Review Article

Influence of number of visits on the outcome of endodontic treatment

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Abstract

The success of endodontic treatment (ET) is largely dependent on the application of a strict protocol for disinfecting the root canal system and may be influenced by the number of visits but remains controversial in the literature. This review provides an overview of published studies comparing ET in single and multiple visits. A search was performed in the electronic databases such as PubMed, Cochrane Library, Science Direct, and Google Scholar from 2017 to 2022. Eligibility criteria were randomized clinical trials, reviews, and studies focusing on single- or multivisit techniques. Twenty-four articles were included. The main characteristics, including healing rates, success, and postoperative pain after ET, were extracted from the studies. The results of the studies included in this review showed that single- and multisession ET are similar in terms of healing rates and long-term complications, although both treatment approaches may be associated with short-term postoperative pain.

Keywords: Endodontic success; multiple visits; postoperative pain; single visit

INTRODUCTION

The success of endodontic treatment (ET) depends in part on the application of a strict protocol for disinfecting the root canal system when avoiding contamination. For a long time, root canal obturation with calcium hydroxide ($Ca(OH)_2$) as an intracanal medicament was used primarily to eliminate microorganisms and their toxins to achieve optimal canal disinfection. However, the question of the optimal protocol for achieving endodontic success is controversial and lies in the choice between a single-visit treatment and a multiple-visit approach.

The concept of single-visit root canal treatment was described as early as 1880. The advantages of performing ET in a single visit include a reduction in the number of appointments per tooth, immediate use of the canal for postretention, particularly in the anterior region for esthetic considerations, lower procedural costs, and decreased morbidity associated with repeated injections and rubber dam placement.[1]

The aim of this work is to identify the factors influencing endodontic success in single or multiple visits and to compare the results of the two protocols.

MATERIALS AND METHODS

Inclusion criteria

For this study, we selected:

- Studies on the success rate of initial nonsurgical ET performed in a single visit versus multiple visits
- Articles comparing single- versus multiple-visit ET in the same study
- Articles concerning clinical studies carried out on human beings
- Studies carried out on mature permanent teeth.

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Search

The search was performed in four databases, Medline (PubMed), Cochrane Library, Science Direct, and Google Scholar, limited to articles written in English, from 2017 to 2022. The search strategy was based on MeSH terms for PubMed. The last search was conducted in January 2023.

Search strategy

- Success rate AND (Endodontic treatment)
- Success rate AND (Endodontic treatment) AND (Single visit)
- Success rate AND (Endodontic treatment) AND (Multiple visits)
- Endodontic treatment AND (Single visit) AND (Multiple visits)
- Success rate AND (Endodontic treatment) AND (Single visit) AND (Multiple visits).

Screening process

Search and screening were conducted by two researchers, who identified relevant articles by first analyzing the titles and abstracts based on the eligibility criteria.

Retrieved records were classified as either "include" or "exclude." The full-text articles of the included and uncertain records were selected for further eligibility screening by the same two reviewers, acting independently. Discrepancies in screening of titles and abstracts or full-text articles were resolved through discussion. In case of disagreement, the opinion of a third reviewer was sought.

RESULTS

Figure 1 presents the flowchart for the study selection.

The initial search yielded 5,588 potentially relevant articles from the four databases.

After eliminating duplicates, an initial selection based on reading the titles yielded 469 articles. Of the 469 articles, 411 were eliminated after reading the abstracts, and 58 articles were retained for full-text reading. In the end, 24 articles were retained for the present study. The selected articles are presented in the form of a flowchart suggested by "The PRISMA Statement" as shown in Figure 1.

Characteristics of the studies included

Table 1 describes the overall sample according to the characteristics of each study as follows: number, authors, year of publication, type of study, objectives, outcomes assessed, methods, and main results.

