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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. The use of contemporary endodontic techniques and equipment, such as use of rubber dam, magnifying devices, electronic apex locators, engine-driven rotary nickel titanium files, 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. 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. The treatment techniques used at that
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, 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.

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 Gutmann 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, 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%. The introduction of the rubber dam was a significant advance in dentistry and in endodontic treatment. 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, 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. 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, 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.\textsuperscript{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.\textsuperscript{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 publications 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.\textsuperscript{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.\textsuperscript{25–28} One study reported slightly more postoperative pain with single-visit treatment, but that result was statistically insignificant.\textsuperscript{29} It was described\textsuperscript{25} 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.\textsuperscript{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.\textsuperscript{26,27} In another study, females were shown to have a higher incidence of postoperative pain than did male patients.\textsuperscript{32} Overinstrumentation and overfilling also showed an increase in postoperative pain.\textsuperscript{23} Postoperative pain was also reported with higher incidence in nonvital teeth in one study;\textsuperscript{26} to the contrary, another study did not show any correlation with tooth vitality status.\textsuperscript{27} The incidence of postoperative pain was reported as being higher in retreatment cases with apical periodontitis.\textsuperscript{25,33} Another study reported that a combination of calcium hydroxide and

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**Table 1** Flowchart of the literature search.

| Search criteria (Endodontic treatment OR endodontic therapy OR root canal treatment OR root canal therapy) AND (single-visit OR one-visit OR 1-visit) |
| Database searched: PubMed (1980–2014) |
| Publications identified (n=200) |
| Publications screened (n=200) Title and abstract reviewed |
| Articles excluded (n=161) Literature reviews, case reports, etc. |
| Full-text publications retrieved (n=39) |
| Full-text publications assessed for eligibility (47) |
| Publications included for review (n=47) |
Table 1: Studies on postoperative complications with single-visit endodontic treatment

