since the study design of many studies displayed significant limitation and the materials and equipment used in endodontic treatment have dramatically changed in recent years, prospective randomized clinical trials are needed to further verify the postoperative pain and success rates of single-visit versus multiple-visit endodontic treatment.

Keywords: single-visit endodontics, non-surgical endodontics, systematic review, root canal therapy

Introduction

Endodontic treatment used to take multiple visits to complete, with one of the main reasons for this being that it required a considerable amount of time to complete the treatment.¹ The use of contemporary endodontics techniques and equipment, such as use of rubber dam,² magnifying devices,^{3,4} electronic apex locators,⁵ engine-driven rotary nickel titanium files,⁶ and so forth, not only increases the success rate of endodontic treatment but also, shortens the time needed for the treatment. Endodontic treatment may therefore be completed in a single visit.

The concept of a single-visit root canal treatment was described as early as the 1880s.⁷⁻⁹ Thereafter, there were reports on immediate root filling describing the criteria for success based on the manner of mechanical cleaning and the method of removing the bacterial origins from the canal system.¹⁰ The treatment techniques used at that

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time were very primitive, and the success rate of single-visit root canal treatment was low. The single-visit treatment was brought back in the 1950s by Ferranti,¹¹ who advocated the use of diathermy for pulpal disinfection and hydrogen peroxide for irrigation. This treatment differed significantly from today's techniques. However, Ferranti was able to describe how the most important criteria for achieving successful results were, in fact, the proper shaping and cleaning of the canals. Currently, these principles are still applied, as important criteria, prior to consideration of single-visit treatment. In 1970, Tosti reported a satisfactory result in his clinical study using a single-visit approach, although the sample size of his study was small.¹²

Nowadays, root canal therapy has become increasingly automated and can be performed more quickly, so some clinicians are incorporating single-visit endodontics into their own clinic routine as a main component of contemporary practice. On the other hand, some dentists believe that the traditional multiple-visit protocol has a long history and a high clinical success rate, preferring to provide multiple-visit endodontic treatment to their patients. This paper aimed to perform a systematic review of clinical studies on the success rate and complications of single-visit endodontic treatment.

Principles of endodontic treatment

Endodontic treatment, or root canal treatment, entails the removal of the dental pulp and the subsequent shaping, cleaning, and obturation of the root canals of a tooth. The key to endodontic success was described by Gutmann¹³ as the debridement and neutralization of any tissue, bacteria, or inflammatory products within the root canal system. According to the International Conference on Endodontics in 1958,¹⁴ there are ten important principles to be followed when a dentist performs endodontic treatment on his/her patient. First, endodontic treatment should be conducted using an aseptic technique. Second, the instruments should be confined to the root canal of the treated tooth. Third, the root canal should be prepared using fine and smooth instruments. Fourth, the root canal should be enlarged regardless of its original size, to enable the removal of contaminated dentinal debris and filling of the root canal. Fifth, the root canal should be copiously irrigated with an antiseptic solution during instrumentation. Sixth, the antiseptic irrigation or agents used should be nonirritating to the periapical tissues. Seventh, the sinus tract, if present, should subside after root canal treatment and should not require surgical intervention (however, an incision of the soft tissue can be performed for cases of acute periapical abscess, to allow drainage). Eighth, the canal should be aptly

shaped and hermetically obturated. Ninth, a negative culture should be obtained prior to obturation. Finally, the root canal filling should be biocompatible.

Although these principles were applied when performing endodontic treatment, the success rate of endodontic treatment in its early days was not high. With the advance of knowledge and skills and the use of up-to-date material and equipment, endodontic treatment nowadays has become a viable treatment to save the tooth, with a high rate of success. The overall success rate has been reported as being as high as 97%.¹⁵ The introduction of the rubber dam was a significant advance in dentistry and in endodontic treatment.¹⁶ Aseptic technique becomes possible as a result of the introduction of the rubber dam, and therefore, rubber dam isolation is now regarded as a mandatory procedure in the first step of endodontic treatment. Rubber dam isolation prevents ingress of saliva contamination to the root canals. It provides good access for the dentist to work on the tooth. It prevents the accidental swallowing of sharp endodontic instruments. It facilitates thorough cleaning and shaping of the canals. It also increases the patient's and dentist's comfort during endodontic treatment.