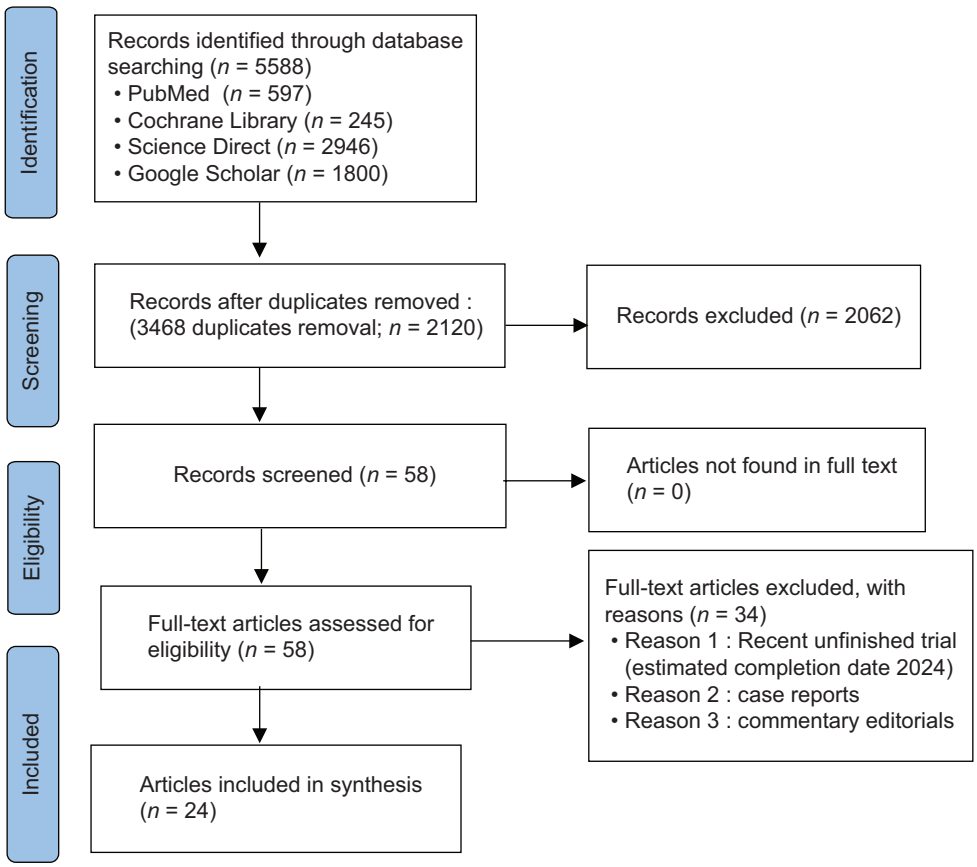

Figure 1: Flowchart of study selection framework with PRISMA 2020 guidelines

DISCUSSION

The aim of this study was to guide clinical decision-making on the number of visits required for a successful ET.

The European Society of Endodontology (ESE) is currently developing the "S3-Level Clinical Practice Guidelines" for the treatment of pulpal and apical periodontitis, aimed at benefiting both clinicians and patients.

The most critical outcome is "tooth survival." The critical outcomes are: pain, tenderness, swelling, need for medication (analgesics and antibiotics); radiographic evidence of reduction in apical lesion size (loose criteria); radiographic evidence of a normal periodontal ligament space (strict criteria); loss of tooth function; and presence of a sinus tract.[26]

The main factors investigated in the studies included in this review that may influence the effectiveness and efficiency of the ET are as follows.

Pulpal status and periapical pathology

The preoperative pulpal and periapical status of a tooth has been extensively studied for its influence on the outcome of endodontic treatment endodontic treatment.

Several included studies[3,7,8,10,12-14,16-19,21,25] showed no significant correlation between preoperative pulpal and periapical status and the efficacy of ET in one versus two or multiple visits. However, other studies showed an ET success rate of over 95% for vital teeth and 85% for nonvital teeth.[27,28] Preoperative pulp vitality is considered a favorable factor for a successful ET.

However, Mergoni *et al*. in 2022,[4] in their systematic review, found no significant difference in the success/failure of the ETs, on teeth with vital or nonvital pulp, with the exception of postoperative pain, which was higher after 1 week in single-visit treatments for vital teeth.

Similarly, in the study by Shubham *et al*.,[9] when vital teeth were treated in multiple visits with apical patency maintained, pain was higher 24 h after treatment compared to the same types of nonvital teeth.

Dhyani *et al*.[2] compared the treatment of teeth with irreversible pulpitis in single versus multiple visits and found a similar incidence of high pain 24 hours after obturation in the single-visit group and after the second appointment in the multiple-visit group. This pain decreased within one week and disappeared by one month for both groups.

