

Review

The Incidence and Intensity of Postendodontic Pain and Flareup in Single and Multiple Visit Root Canal Treatments: A Systematic Review and Meta-Analysis

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Citation: Vishwanathaiah, S.; Maganur, P.C.; Khanagar, S.B.; Chohan, H.; Testarelli, L.; Mazzoni, A.; Gupta, A.A.; Raj, A.T.; Bhandi, S.; Mehta, D.; et al. The Incidence and Intensity of Postendodontic Pain and Flareup in Single and Multiple Visit Root Canal Treatments: A Systematic Review and Meta-Analysis. *Appl. Sci.* **2021**, *11*, 3358. <https://doi.org/10.3390/app11083358>

Academic Editor: Ivana Miletić

Received: 6 March 2021

Accepted: 6 April 2021

Published: 8 April 2021

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Abstract: To assess the incidence and intensity of postendodontic pain and flareup in single and multiple visit root canal treatment (RCT) and determine if the difference between the two is significant, a search of PubMed, Medline, Embase, Cochrane, Scopus and Web of science was conducted. The grey literature was searched using Google Scholar and Saudi digital library. Randomised controlled trials evaluating the incidence and intensity of postendodontic pain and flareup published in English from 1 January 2000 to 15 April 2020 were searched. The PRISMA protocol was followed to select the articles. A random effects model was used for the meta-analysis of the data in the included studies. Twenty-one articles were included in the review. Three compared both the incidence and the intensity, while the rest compared either one of the parameters. Most studies used both hand-driven and rotary instruments and irrigated with sodium hypochlorite. Twelve studies used an intracanal medicament. Although individual studies showed discordant treatment outcomes, the meta-analysis did not reveal any significant difference in the incidence or the intensity of the postendodontic flareup between the single and multiple visit RCT groups. Single or a multiple visit root canal treatment is not an independent determinant for the risk of postendodontic pain or a flareup.

Keywords: endodontics; flareup; pain; root canal treatment; postendodontic pain

1. Introduction

Endodontic therapy or root canal treatment (RCT) aims to eradicate bacteria from an infected root canal [1]. It is generally performed over multiple visits, which is considered a safer procedure than a single visit [2]. One or single visit RCT involves cleaning and shaping, and obturation of the root canal in one appointment; whereas multiple visit RCT provides a gap after placement of an intracanal medicament followed by obturation.

Multivisit RCT has a few disadvantages. There is a risk of contamination of root canal due to microleakage and fracture of the temporary restoration that can cause a flare up [3,4]. Patient needs and expectations have made one/single visit treatment more popular as it is brief and economical [5]. With recent advances in endodontic technology, single-visit endodontics is favoured [6,7]. Factors like preoperative pain and pulpal infection that affect the treatment outcome, determine the appropriate treatment plan, e.g., single or multiple-visit [6]. The existing literature is unclear if either of the options offers an advantage over the other [2,3,5,6].

Pain after RCT is one of the most common complications of endodontic treatment [8]. Postoperative pain from RCT may occur between 3% to 50% of cases [8]. Mild postoperative pain is not rare even when endodontic treatment follows established protocols [9]. A flareup, here, refers to intense pain and/or swelling of the facial soft tissues and the oral mucosa in the area of endodontically treated tooth after initiation of endodontic treatment. The clinical symptoms (pain on biting, chewing or isolated) are so strongly expressed that the patient needs to visit the clinic sooner than scheduled [10–12]. After endodontic treatment, a flareup often manifests as pain of varying intensity with or without swelling [13]. A flareup can occur within a few hours or a few days post RCT [14]. The pain may be a periapical inflammatory response to one or more of the following factors: instrumentation/mechanical, the introduction of medications/chemical injury, apical extrusion of debris into the periapical tissues and psychological influences [15]. Factors such as preoperative symptoms, age, gender, type of tooth, dental anatomy, periapical lesions, sinus tract, tooth vitality, and intracanal medications are associated with the flareup [16,17].

Studies have compared both the incidence and the intensity of postendodontic pain and flareups between a single visit and multiple visit RCT. Reviews on this topic include varying study designs which causes significant heterogeneity in the included data making a quantitative analysis difficult. One review compared single and multiple visit RCT in the presence of apical periodontitis and included research articles of varying study designs. The second review compared the postoperative pain between single and multiple visit RCT but again included both randomised and nonrandomised controlled trials. The strongest scientific evidence is a synthesis of findings produced by well conducted, randomised controlled trials. Our research, therefore, assessed incidence and intensity of postendodontic pain and flareup between single visit versus multiple visit RCT from randomised controlled trials.

2. Materials and Methods

The International Prospective Register of Systematic Reviews (PROSPERO) was searched for studies that compared postendodontic pain and flareups between single and multiple visit RCTs. Finding no similar studies, protocol for the present review was registered (CRD42020216029). The review was carried per the guidelines for preferred reporting items for systematic reviews and meta-analyses (PRISMA).