The materials and equipment used in endodontic treatment have dramatically changed over the past 20 years. It is not uncommon to relate contemporary endodontics with proper rubber dam isolation, magnifying devices, newer sealants and obturating materials, electronic apex locators, crown-down approaches,¹⁷ engine-driven rotary nickel titanium files, ultrasonic instrumentation, the copious use of disinfectants and chelating agents, and the latest digital or computer-aided radiographic imaging and three-dimensional (3D) obturation techniques.¹⁸ Although the materials and equipment differ significantly, the principles remain more or less unchanged. Contemporary endodontic treatment includes the following five principles: 1) use of aseptic technique; 2) cleaning the canals thoroughly and mechanically with the aid of chemical agents; 3) shaping the root canals for ease of obturation; 4) obturation to achieve a tight seal of the root canals; and 5) proper restoration of the tooth to prevent coronal leakage, which can induce future bacterial reinfection.

The concept underlying single-visit techniques, as described by Oliet,¹⁹ is that there is no difference in the treatment criteria to ensure a successful result between multiple-visit and single-visit treatment. The criteria include an accurate diagnosis, proper case selection, and the use of contemporary endodontic techniques. Single-visit endodontic treatment is indicated when both operators and patients want to save chair side time and prefer that anesthetics be adminis-

tered only once.²⁰ Although the treatment can be finished in a single visit, all necessary procedures, such as biomechanical preparation, thorough cleaning, and disinfection, followed by complete obturation of the prepared root canals, should not be compromised. When the tooth is nonvital and there is acute inflammation, single-visit endodontic treatment should not be recommended.²⁰ Moreover, patients who have temporomandibular disorders and/or who cannot endure long treatment period may also not be suitable for single-visit endodontic treatment.

Literature search of clinical trials

A literature review was performed to find descriptions of nonsurgical single-visit endodontic treatment, using the PubMed database, a free search engine primarily accessing the MEDLINE database of references and abstracts on the life sciences and biomedical topics. The keywords used were (endodontic treatment OR endodontic therapy OR root canal treatment OR root canal therapy) AND (single-visit OR one-visit OR 1-visit). The titles and abstracts of articles written in English were screened (Figure 1). A total of 200 publications were identified, and 161 papers were excluded because they were review papers, case reports, data studies, or irrelevant reports. There were 39 papers on clinical trials, and the full texts of these publications were retrieved. A manual search was performed on the references of these papers, leading to the discovery of eight additional publica-

tions on clinical trials. Therefore, a total of 47 publications were included in this review, and the reported postoperative complications and success rate are summarized in Tables 1 and 2, respectively.

Studies on postoperative complications of single-visit treatment

Table 1 summarizes the studies on postoperative complications of single-visit treatments. It was reported that postoperative pain or complications were commonly found after root canal procedures, with duration ranging from one day (same day) to several weeks in the worst scenarios. The complications included swelling, tenderness to percussion, increased mobility, and systemic disturbance. The pain was reported as being from mild grade to severe forms, widely described as flare-ups. The reported findings on postoperative pain differed between studies. Many studies showed no significant differences between single-visit treatment and multiple-visit treatment.^{19–24} The sample sizes ranged from 32 cases to 387 cases. Among the studies, quite a number of treated teeth were limited to single-root cases.

Some studies surprisingly described more postoperative pain developing with conventional multiple-visit treatment.^{25–28} One study reported slightly more postoperative pain with single-visit treatment, but that result was statistically insignificant.²⁹ It was described²⁵ that the incidence of pain on treated molars was double the percentage in the multiple-visit group than in the single-visit group. This does not reflect the general belief among dental practitioners. There were two studies from the literature search that reported significantly more postoperative pain for single-visit treatment.^{30,31} Nowadays, a large proportion of dentists seem to avoid practicing single-visit treatment, especially for molars, because they believed that doing so may lead to more postoperative pain and complications after root canal treatment.

It has been proved that postoperative pain may not correlate to age, sex, or tooth location.^{26,27} In another study, females were shown to have a higher incidence of postoperative pain than did male patients.³² Overinstrumentation and overfilling also showed an increase in postoperative pain.²³ Postoperative pain was also reported with higher incidence in nonvital teeth in one study;²⁶ to the contrary, another study did not show any correlation with tooth vitality status.²⁷ The incidence of postoperative pain was reported as being higher in retreatment cases with apical periodontitis.^{27,33} Another study reported that a combination of calcium hydroxide and