Furthermore, Jethi *et al*.[6] found a high incidence of pain in single-visit treatment of symptomatic irreversible pulpitis. The variable preoperative pain significantly influenced postoperative pain.

Almeida *et al*.,[20] in their meta-analysis of nonvital teeth treated in single versus multiple visits, found no difference in periapical healing and microbiological control between the two treatments. However, the incidence of postoperative pain was reduced by an average of 21% when ET was performed in a single visit versus multiple visits.[20]

Postoperative pain was significantly lower when chemomechanical preparation was performed using a rotary file system (Profile 04) inserted up to the apical constriction (AC). This approach likely minimized tissue irritation and enhanced the precision of root canal instrumentation, which may contribute to better outcomes in terms of post-treatment discomfort. The use of a controlled rotary system provides more consistent results, potentially reducing the inflammatory response that can lead to pain following endodontic procedures.[29]

Postoperative pain and flare-up

Postendodontic flare-up is a genuine complication of ET, characterized by pain and/or swelling of the soft tissues and oral mucosa in the area of the treated tooth, occurring hours or even days after the ET, requiring emergency treatment. It is the result of a combination of microbiological, mechanical, and chemical factors. Its prevalence ranged from 1.4% to 16%.[28]

Jethi *et al*. in 2021[6] showed that postendodontic pain, in single or multiple visits, occurred within 48 h of obturation and then decreased thereafter, with no statistically significant difference. However, the pain score for multivisit treatment was significantly higher than that for in-session treatment, after 12 h ($P = 0.039$) and 48 h ($P = 0.043$), in the study by Gupta *et al*. in 2021.[5] There was no significant difference in the study by Singh *et al*. in 2020.[11]

However, studies[4,13] found that the incidence of pain was lower in multiple-visit ET than in single-visit treatment. This may be explained by the longer working time in the single-visit approach and the trauma associated with obturation of periapical tissues, which provoked a more severe acute inflammatory response.

Schwendicke and Göstemeyer in 2017[24] in their systematic review concluded that the risk of pain did not differ between single- and multivisit treatment. However, patients with ET performed in a single visit had a 2.13 times higher risk of flare-up compared to those who had ET spread over several sessions. A reduction in the incidence of postoperative complications of apical periodontitis treatment (flare-up, pain, swelling, and presence of fistula) and greater efficacy