Research question: Is there a significant difference in the incidence and intensity of postendodontic flareup between a single-visit and multiple-visit RCT?

Literature search: The electronic databases PubMed, Medline, Embase, Cochrane, Scopus, and Web of science were searched. Grey literature was searched in Google Scholar and Saudi digital library. Articles published in English between 1 January 2000 and 15 April 2020 were included. The keywords combinations used were “postoperative pain” or “post obturation pain” and “single visit” or “multiple visits” or “one visit” or “two visits” and “flareup”. The selection was based on PICOS format (Population, Intervention, Comparison, Outcome and Study).

The criteria included: Population—patients with at least one tooth indicated for endodontic treatment; intervention—root canal treatment; comparison—single and multiple visits; outcome—incidence and/or intensity of postoperative pain or flareup; study design—randomised controlled trial.

Selection process: Three reviewers (SV, PM, and SK) screened the studies independently and compared the results. In case of any disagreement, studies were included/excluded after discussion. The articles selected were included for a full text reading to examine their eligibility. The following inclusion criteria were applied in addition to PICOS.

Inclusion criteria:

1. The study must be conducted on permanent vital teeth.
2. The outcome must have been measured post treatment or post initiation of treatment.
3. Clinical procedure was described in detail.

Collection of data: Data from studies was extracted. Characteristics such as number of samples, type of treatment, use of intracanal medicament, the incidence, and the intensity of the postendodontic flareup were identified. The details were tabulated. Figure 1 summarizes the search strategy employed in the study.

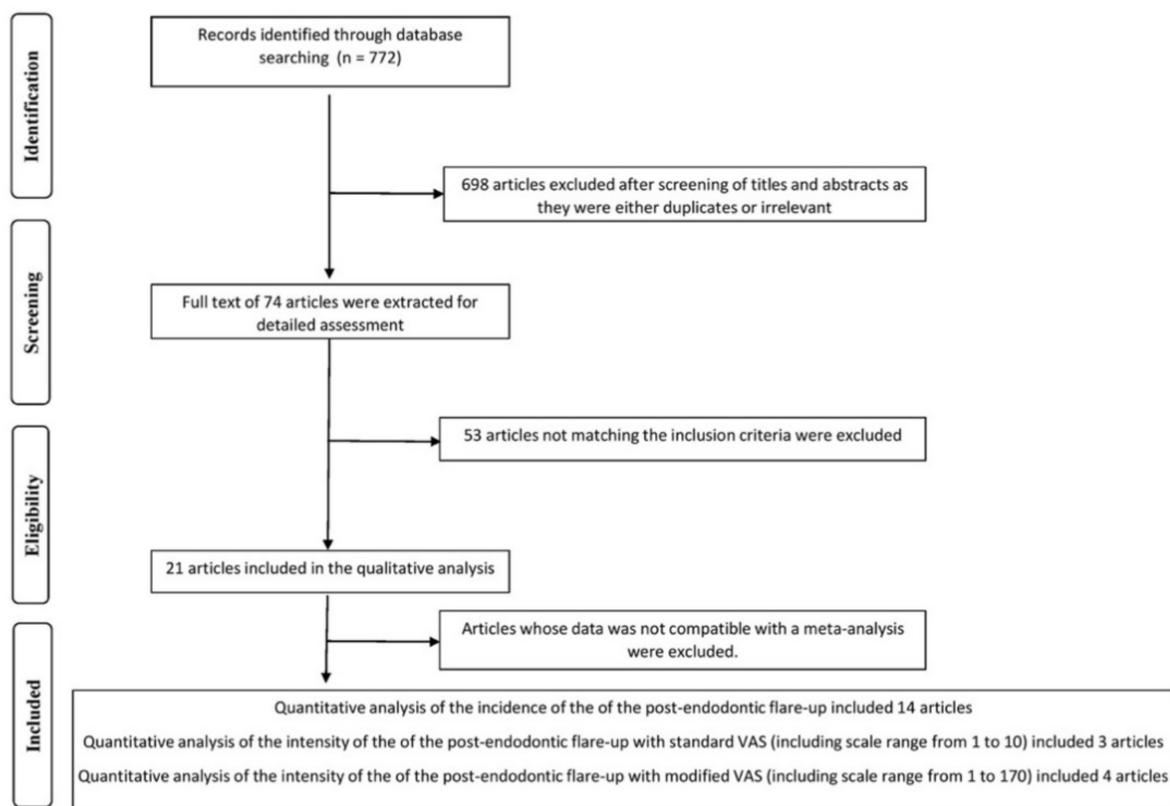


Figure 1. PRISMA flowchart summarizing the selection process employed in the review.

Risk of bias: The Joanna Briggs institute critical appraisal tool for randomised controlled trials was used to determine the risk of bias. This tool evaluates trials on the basis of baseline characteristics and randomisation of groups, allocation, blinding, outcome measures, statistical analysis and method of conduct of trial. The results of the assessment are reported in a tabular and narrative form.