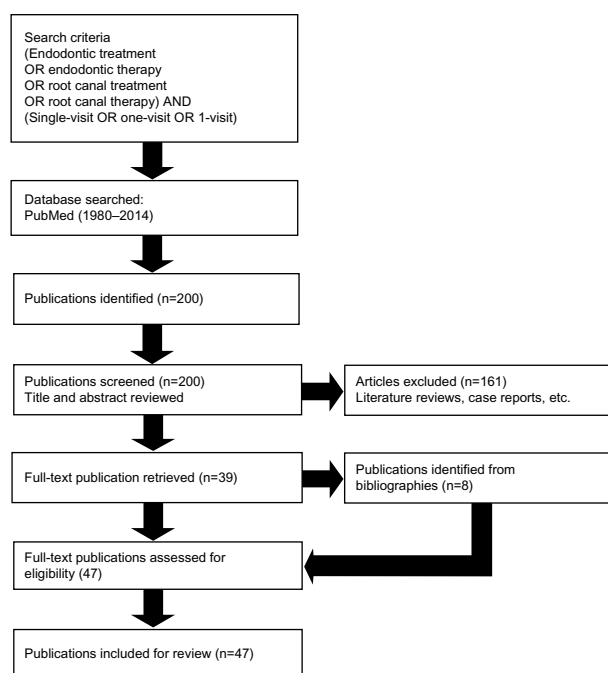


Figure 1 Flowchart of the literature search.

Table 1 Studies on postoperative complications with single-visit endodontic treatment

Authors	Method	Main findings
Akbar et al ³⁶	100 molars Single visit – 50 teeth Multiple visits – 50 teeth	There was no significant difference in the flare-up rate between two groups
Dorasani et al ³⁷	64 single-root teeth Single visit – 34 teeth Multiple visits – 30 teeth	Both single-visit- and multiple-visit-treated teeth had similar clinical presentation, with no significant differences
Xavier et al ⁴⁰	48 nonvital teeth Single visit – 24 teeth Multiple visits – 24 teeth Evaluation period: 2 weeks	Both single-visit and multiple-visit endodontic treatment were effective in reducing bacteria and endotoxins. Two visits were more effective than one visit in reducing endotoxins
Bhagwat and Mehta ⁷⁰	60 patients in single-visit treatments Evaluation period: 2 weeks	Similar incidence of pain in vital and nonvital teeth without apical radiolucency. Teeth with periapical radiolucency exhibited less pain than nonvital teeth without periapical radiolucency
Singh and Garg ⁷¹	200 single-root teeth Single visit – 100 teeth Multiple visits – 100 teeth Evaluation period: 2 days	No significant difference in the incidence and intensity of postobturation pain experienced by the two groups
Ali et al ⁷²	1,328 patients in single-visit treatment Evaluation period: 2 days	The presence of postoperative pain was 4% The factors that influenced the experience of postoperative pain were: old age, female, mandibular teeth, and the presence of preoperative pain
Prashanth et al ⁷³	32 cases Single visit – 16 teeth Multiple visits – 16 teeth Evaluation period: 6 weeks	No significant difference in terms of success, postoperative pain, or tenderness existed when treated with either single-visit or multiple-visit therapy
Xiao and Zhang ⁷⁴	138 teeth Single visit – 76 teeth Multiple visits – 62 teeth Evaluation period: 2 years	Single-visit endodontic treatment had the same clinical efficacy as two-visit treatment in terms of postoperative pain level and short-term healing
Wang et al ²⁴	89 incisors by two endodontists Single visit – 43 teeth Multiple visits – 46 teeth Evaluation period: 7 days	There was no significant difference on the incidence and severity of reported postoperative pain between the two groups
El Mubarak et al ²²	234 teeth Single visit – 32 teeth Multiple visits – 202 teeth Evaluation period: 1 day	Overall incidence of postoperative pain was 9% after 1 day No significant difference between the two groups
Kalhor and Mirza ⁷⁵ Ince et al ⁷⁶	100 patients for single-visit treatment Evaluation period: 1 month 306 patients by two clinicians Single visit – 153 teeth Multiple visits – 153 teeth Evaluation period: 3 days	No flare-ups in 1 month. It was safe in both vital and nonvital teeth, and even in teeth with periapical pathosis No significant difference between the two groups No significant difference between vital and nonvital teeth
Risso et al ²⁵	118 molars with necrotic pulp Single visit – 57 teeth Multiple visits – 61 teeth Evaluation period: 10 days	The frequencies of postoperative pain were 10.5% and 23% for the single-visit and multiple-visit group, respectively, which were of significant difference
Lin and Gao ⁷⁷	142 teeth Single visit – 100 teeth Multiple visits – 42 teeth Evaluation period: 6 months	No statistical significance between the two groups regarding pain after 7 days and healing response after 6 months
Ng et al ³⁴	415 patients Single visit – 91 teeth Multiple visits – 324 teeth Evaluation period: 2 days	40% reported postoperative pain Prevalence associated with the female sex, molar, size of periapical lesion smaller than 3 mm, preexisting pain or swelling and single-visit treatment
Oginni and Udoye ³⁰	243 teeth Single visit – 107 teeth Multiple visits – 136 teeth Evaluation period: 30 days	Flare ups in single-visit group at a rate of 18.3% and in the multiple-visit group at 8.1% $P < 0.05$. Higher incidences for postobturation pain were observed for single-visit treatment than for multiple-visit treatment