Table 1: Characteristics of the selected articles assessing the overall sample

Authors	Type of study	Objectives	Outcomes assessed	Methods	Main results
Dhyani *et al*., 2022[2]	RCT	To compare the efficacy of ET of irreversible pulpitis in single and multiple visits	Postoperative pain Sensitivity to percussion Swelling and flare-ups Use of analgesics	60 patients GA: Single visit: 30 patients GB: Multiple visits: 30 patients ($Ca(OH)_2$ intersession) Follow-up: Preoperatively and after obturation at day 1, day 7, and day 30	Pain + sensitivity to percussion 24 h after obturation: Statistically higher incidence of single visit 1 week after: Pain scores improved significantly in both the groups 1 month after treatment: All subjects in both the groups were pain-free Swelling and flare-up: No swelling or flare-up in either group Analgesics During the first 24 h: Higher use in GA
Kurt *et al*., 2022[3]	RCT	To evaluate the healing of periapical lesions in mandibular molars after one-visit ET, compared with the results of two-visit treatment with intersession $Ca(OH)_2$	Radiographic healing of periapical lesions	Group 1: Single visit (50 teeth treated in one visit + final irrigation with 2% CHX before filling) Group 2: Two visits (50 teeth treated in two visits with $Ca(OH)_2$ in between) Follow-up: Up to 48 months of 86 teeth (44 in Group 1 and 42 in Group 2)	Radiographic healing rate No significant differences Single visit=Two visits
Mergoni *et al*., 2022[4]	Cochrane meta-analysis	To evaluate the benefits and harms of completion of root canal treatment in a single visit compared to root canal treatment over two or more visits, with or without intracanal medication, on vital permanent teeth, nonvital permanent teeth, or both, in people aged over 10 years	Tooth loss Radiological failure after at least 1 year (presence of any periapical radiolucency) Postoperative pain Swelling or flare-up Presence of a sinus tract or fistula formation after at least 1 month Painkiller use	47 studies included with 5805 participants and 5693 teeth analyzed 10 studies with low risk of bias 17 with high risk of bias 20 with uncertain risk of bias	Tooth extraction due to endodontic problems: The evidence is highly uncertain as the results are based on only two studies, one of which was considered to have a high risk of bias Radiological healing: Single visit=Multiple visits Postoperative pain 1-week posttreatment: Single visit > multiple visits for vital teeth Swelling + presence of fistula: Very uncertain evidence Analgesics: No difference between the two treatment groups in the use of analgesics
Gupta *et al*., 2021[5]	RCT	To compare the prevalence of postoperative pain and percussion sensitivity after single versus two-visit ET of the mandibular first molar	Postoperative pain Sensitivity to percussion	70 patients randomly assigned: Group 1: 34 patients treated in a single visit (1 patient lost to follow-up). 20 vital and 14 nonvital pulps Group 2: 34 patients treated in 2 visits with intersession $Ca(OH)_2$ (1 patient excluded due to analgesic intake). 19 vital and 15 nonvital pulps	Postoperative pain: Group 2 > Group 1 after 12 h and 48 h Sensitivity to percussion: No pain after 1-week postobturation for both the groups
Jethi *et al*., 2021[6]	*In vivo* study	To compare the incidence of postobturation pain during ET in one versus multiple visits, using manual (Universal) and rotary (Protaper Gold) Protaper files	Postobturation pain Instrumentation	100 teeth with symptomatic irreversible pulpitis GA: 50 patients treated in a single visit GB: 50 patients treated in multiple visits Pain assessment: Using a modified 100 mm VAS	Postoperative pain At 6-h intervals GA > GB Pain decreased after 48 h for both the groups Instrumentation: Rotary Protaper used in one visit (GA2) had a lower incidence of postobturation pain than manual Protaper (GA1) No significant difference between manual and rotary Protaper in multiple visits
Khabadze *et al*., 2021[7]	Literature review	To evaluate the efficacy of treating CAP in one versus multiple visits	Radiographic healing of periapical inflammation	9 articles included in the review	Radiographic healing: Most studies have shown no significant difference between single- versus multiple visit ET

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Table 1: Contd...

Authors	Type of study	Objectives	Outcomes assessed	Methods	Main results
Özkan Özcan *et al*., 2021[8]	Prospective RCT	To evaluate the effect of low-level laser therapy, used in conjunction with conventional canal disinfection techniques, on postoperative pain after single- and multivisit root canal treatments for chronic apical periodontitis	Postoperative pain LLLT Age and gender Tooth type	100 patients with asymptomatic chronic apical periodontitis In Group I and III: Single visit In Group II and IV: Two visits In Group III and IV: 810 nm diode laser (1.5 weeks, for 20 s), laser tip was inserted 1 mm above the WL Pain assessment: With VAS Follow-up: at 4 h, 8 h, 12 h, day 1, day 2, day 3, day 4, day 5, day 6, and day 7 after the treatments	Postoperative pain: No statistically significant difference between the groups at any time during the observation period Low-level laser therapy: No significant effect on incidence of postoperative pain, in single or multiple visits Age and gender + tooth type: No significant difference in gender, age, and tooth type distribution between the groups
Shubham *et al*., 2021[9]	RCT	To compare postendodontic pain between apical patency and nonpatency groups, depending on number of visits, vitality of teeth, group of teeth, and preoperative pain	Postoperative pain and maintaining apical patency Number of visits Tooth type Pulp vitality Preoperative pain	160 patients were included GA: Apical patency maintained with a size 10 K-file (n=80 teeth) GB: Nonpatency group (n=80 teeth) $Ca(OH)_2$: For subgroups A2 and B2 Pain intensity recorded: Using the NRS-11	Postoperative pain and maintaining apical patency: A statistically significant difference in postoperative pain: GA > GB at day 1, day 2, and day 7 follow-up Postoperative pain and number of visits: No statistically significant difference in pain between one-visit and multiple-visit subgroups at follow-up
Paredes-Vieyra *et al*., 2020[10]	Prospective, controlled, randomized, multicenter clinical trial	To determine whether controlled final irrigation protocol after cleaning and shaping procedures would result in a reduced acute pain rate of single versus two-visit RCT of teeth with necrotic pulp and apical periodontitis	Postoperative pain Periapical radiographic healing Final irrigation Instrumentation	90 patients Group 1: 30 nonvital teeth without apical periodontitis Group 2: 30 nonvital teeth with apical periodontitis Group 3: Control $Ca(OH)_2$: For two-visit ET groups Preoperative pain assessment: With VAS, patients with scores 7, 8, 9, or 10 were incorporated in the study	Postoperative pain The treatment was successful in eradicating pain in 83.33% of cases No statistically significant difference between the groups It is significantly related to treatment of previously symptomatic teeth or teeth with apical periodontitis Radiographic healing: Statistical analysis of the healing results did not show any significant difference between the groups
Singh *et al*., 2020[11]	Clinical trial	To determine the incidence of postoperative flare-up after single- and multiple-visit endodontic therapy in permanent teeth	Postoperative pain and flare-up	64 patients Group I: 32 patients treated in one visit Group II: 32 patients treated in multiple visits Postoperative pain assessment: With VAS Follow-up: Day 1, day 2, day 3, 1 week, 1 month, 3 months, 6 months, and 9 months	Pain and flare-up: Group II > Group I, but no statistically significant difference
Abdurrahman *et al*., 2019[12]	RCT	To compare the postoperative pain following ET of necrotic teeth with apical periodontitis, performed in multiple visits with application of triple antibiotic paste interappointment dressing or in a single visit without interappointment dressing	Postoperative pain	44 participants with an age range of 16–55 years, randomly divided into two groups GA: 22 patients treated in multiple visits GB: 22 patients treated in one visit Postoperative pain assessment: With VAS Follow-up: Day 1, day 2, day 3, and 1 week	Postoperative pain No statistically significant difference between the two groups Nearly 95% of all participants were asymptomatic after 3 days postoperative