Meta-analysis: Quantitative data was extracted from all studies and organised into an extraction sheet for cleaning. Studies found eligible for a meta-analysis were analysed using a random effects model.

3. Results

Study characteristics: The preliminary search yielded 772 articles. Screening based on title and abstracts led to the exclusion of 698 articles that were either duplicates or irrelevant. Full texts of the remaining papers (n = 74) were retrieved. After applying the inclusion

criteria, 21 articles were included. Table 1 summarizes the data retrieved from the included studies. The sample size ranged from 32 to 538 (patients/teeth) in the included studies. Five studies justified the sample size used [18–22]. The studies showed variation in the RCT procedure: some used hand-driven files [23–29] while others used a combination of hand-driven and rotary instruments [7,8,18–22,30–34]. One study used normal saline [23] as an intracanal irrigant, whereas 17 used sodium hypochlorite [18–22,24–35] and the rest did not specify. Twelve studies employed calcium hydroxide [8,18–20,22–25,27,30,33,34] as an intracanal medicament, and the rest kept the cavity sterile (without intracanal medication) [7,21,26,28,29,31,35] until the obturation. Twelve trials included both vital and nonvital teeth [8,19–22,26,28,31–33,35,36] seven had nonvital teeth only [7,23–25,27,30,34] and two included vital teeth only [18,29].

Outcome measures: Postoperative pain and/or flareup was the major outcome assessed in the present review. Pain was assessed by various means in the studies. studies used a four to five-point Likert scale (six studies), a 10-point scale (two studies), and either a Visual Analog Scale (VAS) or modified VAS (12 studies). One study only measured the swelling. The outcomes were measured over a period of 6 h to 2 years. Most studies measured post obturation pain at 24 or 48 h. A few studies considered increase in the intensity of pain as a flareup while others considered swelling, tenderness as a flareup.

Risk of bias: The Joanna Briggs institute (JBI) critical appraisal checklist for randomised controlled trials showed that all the included studies had a moderate risk of bias. Table 2 summarizes the risk of bias assessment. All studies employed some degree of randomisation to assign patients to their respective groups. The patients in both the single and the multiple visit RCT were treated identically. One study had attrition but since nearly equal number of patients from the comparative groups were lost to follow up, it did not affect the outcome. There was no crossover between the treatment groups in any study. The same modalities were employed to assess both groups. The established protocol for the randomised controlled trials were followed and appropriate statistical analysis were done to arrive at a conclusion. There were five parameters—concealment of the treatment groups, the similarity of the patients assigned to the treatment groups, the blinding of the patients, doctors, and the investigators measuring the outcome—which were not followed in any of the studies.

Meta-analysis: Of the 21 included studies, only 14 had quantitative data compatible to analyse the incidence of the postendodontic flareup. Quantitative analyses were performed to evaluate the differences in the incidence of the flareup and in the intensity of the flareup between single and multiple visit RCTs. According to the meta-analysis, there is no significant difference ($p = 0.72$) in the incidence of flareup in single visit RCT compared to multiple visit RCT (Figure 2).

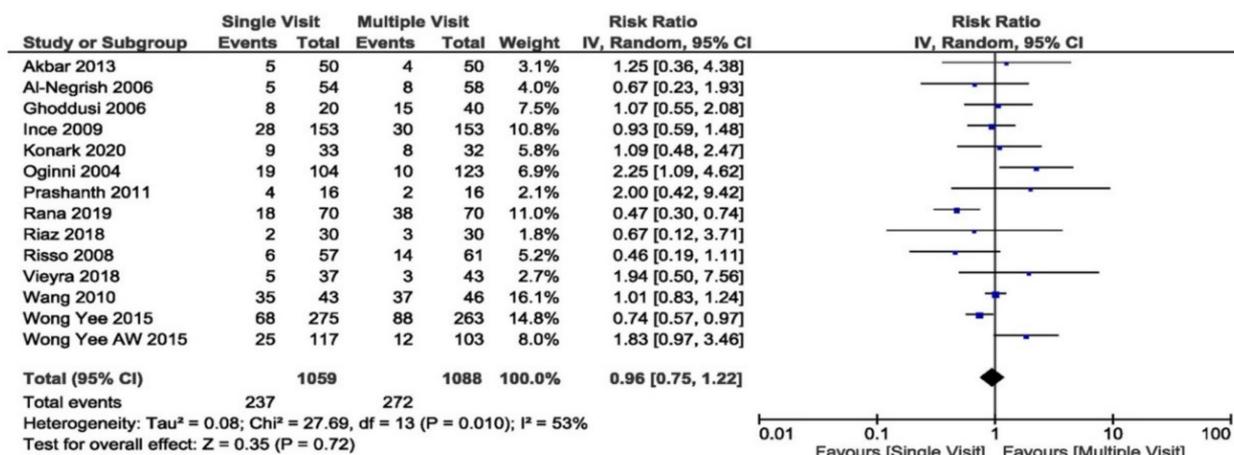


Figure 2. Meta-analysis summarizing the comparison of the incidence of a post endodontic pain and flareup between single and multiple visit root canal treatment (RCT).