(Continued)

Table 1 (Continued)

Authors	Method	Main findings
Yoldas et al ³¹	218 retreatment cases Single visit – 106 teeth Multiple visits – 112 teeth Evaluation period: 1 week	Multiple-visit root canal treatment was more effective in completely eliminating pain than was single-visit treatment of previously symptomatic teeth
DiRenzo et al ²¹	72 molars treated by two operators Single visit – 39 teeth Multiple visits – 33 teeth Evaluation period: 2 days	No difference in postoperative pain between the two groups One patient (1.3%) in the multiple-visit group with preexisting apical periodontitis experienced flare-up
Albashaireh and Alnegrish ²⁶	291 teeth treated by one operator Single visit – 142 teeth Multiple visits – 149 teeth Evaluation period: 1 month	Multiple-visit-treated and nonvital teeth had more postoperative pain. Age, sex, pulpal vitality, tooth type, and preexisting pain were not found to be significant factors
Fava ⁷⁸	90 incisors for single-visit treatment Treated by one operator Evaluation period: 7 days	Incidence of postoperative pain after 2 days and 7 days was 5% for both
Imura and Zuolo ²⁷	1,012 teeth Treated by 2 dentists Single visit – 582 teeth Multiple visits – 430 teeth	There was a significantly higher incidence of flare-ups with multiple-visit than with single-visit treatment
Fava ⁶⁸	60 upper central incisors Single visit – 30 teeth Multiple visits – 30 teeth Evaluation period: 2 days	No difference in pain incidence between the two groups
Trope ³³	226 teeth for single-visit treatment Treated by one operator	No flare-up in cases without preexisting symptoms Higher flare-up rate in retreatment cases with preexisting symptoms
Fava ⁷⁹	60 upper central incisors Single visit – 30 teeth Multiple visits – 30 teeth Evaluation period: 7 days	No difference was observed in the incidence of postoperative pain between the two groups
Yesilsoy et al ⁸⁰	186 patients Single visit – 28 teeth Multiple visits – 158 teeth Evaluation period: 4 days	No significant differences between the two groups
Oliet ¹⁹	387 teeth treated by one operator Single visit – 264 teeth Multiple visits – 123 teeth Evaluation period: 7 days	No significant difference on postoperative pain between the two groups. More pain associated with overfilled teeth
Roane et al ²⁸	359 patients Single visit – 250 teeth Multiple visits – 109 teeth	Multiple-visit treatment had a greater incidence of postoperative pain
Mulhern et al ⁸¹	60 teeth treated by 2 operators Single visit – 30 single-root teeth Multiple visits – 30 single-root teeth Evaluation period: 2 days	No significant difference in the incidence of pain existed between the single- and multiple-visit groups
Rudner and Oliet ²⁰	283 cases Single visit – 98 teeth Multiple visits – 185 teeth	There was no significant difference in the incidence and severity of postoperative pain between the two groups

chlorhexidine intracanal medications was recommended to reduce postoperative pain with preexisting symptoms, in retreatment cases.³¹ Research should continue to attempt to discover more potent and effective antibacterial agents. Cases with preexisting symptoms were reported to lead to increased postoperative pain.^{27,34}

Postoperative intolerable pain or swelling are collectively described as flare-up, which is probably one of the most

concerning issues that dentists practicing single-visit treatment must deal with.³⁵ It was reported that there was no significant difference in flare-up rates between single-visit and multi-visit root canal treatment.^{36,37} The prevalence of flare-ups after single-visit treatment in the published literature was none²¹ to minimal, at 3%.³⁸ It was generally believed that postoperative pain was related to the residual bacterial colonies within the canals. Apart from the iatrogenic factors

Table 2 Clinical studies on healing and success rate of single-visit endodontic treatment