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Table 1: Contd...

Authors	Type of study	Objectives	Outcomes assessed	Methods	Main results
Alomaym *et al*., 2019[13]	RCT	To assess any considerable differences in the incidence and severity of postobturation pain after single- and multiple-visit root canal treatment	Postoperative pain	390 patients Group 1: 195 patients treated in one visit Group 2: 195 patients treated in multiple visits with intracanal $Ca(OH)_2$ + Cavit-G Pre- and post-operative pain assessment: With VAS, modified Heft-Parker Follow-up: 6 h, 12 h, day 1, and day 2 after obturation	Postoperative pain Group 2 < Group 1 An insignificant difference between preoperative and postoperative pain levels of vital and nonvital teeth of both the groups at different time intervals
Londhe *et al*., 2019[14]	Comparative descriptive study	To investigate the effectiveness of single visit as compared with dual visit endodontics	Endodontic failure Age and gender	399 adult patients with pulpal and and periapical diseases of endodontic origin GA: 201 cases treated in one visit (98 posterior teeth, 103 anterior teeth) GB: 198 cases treated in two visits with $Ca(OH)_2$ as an intracanal dressing (98 posterior teeth, 100 anterior teeth) Means of assessment: PAI index preoperatively and during follow-up and Strindberg criteria* Follow-up: Day 7, day 15, day 30, and 9 months	Endodontic failure rate GA: 3.68% GB: 4.78% No statistically significant difference between the two groups Age and gender: Age and gender had no effect on the failure rate
Al-Manei, 2018[15]	Case-control study	To compare the quality of root canal treatment provided by undergraduate dental students in relation to the number of dental visits	The overall quality of ET Obturation length Density Taper Presence or absence of procedural errors	154 patients Group 1: 77 teeth treated in a single visit Group 2: 77 teeth treated in multiple visits	Quality of ET No statistically significant difference between the two treatment groups in terms of obturation length, obturation density, and obturation taper The incidence of procedural errors: No significant difference
Jamali *et al*., 2018[16]	Systematic review and meta-analysis	Clinical and radiographic evaluation of ET performed in one or two visits on teeth with apical periodontitis	Radiographic healing of periapical lesions	5 studies met the inclusion criteria, with a minimum of 44 patients and a maximum of 300 patients The mean number of human teeth: 112.60 GA (1 visit): 58.6 (54.94) GB (2 visits): 54 (51.53) Follow-up: 12 months	Radiographic healing No statistically significant difference between the two groups
Miçooğulları Kurt and Çalışkan, 2018[17]	Prospective comparative study	To evaluate postoperative pain and radiographic evidence of periapical healing in teeth with apical periodontitis treated in a one visit with an additional final irrigation using 2% CHX and to compare the results with conventional two-visit root canal treatment with with an intracanal $Ca(OH)_2$ dressing	Postoperative pain Periapical radiographic healing Final irrigation	82 teeth with asymptomatic apical periodontitis Group 1: 42 teeth treated in 1 visit + final rinse with 2% CHX before obturation Group 2: 40 teeth treated in two visits with $Ca(OH)_2$ as an intracanal medication Postoperative pain assessment on day 1 and Day 2: With VAS Radiographic assessment: PAI index Clinical and radiographic follow-up: 6 months, 12 months, and 24 months	Postoperative pain at 24–48 h + radiographic healing at 24 months: No significant differences between the two groups