| Authors         | Method                                      | Main findings                                                                 |
|-----------------|---------------------------------------------|-------------------------------------------------------------------------------|
| Akbar et al16   | 100 molars                                  | There was no significant difference in the flare-up rate between two groups.   |
|                 | Single visit – 50 teeth                     |                                                                               |
|                 | Multiple visits – 50 teeth                  |                                                                               |
| Dorasani et al17| 64 single-root teeth                       | Both single-visit and multiple-visit-treated teeth had similar clinical       |
|                 | Single visit – 34 teeth                     | presentation, with no significant differences.                                 |
|                 | Multiple visits – 30 teeth                  |                                                                               |
| Xavier et al18  | 48 nonvital teeth                           | Both single-visit and multiple-visit endodontic treatment were effective in   |
|                 | Single visit – 24 teeth                     | reducing bacteria and endotoxins. Two visits were more effective than one visit |
|                 | Multiple visits – 24 teeth                  | in reducing endotoxins.                                                      |
|                 | Evaluation period: 2 weeks                  |                                                                               |
| Bhagwat and Mehta70 | 60 patients in single-visit treatments   | Similar incidence of pain in vital and nonvital teeth without apical          |
|                 | Evaluation period: 2 weeks                  | radioluency. Teeth with periapical radioluency exhibited less pain than nonvital |
|                 |                                             | teeth without periapical radioluency.                                        |
| Singh and Garg1 | 200 single-root teeth                       | No significant difference in the incidence and intensity of postobturation    |
|                 | Single visit – 100 teeth                    | pain experienced by the two groups.                                          |
|                 | Multiple visits – 100 teeth                 |                                                                               |
|                 | Evaluation period: 2 days                  |                                                                               |
| Ali et al12     | 1,328 patients in single-visit treatment   | The presence of postoperative pain was 4%.                                   |
|                 | Evaluation period: 2 days                  | The factors that influenced the experience of postoperative pain were:         |
|                 |                                             | old age, female, mandibular teeth, and the presence of preoperative pain.     |
| Prashanth et al13 | 32 cases                                   | No significant difference in terms of success, postoperative pain, or         |
|                 | Single visit – 16 teeth                     | tenderness existed when treated with either single-visit or multiple-visit    |
|                 | Multiple visits – 16 teeth                  | therapy.                                                                      |
|                 | Evaluation period: 6 weeks                  |                                                                               |
| Xiao and Zhang24| 138 teeth                                   | Single-visit endodontic treatment had the same clinical efficacy as two-visit  |
|                 | Single visit – 76 teeth                     | treatment in terms of postoperative pain level and short-term healing.        |
|                 | Multiple visits – 62 teeth                  |                                                                               |
|                 | Evaluation period: 7 days                  |                                                                               |
| Wang et al24    | 89 incisors by two endodontists             | There was no significant difference on the incidence and severity of          |
|                 | Single visit – 43 teeth                     | reported postoperative pain between the two groups.                          |
|                 | Multiple visits – 46 teeth                  |                                                                               |
|                 | Evaluation period: 2 years                  |                                                                               |
| El Mubarak et al22 | 234 teeth                               | Overall incidence of postoperative pain was 9% after 1 day.                   |
|                 | Single visit – 32 teeth                     | No significant difference between the two groups.                             |
|                 | Multiple visits – 202 teeth                 |                                                                               |
|                 | Evaluation period: 1 day                   |                                                                               |
| Kalhoro and Mirza13 | 100 patients for single-visit treatment | No flare-ups in 1 month. It was safe in both vital and nonvital teeth, and   |
|                 | Evaluation period: 1 month                  | even in teeth with periapical pathosis.                                      |
| Ince et al14    | 306 patients by two clinicians              | No significant difference between the two groups.                             |
|                 | Single visit – 153 teeth                    |                                                                               |
|                 | Multiple visits – 153 teeth                 | No significant difference between vital and nonvital teeth.                   |
|                 | Evaluation period: 3 days                  |                                                                               |
| Risso et al25   | 118 molars with necrotic pulp               | The frequencies of postoperative pain were 10.5% and 23% for the single-visit   |
|                 | Single visit – 57 teeth                     | and multiple-visit group, respectively, which were of significant difference. |
|                 | Multiple visits – 61 teeth                  |                                                                               |
|                 | Evaluation period: 10 days                 |                                                                               |
| Lin and Gao27   | 142 teeth                                   | No statistical significance between the two groups regarding pain after 7 days  |
|                 | Single visit – 100 teeth                    | and healing response after 6 months.                                         |
|                 | Multiple visits – 42 teeth                  |                                                                               |
|                 | Evaluation period: 6 months                |                                                                               |
| Ng et al14      | 415 patients                                | 40% reported postoperative pain.                                             |
|                 | Single visit – 91 teeth                     | Prevalence associated with the female sex, molar, size of periapical lesion    |
|                 | Multiple visits – 324 teeth                 | smaller than 3 mm, preexisting pain or swelling and single-visit treatment.  |
|                 | Evaluation period: 2 days                  |                                                                               |
| Oginni and Udoye50 | 243 teeth                           | Flare ups in single-visit group at a rate of 18.3% and in the multiple-visit  |
|                 | Single visit – 107 teeth                    | group at 8.1% P<0.05. Higher incidences for postobturation pain were          |
|                 | Multiple visits – 136 teeth                 | observed for single-visit treatment than for multiple-visit treatment.        |
|                 | Evaluation period: 30 days                  |                                                                               |

(Continued)
Nonsurgical single-visit vs multiple-visit endodontic treatment

Table 1 (Continued)