Authors	Method	Main findings
Dorasani et al ³⁷	64 single root teeth Single visit – 34 teeth Multiple visits – 30 teeth	Both single-visit and multiple-visit-treated teeth healed satisfactorily with no significant differences
Paredes-Vieyra and Enriquez ⁴²	282 teeth with apical periodontitis Single visit – 146 teeth Multiple visits – 136 teeth Evaluation period: 2 years	No significant difference in healing results between the two groups Single-visit treatment can be as successful as multiple-visit treatment
Penesis et al ⁴³	63 patients Single visit – 33 Multiple visits – 30 Evaluation period: 12 months	No significant difference in success rates between the two groups
Molander et al ⁴⁴	101 teeth Single-visit – 53 teeth Multiple-visit – 48 teeth Evaluation period: 24 months	There was no significant difference in term of healing results between single-visit and multiple-visit treatment
Waltimo et al ⁴⁵	50 teeth with apical periodontitis Single visit – 20 teeth Multiple visits – 30 teeth Evaluation period: 52 weeks	No significant differences in periapical healing were observed between the two groups
Field et al ⁴⁹	Single visit – 223 teeth	The overall success rate was 89.2% No significant differences based on sex, age, arch, or operators Anterior teeth were treated more successfully than posterior teeth
Kvist et al ⁴⁶	96 teeth with apical periodontitis Single visit – 48 teeth Multiple visits – 48 teeth	No significant difference between the two groups
Peters and Wesselink ⁴⁷	39 patients treated by one operator Single visit – 21 teeth Multiple visits – 18 teeth Evaluation period: 4.5 years	No significant difference in success rate between the two groups
Trope et al ⁴⁸	102 teeth with apical periodontitis Single visit – 45 teeth Multiple visits – 57 teeth Evaluation period: 1 year	The two groups had a similar success rate
Sjogren et al ⁵³	Single visit – 55 single-rooted teeth	Complete periapical healing for 5 years was 94%
Jurcak et al ⁵¹	102 teeth Single-visit treatment	The overall success rate was 89%
Pekruhn et al ⁵⁰	925 teeth done by one operator for single-visit treatment Evaluation period: 1 year	The overall success rate was 95% The incidence of failure was higher with retreatment and presence of apical periodontitis
Southard and Rooney ⁵²	19 patients single-visit treatment Evaluation period: 1 year	No patients experienced exacerbations of presenting signs and symptoms after treatment Eleven of 19 patients attended 1-year recall, and they all were asymptomatic

generated in root canal treatment, apical periodontitis has been directly correlated with residual polymicrobial colonies and its by-products, which are embedded in the dentinal tubules. Neither single-visit treatment nor multiple-visit treatment with intracanal medications can completely eliminate microbial colonies, eg, *Enterococci faecalis*.³⁹ It was reported that one-visit treatment may be less effective in reducing endotoxins than multiple-visit treatment.⁴⁰

A meta-analysis of the selected studies was performed to compare postoperative complications of single-visit with multiple-visit endodontic treatment (Table 3). Those studies which reported only single-visit treatment were excluded in

the analysis. The data were analyzed by Stata[®] 11.1 software (StataCorp LP, College Station, TX, USA), and Figure 2 shows the results as forest plot. The results showed that the postoperative complications of single-visit and multiple-visit endodontic treatment were similar. Thus, it was concluded that there was no significant difference in postoperative complications between single-visit and multiple-visit endodontic treatment.

Studies on healing and success rate of single-visit treatment

Table 2 summarizes studies on the healing and success rate of single-visit treatment. It has been published to clarify healing

Table 3 Meta-analysis table of clinical studies on postoperative complications of single-visit versus multiple-visit endodontic treatment