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Table 1: Contd...

Authors	Type of study	Objectives	Outcomes assessed	Methods	Main results
Riaz *et al.*, 2018[18]	RCT	To determine the pain of single versus multiple visit ET after obturation in teeth with necrotic pulps and infected canals	Postoperative pain	60 patients (34 women and 26 men), aged between 18 and 60, divided into two groups Group I: 30 teeth treated in 1 visit Group II: 30 teeth treated in multiple visits + placement of intracanal $Ca(OH)_2$ dressing Pain assessment: with VAS Follow-up: Day 2	Postoperative pain No significant difference between the two groups The frequency of postoperative pain: not significant either between the two groups ($P>0.05$)
Tarallo *et al.*, 2018[19]	RCT	To evaluate the influence of two different foraminal WLs on postoperative pain and mechanical allodynia after ET completed in a single-visit or two-visits	Postoperative pain WL	48 patients with asymptomatic apical periodontitis SV0: 12 single-visit root canal treatments and instrumentation performed on foraminal WL SV+1: 12 single-visit root canal treatments and instrumentation performed 1 mm beyond the apical foramen TV0: 12 two-visit root canal treatments and instrumentation performed on foraminal WL TV+1: 12 two-visit root canal treatments and instrumentation performed 1 mm beyond the apical foramen Postoperative pain assessment: With VAS at 3 h, 6 h, 12 h, day 1, day 2, day 3, and day 7 Assessment of mechanical allodynia: A bite force measurement was performed using a digital gnathodynamometer, just before and 7 days after treatment	Postoperative pain No statistically significant difference between the 4 groups in any of the evaluated periods Bite force values: Significantly higher for all experimental groups, 7 days after ET, indicating that there was a significant reduction of mechanical pain in all groups. However, there was no significant difference among the groups regarding gain of strength Foraminal WL The variation between 0 mm and 1 mm beyond the apical foramen in asymptomatic necrotic teeth resulted in Almost the same rate of low postoperative pain and mechanical allodynia after ET completed in a single-visit or two-visits
Almeida *et al.*, 2018[20]	Meta-analysis and systematic review	To evaluate the outcomes of ET, of nonvital teeth, carried out in one versus multiple visits	Periapical repair: Cured/not cured Microbiological control: Negative/positive cultures Postobturation pain: Presence/absence of pain	This meta-analysis includes 17 randomized clinical trials 6 on periapical repair 4 based on microbiological controls 8 on postobturation pain	Apical repair + microbiological control No difference observed between single and multiple-visit treatments Postoperative pain 21% less pain when endodontic therapy was performed in a single visit compared to multiple visits
Chhabra *et al.*, 2017[21]	RCT	To compare and evaluate the clinical and radiographic outcome of single- versus multivisit ET in teeth with periapical pathology	Periapical radiographic healing	60 single- and multirooted teeth with PAI ≥3 Group I: 30 teeth medicated with ApexCal paste and obturated in second visit 7–10 days later Group II: 30 teeth obturated at the first visit Radiographic evaluation: PAI scoring system Follow-up: 1 month, 3 months, 6 months	Clinical symptoms Rare during the follow-up period Radiographic healing No significant difference between subgroups during the follow-up period The decrease in mean PAI scores showed improvement in all subgroups, with highly significant $P\leq0.001$
Fonzar *et al.*, 2017[22]	Multicenter RCT	To evaluate whether it is more effective to complete ET in a single visit, or rather in two visits with 1-week intracanal calcium hydroxide medication in symptomatic teeth and asymptomatic teeth with periapical lesions	Tooth loss Any complication Radiographic healing Posttreatment pain Amount of painkillers used	199 patients being 18 years or older were randomized Group 1: 99 patients treated in one visit Group 2: 100 patients treated in two visits with application of $Ca(OH)_2$ for 1 week Follow-up: Up to 1-year posttreatment	Tooth loss and complications No statistically significant differences between the two groups Radiographic healing No statistically significant differences after 1-year posttreatment between the two groups Postoperative pain Group 1 < Group 2, after 1 week and 2 weeks 4Analgesic use: Group 1 < Group 2, after 1 week and 2 weeks