| Authors                        | Method                                      | Main findings                                                                 |
|--------------------------------|---------------------------------------------|-------------------------------------------------------------------------------|
| Yoldas et al31                 | 218 retreatment cases                       | Multiple-visit root canal treatment was more effective in completely eliminating pain than was single-visit treatment of previously symptomatic teeth. |
| DiRenzo et al32                | 72 molars treated by two operators          | 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 Alnegrish26    | 291 teeth treated by one operator           | Multiple-visit-treated and nonvital teeth had more postoperative pain.        |
|                               | Single visit – 142 teeth                    | Age, sex, pulpal vitality, tooth type, and preexisting pain were not found to be significant factors. |
| DiRenzo et al21                | 72 molars treated by two operators          | 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 Alnegrish26    | 291 teeth treated by one operator           | Multiple-visit-treated and nonvital teeth had more postoperative pain.        |
|                               | Single visit – 142 teeth                    | Age, sex, pulpal vitality, tooth type, and preexisting pain were not found to be significant factors. |
| Fava et al28                   | 90 incisors for single-visit treatment      | Incidence of postoperative pain after 2 days and 7 days was 5% for both groups. |
| Fava et al28                   | Treated by one operator                     | No difference in pain incidence between the two groups.                       |
| Fava et al28                   | 60 upper central incisors                   | No difference in pain incidence between the two groups.                       |
| Trope33                        | 226 teeth for single-visit treatment        | No flare-up in cases without preexisting symptoms.                           |
| Fava et al28                   | Single visit – 30 teeth                     | Higher flare-up rate in retreatment cases with preexisting symptoms.         |
| Fava et al28                   | Single visit – 30 teeth                     | Higher flare-up rate in retreatment cases with preexisting symptoms.         |
| Yesilsoy et al30               | 186 patients                                | No significant differences between the two groups.                            |
| Oliet19                        | 387 teeth treated by one operator           | No significant difference on postoperative pain between the two groups.       |
| Roane et al38                  | 359 patients                                | Multiple-visit treatment had a greater incidence of postoperative pain.       |
| Mulhern et al31                | 60 teeth treated by 2 operators             | No significant difference in the incidence of pain existed between the single- and multiple-visit groups. |
| Rudner20                       | 283 cases                                   | 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...
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*. It was reported that one-visit treatment may be less effective in reducing endotoxins than multiple-visit treatment.

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

| Authors | Method | Main findings |
|---------|--------|---------------|
| Dorasani et al | 64 single root teeth<br>Single visit – 34 teeth<br>Multiple visits – 30 teeth | Both single-visit and multiple-visit-treated teeth healed satisfactorily with no significant differences |
| Paredes-Vieyra and Enriquez | 282 teeth with apical periodontitis<br>Single visit – 146 teeth<br>Multiple visits – 136 teeth | No significant difference in healing results between the two groups |
| Penesis et al | 63 patients<br>Single visit – 33<br>Multiple visits – 30<br>Evaluation period: 2 years | Single-visit treatment can be as successful as multiple-visit treatment |
| Molander et al | 101 teeth<br>Single-visit – 53 teeth<br>Multiple-visit – 48 teeth<br>Evaluation period: 24 months | There was no significant difference in term of healing results between single-visit and multiple-visit treatment |
| Waltimo et al | 50 teeth with apical periodontitis<br>Single visit – 20 teeth<br>Multiple visits – 30 teeth<br>Evaluation period: 52 weeks | No significant differences in periapical healing were observed between the two groups |
| Field et al | Single visit – 223 teeth | The overall success rate was 89.2% |
| Kvist et al | 96 teeth with apical periodontitis<br>Single visit – 48 teeth<br>Multiple visits – 48 teeth | No significant difference between the two groups |
| Peters and Wesselin | 39 patients treated by one operator<br>Single visit – 21 teeth<br>Multiple visits – 18 teeth<br>Evaluation period: 4.5 years | No significant difference in success rate between the two groups |
| Trope et al | 102 teeth with apical periodontitis<br>Single visit – 45 teeth<br>Multiple visits – 57 teeth<br>Evaluation period: 1 year | The two groups had a similar success rate |
| Sjogren et al | Single visit – 55 single-rooted teeth<br>Evaluation period: 5 years | Complete periapical healing for 5 years was 94% |
| Jurcak et al | 102 teeth<br>Single-visit treatment | The overall success rate was 89% |
| Pekruhn et al | 923 teeth done by one operator<br>for single-visit treatment<br>Evaluation period: 1 year | The overall success rate was 95% |
| Southard and Rooney | 19 patients single-visit treatment<br>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.
endodontic 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.\textsuperscript{41–48} A study by Field et al\textsuperscript{49} 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.\textsuperscript{50} The reported success rate for single-visit treatment ranged from 89%\textsuperscript{51} to 95%.\textsuperscript{50} The evaluation period for the studies ranged from a minimum of 1 year\textsuperscript{52} up to 5 years.\textsuperscript{55}

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\textsuperscript{®} 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.