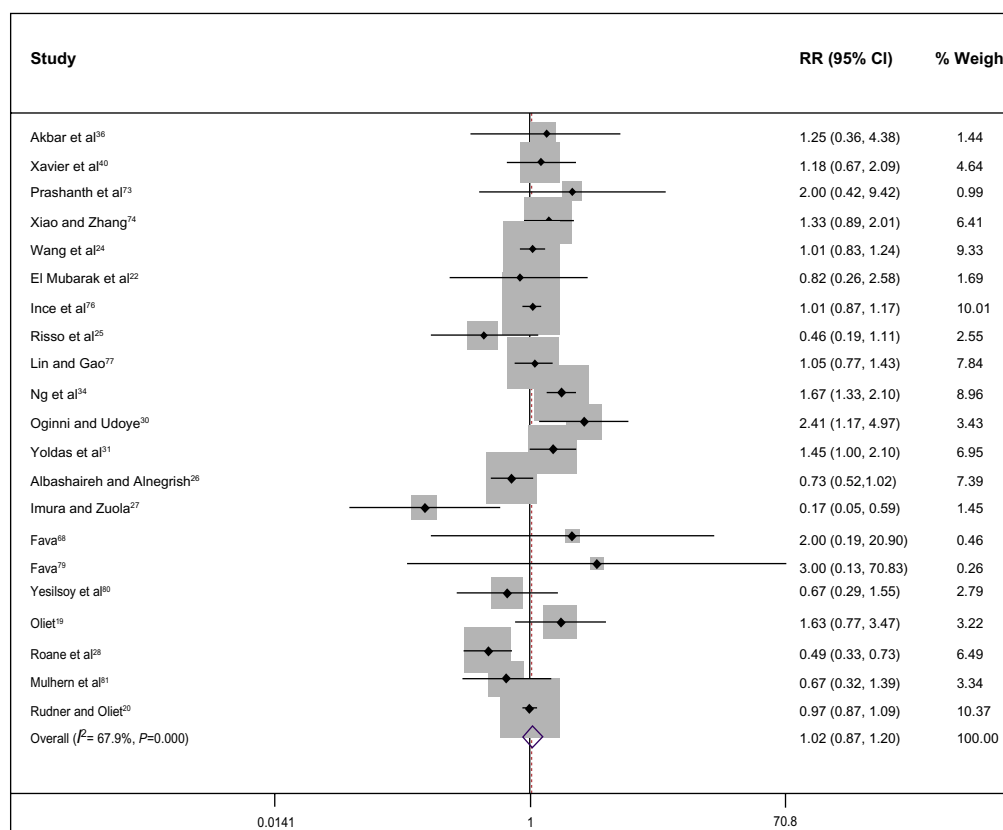
Authors	RR	95% CI	% weight
Akbar et al ³⁶	1.250	0.356–4.385	1.44
Xavier et al ⁴⁰	1.182	0.669–2.089	4.64
Prashanth et al ⁷³	2.000	0.425–9.418	0.99
Xiao and Zhang ⁷⁴	1.335	0.885–2.013	6.41
Wang et al ²⁴	1.012	0.827–1.238	9.33
El Mubarak et al ²²	0.823	0.262–2.584	1.69
Ince et al ⁷⁶	1.009	0.871–1.171	10.01
Risso et al ²⁵	0.459	0.189–1.112	2.55
Lin and Gao ⁷⁷	1.050	0.772–1.427	7.84
Ng et al ³⁴	1.670	1.328–2.100	8.96
Oginni and Udoye ³⁰	2.415	1.172–4.974	3.43
Yoldas et al ³¹	1.453	1.004–2.103	6.95
Albashaireh and Alnegrish ²⁶	0.731	0.521–1.025	7.39
Imura and Zuolo ²⁷	0.170	0.049–0.595	1.45
Fava ⁶⁸	2.000	0.191–20.898	0.46
Fava ⁷⁹	3.000	0.127–70.829	0.26
Yesilsoy et al ⁸⁰	0.672	0.291–1.549	2.79
Oliet ¹⁹	1.631	0.766–3.473	3.22
Roane et al ²⁸	0.487	0.325–0.730	6.49
Mulhern et al ⁸¹	0.667	0.319–1.394	3.34
Rudner and Oliet ²⁰	0.974	0.870–1.091	10.37
D + L pooled RR	1.020	0.868–1.199	100.00

Note: D + L refers to random effect method⁸² for meta-analysis.

Abbreviations: CI, confidence interval; RR, relative risk.

and success rates in the context of single-visit root canal treatment. The sample size of the studies ranged from small (n=19) to large (n=925). They all demonstrated no significant difference in radiographic evidence of healing between single-visit and multiple visit treatment.^{41–48} A study by Field et al⁴⁹ reported that the success rate might be higher in the anterior teeth than the posterior teeth. They also commented that there were no significant differences in terms of the factors of sex, age, arch, and operators. Another study argued that no correlation existed between success rate and the tooth type.⁵⁰ The reported success rate for single-visit treatment ranged from 89%⁵¹ to 95%.⁵⁰ The evaluation period for the studies ranged from a minimum of 1 year⁵² up to 5 years.⁵³

A meta-analysis on the selected studies was performed to compare the success rate of single-visit with multiple-visit endodontic treatment (Table 4). Those studies that reported only single-visit treatment were excluded in the analysis. The data was analyzed with Stata[®] 11.1 software, and Figure 3 shows the results as a forest plot. The results showed that the success rates of single-visit and multiple-visit endodontic treatment were similar. Therefore, it was concluded there was no significant difference in the success rate of single-visit and multiple-visit treatment.

**Figure 2** Forest plot for postoperative complications of single-visit versus multiple-visit endodontic treatment.

Note: Weights are from random effects analysis.

Abbreviations: CI, confidence interval; RR, relative risk.