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Authors	Type of study	Objectives	Outcomes assessed	Methods	Main results
Moreira *et al*., 2017[23]	Umbrella review	Form a consensus that guides clinical decision making in endodontics related to the number of sessions required for effective and safe ET	Immediate postoperative complications Flare-up Pain Swelling Presence fistula, and other Tissue repair Success rate	62 studies were originally analyzed by the 8 SRs included in this overview Of these, 6 SRs showed low to moderate risk of bias	Tissue repair + success rate: No statistically significant difference between single versus multivisit treatment, regardless of the precondition of the pulp and periapex Postoperative complications: Single-visit approach: reduced incidence of postoperative complications in the apical periodontitis subgroup
Schwendicke and Göstemeyer, 2017[24]	Systematic review, meta-analysis and trial-sequential analysis	To evaluate the risk of complications after single-visit or multiple-visit root canal treatment	Long-term complications Short-term postoperative pain Flare-up	29 studies included 4341 patients	Long-term complications: Single-visit = Multiple visits Short-term incidence of pain Single-visit = Multiple visits Flare-up: 2.13 times greater risk after single-visit versus multiple-visit treatment
Sharma *et al*., 2017[25]	Clinical trial	To evaluate the incidence of postoperative pain in single versus multiple visit root canal treatment of vital and nonvital single rooted teeth	Postoperative pain and Gender Age Number of visits Pulp vitality	200 patients with an age range of 16–35 years Group I: 100 vital pulps, out of which 50 were endodontically treated in a single visit and 50 in multiple visits Group II: 100 nonvital pulps, out of which 50 were endodontically treated in a single visit and 50 in multiple visits	Postoperative pain: No statistically significant differences were found between gender, age, number of visits, and pulpal status

CAP: Chronic apical periodontitis, ET: Endodontic treatment, GA: Group A, GB: Group B, LLLT: Low-level laser therapy, NRS: Numerical Rating Scale, PAI: Periapical index, SRs: Systematic reviews, VAS: Visual Analog Scale, WL: Working length, CHX: Chlorhexidine

and efficiency for single-visit ET was noted in the overview of systematic reviews by Moreira *et al*.[23]

The rest of the studies included in our work[8-10,12,17-19,24,25] showed no significant difference in pain perception in people treated in one versus multiple visits.

Furthermore, several studies in the literature[30-32] failed to demonstrate any significant difference in the incidence of postoperative pain/flare-up between the two treatment approaches.

Postoperative pain was significantly related to treatments of teeth that were previously sensitive, symptomatic, or with apical periodontitis. Preoperative pain showed a positive correlation with postoperative pain.[6,9,10]

Postoperative pain and root canal medication

Sodium hypochlorite is the irrigant solution commonly used for canal disinfection due to its greater dissolution capacity and antimicrobial activity. However, in a recent clinical trial,[33] postoperative pain was significantly higher with the use of 8.25% NaOCl compared to 2.5% NaOCl, with a higher incidence of pain observed in the 8.25% NaOCl group, during the 12-hour to 3-day period.[33]

Intracanal medication is still indicated in cases of preoperative pain associated with apical periodontitis of endodontic origin, persistent root canal seepage, or the presence of root resorptions.