Table 1. Summary of the data extracted from the studies included in the systematic review.

S. no	First Author/Country/Year [Reference Number]	Sample after Dropouts (Groups)	Vital/Nonvital Tooth	Intra Canal Medicament	Pain Assessment [Pre/Postoperative]	Pain Assessment Scale	Follow up Visits Postoperatively	Outcome Measure (Pain/Flare)	Frequency/Incidence of Pain/Flare among Groups	Statistical Significance	Authors Conclusions/Suggestions
1	DiRenzo/USA/2002 [35]	72 patients (Single visit: 39, Multiple visits: 33)	Vital and nonvital teeth	Sterile cavity	Preoperative and post obturation pain	Modified VAS	6, 12, 24, and 48 h	Pain	Evenly distributed minimal pain within 24 to 48 h	No statistically significant difference	No difference in postoperative pain between two visits.
2	Oginni/Nigeria/2004 [36]	222 patients (Single visit: 102, Multiple visits: 120)	Vital and nonvital teeth	Not mentioned	Preoperative Interappointment Post obturation	None/Slight/Moderate/Severe	1st, 7th and 30th day	Pain/flare up	Flareups seen in both groups 10 flareups (Pain or swelling) in multiple visits 19 flareups in a single visit.	A significant difference was seen between single and multiple visits.	Higher incidence of post obturation pain and flareups following single-visit procedures.
3	Ghoddusi/Iran/2006 [23]	60 patients (Single visit, Multiple visit, Multiple visit with intracanal medicament)	Nonvital teeth	Calcium hydroxide for 1 week	Postoperative	Modified VAS	Recalled after 72 h	Pain/swelling	The frequency of pain was seen more with multiple visits. Frequency/incidence of pain and swelling more in a single visit.	A significant difference in the incidence and severity of pain between multiple visits and pain/swelling between single and multiple visits.	Intracanal dressing (Calcium hydroxide) could be effective to decrease postoperative pain and swelling.
4	Al-Negrish/Jordan/2006 [24]	112 (Single visit: 54 Multiple visits: 58)	Nonvital teeth	Calcium hydroxide for 1 week	Postoperative	No pain, slight pain, moderate pain, and severe pain	2 and 7 days post obturation	Pain/swelling	The pain was seen in both groups. After 2 days, the flareup rate was 9.2% for a single visit and 13.8% for two visits. After 7 days the flareup rate was 1.8% for one visit and 5.2% for the two visits.	No significant difference in incidence and degree of postoperative pain.	There was no difference in the flareup rate between single and two appointment techniques. The rate of flareup was 11.6 and 3, 6 after 2 and 7 days, respectively
5	Risso/Brazil/2008 [25]	118 patients (One visit: 57, Two visits: 61)	Nonvital teeth	Calcium hydroxide	Preoperative and post obturation	VAS	10 day follow up [recorded after 6, 12 and 24 h and then 24 h during 9 following days]	Pain/flareup	The frequency of pain was seen in 10.5% (6/57) in one visit group and 23(14/61) in two visit group. Flareup was seen in 1.75% (1/57) in one visit group and 1.65% (1/61) in two visit group.	No statistically significant difference between the groups.	The pain was observed more in two visit group. No difference was seen in the intensity of post obturation pain.
6	Ince/Turkey/2009 [26]	306 (single visit: 153, Multiple visits: 153)	Vital and nonvital teeth	Sterile cavity	Postoperative pain	No, mild, moderate and severe pain	3 days post obturation	Pain	Postoperative pain occurred in 107 patients in a single visit and 106 patients in multiple visits. It occurred in 35 patients with vital pulp and 23 patients with nonvital pulp.	No significant difference in postoperative pain between the two groups	Postoperative pain after endodontic therapy is related to preoperative pain.

Table 1. Cont.