Table 4 Meta-analysis table of clinical studies on the success rate of single-visit versus multiple-visit endodontic treatment

Authors	RR	95% CI	% weight
Dorasani et al ³⁷	1.643	0.655–4.121	15.16
Paredes-Vieyra and Enriquez ⁴²	0.233	0.026–2.058	3.08
Penesis et al ⁴³	1.111	0.536–2.304	22.14
Molander et al ⁴⁴	1.388	0.717–2.685	25.78
Peters and Wesselink ⁴⁷	0.686	0.216–2.175	10.17
Trope et al ⁴⁸	0.633	0.315–1.273	23.68
D + L pooled RR	0.992	0.673–1.462	100.00

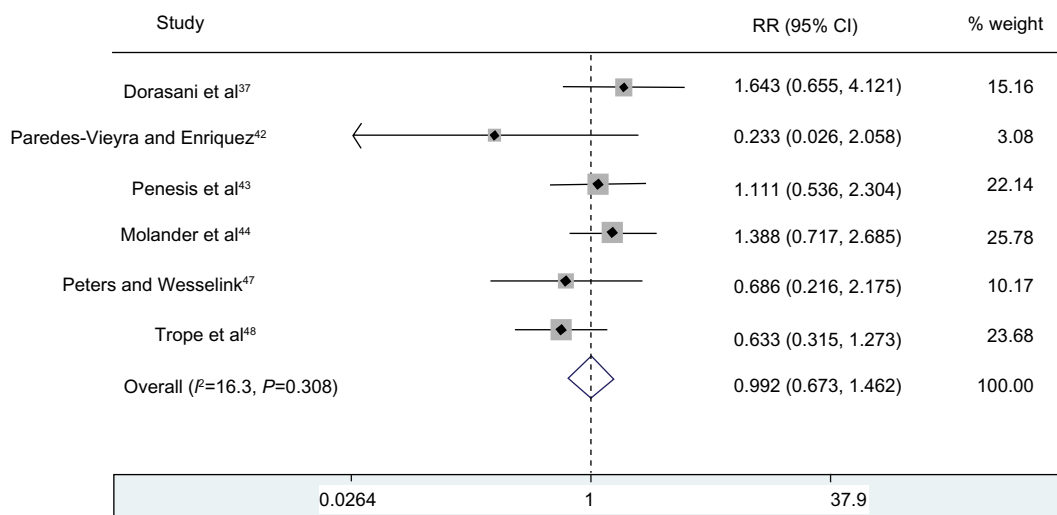
Note: D + L refers to random effect method⁶² for meta-analysis.

Abbreviations: CI, confidence interval; RR, relative risk.

It was interesting to find that the results may contradict the general dentists' belief on root canal treatment. Single-visit treatment was generally avoided due to the possible higher failure rate for a tooth treated by single-visit procedure. The results surprisingly proved that there was no significant difference in the success rates. The preference for selection of either single-visit or multiple-visit endodontic treatment has been based on significant cultural differences. Two surveys of US endodontic teaching institutes and practicing dentists reported that 70% and 90% of respondents, respectively, would consider single-visit endodontic treatment, after selection, in certain cases.^{54,55} The survey found that 56% of American endodontists would complete endodontic treatment in a single visit, and 35% would do this even on infected root canal systems. Another survey reported that a majority of the Australian endodontists would perform single-visit endodontic treatment but not as a routine practice.⁵⁶ They preferred the multiple-visit approach based on their experience, unrelated to the biological concerns or patient interest. A survey in

Japan found single-visit endodontic treatment was not popular among the dentists in Japan.⁵⁷

With the introduction of new technology, such as rotary nickel-titanium instruments, that can efficiently clean and shape the canals, endodontic treatment time can be substantially reduced. This allows more dentists to consider single-visit endodontic treatment. Figini et al⁵⁸ suggested that it was becoming more popular to complete the entire endodontic procedure in a single visit, in particular for endodontists and skilled general practitioners. There are a number of advantages to single-visit endodontic treatment. First, the reduced number of appointments is more convenient for patients making several visits for endodontic treatment. It reduces the need for repeated episodes of antibiotics in cardiovascular-susceptible individuals. It is also an alternative to offer for busy patients with time-restraints for treatment. Second, the reduced number of appointments allows clinicians to manage office time efficiently, by reducing time wasted on failed appointments and rescheduling. Third, single-visit endodontic treatment reduces patient discomfort and risks associated with local anesthesia. It also reduces the episodes of pain and anxiety that may arise from each appointment. Fourth, single-visit endodontic treatment minimizes the possible chance of iatrogenic errors (eg, perforation, ledging, stripping, and extrusion of antimicrobial irrigants due to longer exposures in instrumentation procedures). Fifth, it allows dentists to obturate the canals that are well-oriented and the operator is familiar with. Sixth, with single-visit treatment, there is no need for provisional restoration between appointments and thus no bacterial contamination through the leakage beneath

**Figure 3** Forest plot for the success rate of single-visit versus multiple-visit endodontic treatment.

Note: Weights are from random effects analysis.

Abbreviations: CI, confidence interval; RR, relative risk.

the provisional restoration. Finally, single-visit endodontic treatment allows for resumption of the tooth function efficiently and immediately after treatment.