Thanks to its bactericidal effect and biological capacity for repair and remineralization, calcium hydroxide disrupts the cytoplasmic membrane, inhibits bacterial enzyme activity, and prevents DNA replication. It also acts through a physical mechanism, creating a barrier that prevents bacterial invasion between appointments and limits the space for residual bacteria to multiply.[34]

The results of our review are controversial. A few studies included in our review report differing outcomes between single-visit endodontic therapy (ET) and two or more visits with interappointment calcium hydroxide (Ca(OH)2) applications. Alomaym *et al*.[13] found a lower incidence of pain in the multivisit group compared to the single-visit group, for both vital and non-vital teeth. In contrast, Fonzar *et al*.[22] observed that patients in the two-visit group endured significantly higher levels of pain and consumed more ibuprofen at 1 and 2 weeks postoperatively than those treated in a single visit.

Other studies included in our review[3,8,9,11,15,18-20,22] found no difference in the results of ETs in one visit versus two or more visits with interappointment application of $Ca(OH)_2$.

AbdurRahman *et al*.[12] (2019) conducted endodontic treatments on necrotic teeth with apical periodontitis, comparing single-visit versus multiple-visit protocols with intermediate application of a triple antibiotic paste (ciprofloxacin, metronidazole, and doxycycline mixed with saline). They found no statistically significant difference in postoperative pain between the two treatment groups.. Triple antibiotic paste as an interappointment dressing in multiple-visit ET did not reduce the postoperative pain compared to a single-visit ET, in patients with necrotic teeth with apical periodontitis.[12] On the other hand, studies based on molecular biology have compared calcium hydroxide and sodium hypochlorite and found no difference in terms of efficacy.[35]

Indeed, Waltimo *et al*.'s randomized study[36] compared the 12-month success rate of teeth treated in one or more visits and found that interappointment calcium hydroxide placement was not associated with a better success rate.

Furthermore, a meta-analysis showed contrasting results concerning the *in vitro* or *ex vivo* effect of adding chlorhexidine on the antibacterial activity of calcium hydroxide alone on *Enterococcus faecalis*.[37] Of 21 comparisons analyzed (9 studies), 10 were in favor of the Ca(OH)2 + Chlorhexidine (CHX) combination, 8 showed no difference between Ca(OH)2 + CHX and Ca(OH)2 alone, and 3 were in favor of Ca(OH)2 alone.

Although calcium hydroxide is not effective against all bacteria present in the root canal, it remains the medication of choice when immediate root canal obturation is not possible.

Periapical healing and postoperative follow-up

The ultimate goal of ET, regardless of the number of visits, is periapical healing.

Indeed, healing only occurs once the antigen has been neutralized during the inflammatory response. No regeneration will occur until the irritants have been eliminated from the root canal system, and the latter has been isolated from the rest of the body by sealing the endodontium. Finally, a root canal obturation and a watertight coronal reconstruction seal the endodontium and maintain the result obtained.

The healing rate of apical lesions in response to conventional ET is at best approximately 80%, and the healing kinetics can take many months.[38]

In all the studies included in this review that assessed periapical healing,[3,4,10,14,16,17,20-23] no significant difference in periapical healing was observed in single-visit ETs compared to multiple-visit treatments.

Kurt *et al*. in 2022,[3] on large periapical lesions, showed no significant difference in radiographic healing rates between the single-visit group (91%) with final 2% CHX irrigation and the two-visit group (88%) with intermediate $Ca(OH)_2$ applications over a 48-month period.

Similarly, Su *et al*. in 2011,[39] in their systematic review, showed no significant difference in healing rate between single- and multivisit ET for teeth with infected root canals.

The endodontic failure rate showed no statistically significant difference between teeth treated in a single visit versus two visits.[14]

The healing process can last from 6 months to 2 years, hence the importance of regular postoperative follow-up. Postoperative dynamics may generate different signs and symptoms over time. Consequently, the results of studies with short follow-up periods do not necessarily reflect the definitive prognosis of treatment. According to Orstavik[40] and the recommendations of the ESE, a minimum follow-up period of 12 months is essential to properly assess the first signs of success. All root canal treatments should be evaluated clinically and radiographically immediately, at 1 year, and then periodically, depending on the situation.

A follow-up of 3 or 4 years may be necessary to record a stable treatment result.[41] Moreover, the success of ET is linked to a number of factors that may contribute to late failure or to the appearance of a periapical lesion a few months after treatment has been completed.

CONCLUSION

This literature review shows that single-visit endodontics can be considered an alternative treatment modality to multiple visits endodontics.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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