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

| Authors | RR | 95% CI | % weight |
|---------|----|--------|----------|
| Alkar et al\textsuperscript{66} | 1.250 | 0.356–4.385 | 1.44 |
| Xavier et al\textsuperscript{60} | 1.182 | 0.669–2.089 | 4.64 |
| Prashanth et al\textsuperscript{71} | 2.000 | 0.425–9.418 | 0.99 |
| Xiao and Zhang\textsuperscript{24} | 1.335 | 0.885–2.013 | 6.41 |
| Wang et al\textsuperscript{24} | 1.012 | 0.827–1.238 | 9.33 |
| El Mubarak et al\textsuperscript{22} | 0.823 | 0.262–2.584 | 1.69 |
| Ince et al\textsuperscript{66} | 1.009 | 0.871–1.171 | 10.01 |
| Risso et al\textsuperscript{15} | 0.459 | 0.189–1.112 | 2.55 |
| Lin and Gao\textsuperscript{77} | 1.050 | 0.772–1.427 | 7.84 |
| Ng et al\textsuperscript{14} | 1.670 | 1.328–2.100 | 8.96 |
| Oginni and Udoye\textsuperscript{10} | 2.415 | 1.172–4.974 | 3.43 |
| Yoldas et al\textsuperscript{81} | 1.453 | 1.004–2.103 | 6.95 |
| Albashaireh and Alnegrish\textsuperscript{24} | 0.731 | 0.521–1.025 | 7.39 |
| Imura and Zuolo\textsuperscript{27} | 0.170 | 0.049–0.595 | 1.45 |
| Fava\textsuperscript{68} | 2.000 | 0.191–20.898 | 0.46 |
| Fava\textsuperscript{67} | 3.000 | 0.127–70.829 | 0.26 |
| Yesilsoy et al\textsuperscript{80} | 0.672 | 0.291–1.549 | 2.79 |
| Oliet\textsuperscript{19} | 1.631 | 0.766–3.473 | 3.22 |
| Roane et al\textsuperscript{88} | 0.487 | 0.325–0.730 | 6.49 |
| Muñoz et al\textsuperscript{89} | 0.667 | 0.319–1.394 | 3.34 |
| Rudner and Oliet\textsuperscript{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 method\textsuperscript{66} for meta-analysis.

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

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.
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. 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. 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.

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 al suggested 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 (e.g., 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

| Authors                     | RR    | 95% CI       | % weight |
|-----------------------------|-------|--------------|----------|
| Dorasani et al37            | 1.643 | 0.655–4.121  | 15.16    |
| Paredes-Vieyra and Enriquez42| 0.233 | 0.026–2.058  | 3.08     |
| Penesis et al43             | 1.111 | 0.536–2.304  | 22.14    |
| Molander et al44            | 1.388 | 0.717–2.685  | 25.78    |
| Peters and Wesselink47      | 0.686 | 0.216–2.175  | 10.17    |
| Trope et al48               | 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 method for meta-analysis.

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

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 al suggested 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 (e.g., 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.

![Forest plot](image-url)
Factors to consider in performing single-visit endodontic treatment

Ashkenaz\textsuperscript{15} 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. Carrotte\textsuperscript{69} 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.\textsuperscript{68} Sjogren et al\textsuperscript{43} 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.\textsuperscript{61-63} For example, Peters et al\textsuperscript{61} 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 al\textsuperscript{43} 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.\textsuperscript{20,65}

There are currently two measures to reduce bacterial persistence and reinfestation 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.\textsuperscript{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.\textsuperscript{48,67} However, other studies have suggested that the additional disinfecting effect of intracanal calcium hydroxide used in multi-visit treatment cannot be overstressed.\textsuperscript{45,68} Despite the high alkaline antibacterial properties of calcium hydroxide, some bacteria species, such as \textit{E. faecalis} and \textit{Candida albicans}, have been found to be resistant to it.\textsuperscript{45} Chong and Pitt Ford\textsuperscript{69} 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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