S. no	First Author/Country/Year [Reference Number]	Sample after Dropouts (Groups)	Vital/Nonvital Tooth	Intra Canal Medicament	Pain Assessment [Pre/Postoperative]	Pain Assessment Scale	Follow up Visits Postoperatively	Outcome Measure (Pain/Flare)	Frequency/Incidence of Pain/Flare among Groups	Statistical Significance	Authors Conclusions/Suggestions
7	Wang/China/2010 [18]	89 (one visit: 43, two visits: 46)	Vital teeth	Calcium hydroxide for 1 week	Preoperative and post obturation	Modified Verbal descriptor scale [VDS]	6, 24, 48 h and 1 week after obturation	Pain/flareups	No pain or slight pain was observed between both groups. Flareup and slight swelling were seen in 1 in each group.	No statistically significant difference in the incidence and intensity of post obturation pain.	The experience of incidence and intensity of post obturation pain in vital teeth was similar following one or two-visit.
8	Prashanth/India/2011 [32]	32 (single visit—vital pulp, necrotic pulp, multiple visit—vital pulps, necrotic pulp)	Vital and nonvital teeth	Not mentioned	Post obturation	Unclear (mild, moderate, severe)	48 h (postoperative pain). 1 week, 4 to 6 weeks.	Pain/swelling/tenderness	After 48 h, pain in necrotic pulp groups. Tenderness in 25% in single visit vital teeth, 12.5% in single visit non vital and multiple visit vital teeth after 48 h.	No statistically significant difference was seen during the 48 h of follow up.	There was no difference in postoperative pain, tenderness/swelling between single and multiple visits.
9	Singh/India/2012 [33]	188 (single visit: 94 two visits: 94)	Vital and nonvital teeth	Sterile cavity	Preoperative and postoperative pain	Modified Heft Parker visual analogue scale	6, 12, 24 and 48 h	Pain	Incidence and intensity of post obturation pain were similar in both the groups, but the multivisit group experienced more pain compared to a single visit.	No significant difference was seen	Multivisit endodontics does not reduce the incidence of pain.
10	Tarale/India/2013 [34]	60 patients (one visit: 20, two visits: 20 with medicament and without: 20)	Vital and nonvital teeth	Calcium hydroxide	Preoperative and post obturation	Modified VAS,	6, 12, 24 and 48 h	Pain	After 6 h, one visit had more pain. No difference among all groups after 12, 24 and 48 h.	No statistically significant difference was seen after 6, 12, 24 and 48 h.	Postoperative pain was the same with a single and multivisit appointment with or without calcium hydroxide dressing.
11	Akbar/Saudi Arabia/2013 [27]	100 patients (one visit: 50, two visits: 50)	Nonvital teeth	Calcium hydroxide	Post obturation	Not specified	Daily for 7 days	Flareups	5 patients in one visit and 4 patients in two visits experienced flareups.	No statistically significant difference was seen with no of visits, age, and gender	Postoperative flareups have no relationship with one visit or two visits.
12	Rao/India/2014 [7]	148 (single visit: 74, two visits: 74)	Nonvital teeth	Not mentioned	Post obturation	Modified VAS	After 6 h, 24 h, 48 h, and 7 days	Pain	The single-visit group experienced slightly less pain than two visit group at all study intervals	No statistically significant difference was seen	The post obturation pain was similar between patients treated either in one appointment or with two appointments.
13	Wong/China/2015 [19]	538 (single visit: 275, multiple visits: 263)	Vital and nonvital teeth	Calcium hydroxide	Preoperative and post obturation	10 point Likert scale—No pain to extreme pain	1 week after obturation	pain	A day later, 68 teeth for a single visit and 88 teeth for two visits and after 7 days, 11 for a single visit, 14 for two visits had pain.	No significant difference in the incidence of post obturation pain after one day or seven days among the groups	The single visit group had a lower intensity of pain than the multiple visit group

Table 1. Cont.