Single-visit endodontic treatment, however, has some disadvantages. Completing treatment in a single appointment may involve time restraints and causes fatigue in both the clinician and the patient. Preexisting temporomandibular joint dysfunction is a contraindication because the long treatment time can induce stress and joint dysfunction in the patient. Single-visit endodontic treatment should not be performed when the root canals cannot be dried due to exudates from the acute apical periodontitis. There are studies^{30,31,34} reporting an increase in postoperative pain and flare-up rate by one visit for endodontic treatment, but there are also studies^{22,24,36,80} reported no increase in postoperative complication.

Factors to consider in performing single-visit endodontic treatment

Ashkenaz¹⁵ suggested that the dentist's clinical experience, prescheduled appointment times, clinical techniques, restorative concerns, pulpal status, and preexisting symptoms should be considered before performing single-visit endodontic treatment. Carrotte⁵⁹ proposed that it would be appropriate to proceed with obturation once the dentist has completed the root canal preparation and debridement. If the root canals cannot be dried due to persistent apical exudates, the canals should be dressed with intervisit medications, such as nonsetting calcium hydroxide. A temporary filling with a good coronal seal, such as obtained with zinc oxide and eugenol, is necessary to prevent leakage. Otherwise, there will be bacterial recolonization, which jeopardizes the success of endodontic treatment.⁶⁰ Sjogren et al⁵³ reported that the success rate in terms of periapical healing is higher (94%) with a negative culture prior to obturation as compared to that with a positive culture (68%).

Some studies reported significant disinfection of the root canals using low-energy laser photodynamic therapy.^{61–63} For example, Peters et al⁶¹ demonstrated that erbium: yttrium-aluminum-garnet (Er:YAG) laser-pulsed irradiation considerably decreased the bacterial count in the infected root canal during endodontic treatment. Nevertheless, Meire et al⁶⁴ reported that the effect of Er, chromium (Cr):yttrium-scandium-gallium-garnet (YSGG) laser irradiation was less efficient than conventional sodium hypochlorite irrigation in disinfection of the contaminated root canals. Since there are limited studies in the literature, further studies are necessary to show whether laser should be used in endodontic treatment. However, it is generally agreed upon that the prepared canals

can never be sterile before obturation, no matter how potent the antibacterial irrigants or intracanal medications are. If the principles of removal of microbial contaminants in the canals and dentinal walls, as much as possible by thoroughly cleaning, disinfecting, shaping, and obturation, the body's immune system would take care of the healing eventually.^{20,65}

There are currently two measures to reduce bacterial persistence and reinfection in the canals. We can either dress the canals with antibacterial agents in multiple visits or immediately obturate the canals, to reduce the space for bacterial colonization, in a single-visit approach. Nonsetting calcium hydroxide is the most popular intracanal medication used among the variety of different antibacterial agents.⁶⁶ However, its efficacy in controlling bacterial colonization has been debated. Studies have reported that the clinical outcome of multiple-visit endodontic treatment was better for teeth treated with the intracanal calcium hydroxide than for those with root canals left empty.^{48,67} However, other studies have suggested that the additional disinfecting effect of intracanal calcium hydroxide used in multi-visit treatment cannot be overstressed.^{45,68} Despite the high alkaline antibacterial properties of calcium hydroxide, some bacteria species, such as *E. faecalis* and *Candida albicans*, have been found to be resistant to it.⁴⁵ Chong and Pitt Ford⁶⁹ questioned the efficacy of nonsetting calcium hydroxide as a dressing in endodontic treatment. It is therefore generally considered that nonsetting calcium hydroxide should be used as a supplement to antibacterial irrigations.

Single-visit endodontic treatment and multiple-endodontic treatment have their advantages and disadvantages. In general, many dentists considered the single-visit approach to be an alternative to a multiple-visit but have no trouble replacing it. The success of endodontic treatment should be based on careful case selection. There should be no shortcuts in any of the steps throughout the treatment procedures. Clinicians should evaluate their own clinical skills and the needs of the patient. Notwithstanding the single-visit treatment approach, the clinicians should directly follow endodontic principles.

Conclusion

In conclusion, the studies reported in the literature showed that neither single-visit endodontic treatment nor multiple-visit treatment could be carried out with consequent induction of postoperative pain. Similarly neither single-visit endodontic treatment nor multiple-visit treatment has superior results over the other in terms of healing or success rate. The sample size of many studies was small, and studies with a large enough sample size for statistical analysis should be

performed. In addition, a prospective, randomized clinical trial is needed to further verify the postoperative pain and success rate of single-visit versus multiple-visit endodontic treatment.

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