S. no	First Author/Country/Year [Reference Number]	Sample after Dropouts (Groups)	Vital/Nonvital Tooth	Intra Canal Medicament	Pain Assessment [Pre/Postoperative]	Pain Assessment Scale	Follow up Visits Postoperatively	Outcome Measure (Pain/Flare)	Frequency/Incidence of Pain/Flare among Groups	Statistical Significance	Authors Conclusions/Suggestions
14	Wong/China/2015 [20]	220 teeth (single visit: 117, multiple visits: 103 teeth)	Vital and nonvital teeth	Calcium hydroxide for a week	Postoperative pain	10 point Likert scale—No pain to extreme pain	1 week after obturation and 18 months after treatment	Pain/tenderness on percussion	Postoperative pain after 1 week, 21% in a single visit and 12% in multiple visits. After 18 months it was 0.9% and 1.0%, respectively.	No statistically significant difference was seen.	The prevalence of postoperative pain was the same between the two treatment groups.
15	Keskin/Turkey/2015 [8]	288 patients (single visit: 140, Multiple visits: 148)	Vital and nonvital teeth	Calcium hydroxide	Postoperative pain	VAS	24, 48 and 72 h	Pain	The intensity of pain reduced over the followup. The majority of patients from both groups reported no pain.	No significant difference in the incidence of postoperative pain.	No difference was seen between single vs. multiple visits. The intensity of postoperative pain does not depend on the vitality of the pulp, gender, and tooth type.
16	Patil/India/2016 [21]	Single visit: 32, Two visits: 33	Vital and nonvital teeth	Sterile cavity	Preoperative and postoperative pain	Modified Heft-Parker VAS	6 h, 12 h, 24 h, and 48 h, respectively. After 1 week clinical evaluation of pain was done	Pain	The incidence of pain was higher in the multivisit group when compared to the single-visit group after 6 h, 12 h, and 24 h. After 48 h, there was no difference in pain experienced between the two groups	No significant difference was seen	Multiple visit endodontics does not reduce the pain incidence. Incidence of pain is the same when compared between one visit or two visits.
17	Riaz/Pakistan/2018 [34]	Single visit: 30, Multiple visits: 30	Nonvital teeth	Calcium hydroxide for 5 days	Preoperative and postoperative	VAS	48 h	Pain	The pain was observed in 2 patients in a single visit and 3 patients in multiple visits	No statistically significant difference between the two groups	Pain frequency is similar in a single visit or multivisit
18	Vieyra/USA/2018 [26]	97 (one visit: 46, two visits: 51)	Nonvital teeth	Calcium hydroxide for 1 week	Postoperative pain	No, mild, moderate and severe pain	2 year follow up	pain/swelling	Moderate pain was observed in 5% of the treatment cases and 16.67% of the retreatment cases.	Statistically, a significant difference was seen with the occurrence of flareups when comparing treatment cases with retreatment cases.	A higher incidence of flareups was seen in teeth that require retreatment than the primary treatment.
19	Rana/Pakistan/2019 [28]	140 (single visit: 70, two visits: 70)	Vital teeth nonvital teeth	Sterile cavity	Preoperative Post operatively pain	Heft-parker VAS	24 h	Pain	The pain was less in single visit (18 patients) than two visit group (38 patients)	A highly statistically significant difference was seen between both groups	Single-visit endodontic therapy is better than multiple visits endodontic about post obturation pain. Post obturation of pain was not related to age and gender.

Table 1. Cont.

S. no	First Author/Country/Year [Reference Number]	Sample after Dropouts (Groups)	Vital/Nonvital Tooth	Intra Canal Medicament	Pain Assessment [Pre/Postoperative]	Pain Assessment Scale	Follow up Visits Postoperatively	Outcome Measure (Pain/Flare)	Frequency/Incidence of Pain/Flare among Groups	Statistical Significance	Authors Conclusions/Suggestions
20	Alomaym/Saudi Arabia/2020 [22]	390 patients (single visit: 195, multiple visit: 195)	Vital and nonvital teeth	Calcium hydroxide	Preoperatively	VAS, Modified Heft Parker	6,12,24 and 48 h post obturation	Pain/flare ups	Incidence and intensity of pain were more in a single visit.	No statistically significant difference was seen between multiple visits and a single visit	The incidence of pain was more in a single visit when compared to multivisit.
21	Konark/India/2020 [29]	64 (single visit: 32, multiple visits: 32)	Vital teeth	Not mentioned	Preoperative and post obturation	VAS	24, 48, 72 (h), 1 week, 1,3,6 and 9 (months)	Flareups (Pain, discomfort, swelling, tenderness on percussion, etc.)	At all intervals, postoperative pain was more in the multivisit group when compared with a single visit group except 24 and 48 h interval. Incidence of discomfort and swelling was less in a single visit	Statistically, a significant difference was seen concerning discomfort, gingival swelling, and tenderness to percussion between groups.	Single-visit endodontic therapy showed encouraging results. Postoperative pain was higher in multiple visits compared to the single-visit group.

A wide range of pain assessment tools were employed to measure the intensity of the pain and flareups. Seven studies had data measured using VAS that was compatible for a quantitative analysis. Among these, three used the standard VAS, (pain scale ranged between 1 to 10) and four studies employed the modified VAS, (pain scale ranged from 1 to 170). Thus, two quantitative analysis was performed to assess the intensity of the post endodontic pain and flareup between the single and multiple visit RCT. The meta-analysis of the studies did not show a significant difference in the mean intensity of pain experienced by patients as measured by both the standard ($p = 0.82$) and the modified ($p = 0.48$) VAS scale (Figures 3 and 4, respectively).

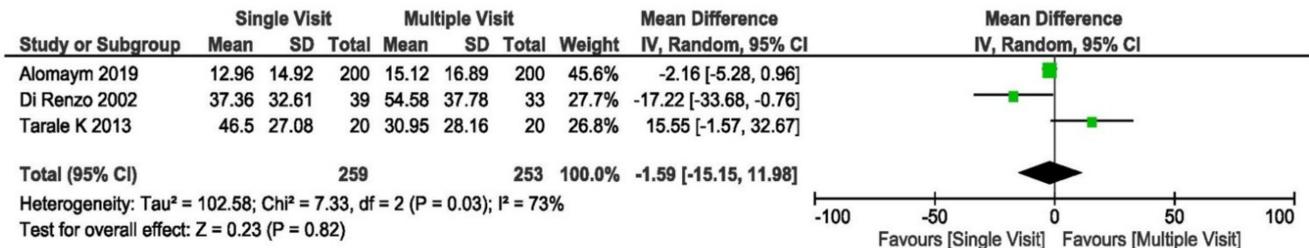


Figure 3. Meta-analysis summarizing the comparison of the intensity of postendodontic pain and flareup between single and multiple visit RCT as measured by the standard visual analogue scale (VAS) with a pain scale of 1 to 10.

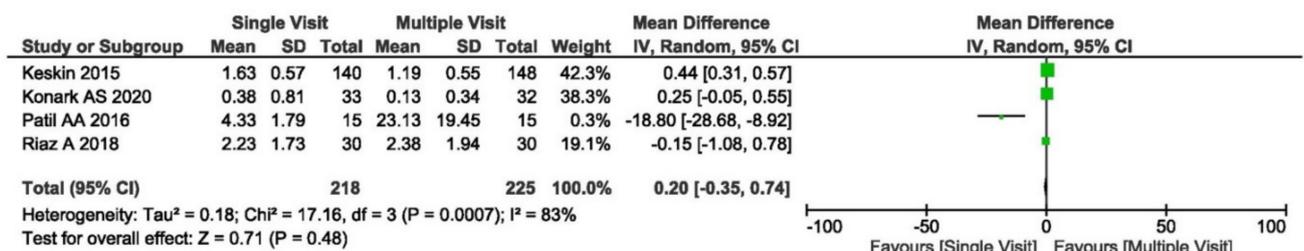


Figure 4. Meta-analysis summarizing the comparison of the intensity of postendodontic pain and flareup between single and multiple visit RCT as measured by the modified VAS with a pain scale of 1 to 170.

4. Discussion

Endodontic procedures can make patients apprehensive. The development of procedural complications and emergencies can further increase this apprehension [17]. Severe pain and flareup after root canal treatment reflect the clinical expression of complex physiological changes occurring at a cellular stage [37]. There are three possible outcomes once endodontic therapy begins—no symptoms, tolerable pain or pressure (rare) or development of severe pain and/or swelling leading to an unscheduled clinical visit [38]. The last outcome is detrimental to the patient’s well-being and the clinician must consider the factors which contribute to it and minimize or eliminate them. Factors such as single/multiple visits, the involvement of vital/nonvital teeth, pre-/postoperative pain, demographic status, chemo-mechanical cleaning, estimation of pain, etc., govern the occurrence of postobturation or interappointment pain and flareups that cause discomfort after endodontic therapy/RCT. In this review, the occurrence of severe pain and/or swelling in relation to the number of visits for endodontic therapy was researched.

Since endodontic treatment techniques are constantly evolving, the aim was to concentrate on the more common methods of the present day. The search was thus restricted to the past two decades. The search resulted in 21 clinical trials conducted in the last 20 years. The inclusion of studies was not restricted by specifying the technique of endodontic treatment used or the preoperative conditions of the tooth. The aim was to evaluate if the number of visits were a primary determinant of postoperative pain and flare up.

The studies were evaluated qualitatively using the JBI tool for critical appraisal of randomised controlled trial. Those found to have a high risk of bias were to be excluded

from review. The JBI tool is a questionnaire used to assess the quality of trials by binary answers (yes/no). However, the tool is not a mere checklist to be ticked off. The JBI manual of evidence synthesis describes the method of using it in detail. We found a moderate risk of bias in the included studies. Most studies were inadequate in the blinding. The lack of blinding of patients and operating dentists is justified. Patients and doctors would be aware of receiving a single or a multiple visit. It was possible to blind the assessor, who could be ignorant of the treatment and solely measure outcomes. The studies lacked data on matching patients between treatment groups. Thus, it is possible that there were potential confounders which in turn could have affected the outcome and increased the overall risk of bias.

Multivisit endodontics are usually performed to guarantee the root canal system's sterility before obturation to minimize the microbial loads present in the affected canals by the placement of a temporary seal and intracanal dressing until the next visit [39]. Single-visit therapy raises the concern that patients can develop postoperative pain post obturation but also offers the advantage of eliminating a temporary seal and interappointment leakage [40]. It also reduces chairside time and visits and has increased patient acceptance [35,41]. Conversely, single-visit procedures eliminate certain controls present in multivisit treatment, such as culturing microbes to provide specific antimicrobials if necessary [42]. The evolution of materials, instruments and a better understanding of internal tooth anatomy have transformed the treatment of routine cases, reducing postoperative issues, particularly pain [43].

Most of the studies included in this review did not find a significant difference between the two groups. Some studies have shown higher flareups and pain in single visit [22,36] contrary to those which show increased incidence in multiple visits [19,23,25,28,30,31,35]. The two studies [23,36] which found significant differences between groups did not have any characteristics in common. Both studies favoured multiple visit root canal therapy. It is interesting to note that both these studies were carried out at the beginning of our selected period (2004 and 2006). The studies that have been done since, till April 2020, found no significant difference between the two procedures. This is possibly due to evolution of the techniques of root canal preparation, endodontic irrigation and obturation that improved the quality of single visit treatment, i.e., apical extrusion is an issue which has been addressed.

Currently, evidence on precautions to minimize postoperative flare ups is scarce [44]. Studies have examined various factors that contribute, such as operator skills and pulp vitality. In our findings, we found similar results in studies regardless of pulp vitality. Studies included in the present review and previous studies have not found any link between pulp vitality and postoperative pain and flare ups. Again, the studies that found a significant effect of vitality in our review were [23,36] which are older. Periapical inflammation and microbial colonization is easier in necrotic tissue [3,15]. This can cause inflammation in a single visit procedure due to apical extrusion of necrotic tissue during cleaning and shaping. Since present day techniques minimize this phenomenon, it is possible that tooth vitality does not play a role in postoperative pain and flare up.

The included studies were unclear on the matching of the baseline characteristics of the included groups. These should be matched to the best possible extent to avoid confounding. Variation in tooth anatomy leads to difficulty in the adequate endodontic treatment of teeth. Molar teeth especially, have a complex anatomy and are difficult to access due to their location, which has been linked to postoperative pain [27,45]. However, some studies show that postoperative pain does not have any correlation with the number of roots [18,19,46] and gender [7,20,22].

The studies included in the review had variation in several characteristics. Multiple visit groups used intracanal medicaments in some studies, i.e., calcium hydroxide, the most popular option [47]. A medicament is used to provide anti-inflammatory and antimicrobial effect. Evidence suggests that calcium hydroxide may not be able to maintain sterile canals [48] and aid healing [21] in all cases. According to a study [49], it may infect, allow

regrowth of microbes. The studies in this review that used calcium hydroxide medicament as a separate group included [23] which suggested a possible role and [34] that established no relation between the use of calcium hydroxide and postoperative pain and flare ups. Cleaning and shaping procedures also varied among studies using both manual and rotary techniques. Different irrigants such as sterile saline, EDTA, sodium hypochlorite and chlorhexidine were used. Using the correct technique of mechanical preparation may play a more important role as studies suggest no relation between the irrigant used and postoperative pain [50].

The variations mentioned above led to considerable clinical heterogeneity in studies. The meta-analysis was done on cleaned data that included only 14 studies with quantified results. Most of the studies showed very little variation in the outcome, with the forest plot showing few studies that favoured either outcome. The weight distribution was such that no single study was able to influence the overall risk ratio. The overall risk ratio was 0.96, which favoured the single visit treatment, but the confidence interval extended from 0.75 to 1.22. Thus, we cannot favour either modality.

Due to the variation in the assessment of the intensity, the seven studies that evaluated this outcome had to be grouped further into those using the VAS and modified VAS. Those using the standard VAS scale (Figure 3) had one study that favoured multiple visits. Though the weightage of studies favouring single visit treatment was more (nearly 72%) the mean difference for both was minimal compared to the one favouring multivisit treatment leading to a result that favoured neither. In the analysis of studies using the modified VAS scale (Figure 4), a study that had a larger mean difference had minimum weightage leading to an inconclusive result.

There are multiple factors that have been shown to affect postoperative pain which were not considered in our studies. The operator's experience can make a difference in the quality of care provided. A new graduate may find it harder to locate accessory canals compared to a more experienced endodontist. This can affect the outcome of a trial. Law and colleagues [51] reported that the impact of clinical experience on postobturation pain was harder to evaluate. Future studies can minimize this impact by restricting the number of operators and assigning cases to operators with similar experience. The studies also did not distinguish the presence of preoperative pain and previous endodontic experience, which may prime the patient towards perception or lack of pain. Thus, further research needs to take into account these factors to provide robust data for future analysis. Studies also need to pay attention to the technique used, as the evolution of materials and methods in endodontics will improve and can change the factors that influence aspects of treatment such as postoperative endodontic pain and flare up.

5. Conclusions

Taking into account the limitations of this study, the meta-analysis showed that there was no significant difference in the incidence, or the intensity of the pain as measured between single visit RCT and multiple visit RCT. The decision on the number of visits required for the RCT must be determined solely based on the requirement of the individual case. The major limitations of the included studies were the lack of blinding, the assessment of the technique and the evaluation of preoperative conditions. Future studies can consider these factors in randomised controlled trials. Objective parameters including the measurement of biomarkers such as C-reactive protein can be used as an adjunct to predict any potential postendodontic pain and flareup.

Author Contributions: Conceptualization, S.V. and S.P.; methodology, P.C.M.; software, S.B.; validation, S.B.K., H.C. and S.P.; formal analysis, A.A.G.; investigation, A.T.R.; resources, S.V.; data curation, D.M.; writing—original draft preparation, S.V.; writing—review and editing, A.M.; visualization, L.T.; supervision, S.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare that they have no conflict of interest.

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