SYSTEMATIC REVIEW

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Assessment of apical patency maintenance and its influence on post-endodontic pain of root canal treated teeth: A systematic review and meta-analysis

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Purpose: The purpose of this study was to determine the effect of apical patency versus non-apical patency filing on post-endodontic pain in root canal treated teeth in permanent dentition.

Methods: A search was conducted in Medline, Google Scholar, Scopus, Web of science, and Cochrane databases for randomized controlled trials and clinical trials comparing post-endodontic pain with apical patency and without apical patency maintenance with a follow-up period of 12 h, 24 h, 2 days, and 7 days. Certainty of evidence was determined using the grading of recommendations, assessment, development, and evaluations assessment tool. A random-effect model was used to assess the mean differences between the two used techniques.

Results: Five studies met the inclusion criteria. A total of 372 patients with apical filling versus 372 with no apical filling were available for analysis at end of 24 and 48 h. Apical patency maintenance was associated with lesser post-endodontic pain with a statistically significant difference at 12 h (MD = –1.49; p = 0.003) and 2 days (MD = –0.85; p = 0.04). Certainty of evidence for this association was moderate.

Conclusion: This meta-analysis presents evidence for reduced post-endodontic pain in permanent dentition when the apical patency technique is used for recapitulation. Clinical trials are further recommended so that research evidence may again be substantiated in the future.

Keywords: Apical patency; post-endodontic pain; root canal treatment.

Introduction

The American association of endodontists, in 2012, defines apical patency as a technique where the apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen (1). Accumulation of dentinal debris and soft tissues in the apical third of the root canals can cause procedural errors such as blockage, transportation, ledges, and perforations (2). In this technique, the patency file is set at a length 1 mm longer than the working length with the file passively moving through the apical constriction and a width of 0.5–1 mm, without further widening it (3-4).

Schilder presented the concept of apical patency in 1967, and later, Buchnan popularized the concept that if patency file is used during instrumentation, the blockage of the apical portion can be avoided (4-6). In vital teeth, an apical plug is formed at the root apex during mechanical

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preparation which can interfere in working length determination. Apical patency prevents clogging of debris and facilitates thorough cleaning and shaping (7). In teeth with necrotic pulp and apical periodontitis, maintenance of apical patency may help to remove bacterial biofilms from the apical region as well as from around the apical foramen (8). In addition, maintenance of apical patency aids in improving tactile sensation, facilitation of irrigation in the apical third of the root canal, and preservation of working length (9-10).

Despite the early introduction, this technique has been controversial. It is taught in only 50% of the dental schools in the United States. The other 50% claims that apical patency can irritate the periodontal ligament by displacement of debris (2). Irritants such as dentinal debris, microbes, necrotic tissue, and irrigant solutions from the root canal may gain access to periapical tissues causing inflammation and post-operative pain (11).

Post-operative pain is a complication in root canal treated teeth in approximately as high as 60% of patients (12). Apical patency filing is regarded as responsible for the post-endodontic pains by a few authors while others believe against it. However, evidence from the studies is inconsistent (13-14). Yaylali et al. (14), in 2018, conducted a systematic review and concluded that maintaining apical patency does not increase post-operative pain . Abdulrab et al. (15), in 2018, conducted a meta-analysis evaluating the effect of apical patency on post-operative pain and noted no significant difference between the two techniques . However, the evidence was not conclusive as only four studies were included and an assessment of the certainty of the evidence was not made.

The risk and fear of post-endodontic pain have always been a concern among treating dentists and patients. This meta-analysis aims to evaluate the effect of apical patency versus non-apical patency on post-endodontic pain in root canal treated permanent teeth. The review includes updated search criteria, quality assessment of the included studies, and an assessment for the certainty of evidence. The population intervention comparison outcome question was population: Patients undergoing root canal treatment; intervention: maintenance of apical patency; comparison: Patients undergoing root canal treatment without apical patency maintenance; and outcome: Post-endodontic pain in root canal treated teeth (Table 1).

Materials and Methods

Search Strategy

The search for articles published up to October 2022 was conducted in Medline, Google Scholar, Scopus, Web of Science, and Cochrane databases. The Boolean operator was used with the keywords apical patency and post-endodontic pain. The Cochrane databases of systemic reviews were searched for pertinent publications. References in the papers selected were manually reviewed and retrieved if relevant. The articles were searched using English keywords. An attempt was made to retrieve data from the grey literature and unpublished data. Preferred reporting items for systematic reviews and meta-analyses guidelines were followed for the meta-analysis.

Study Selection Criteria

Randomized control trials and clinical studies evaluating the effect of maintenance of apical patency on post-endodontic pain of the root canal treated tooth were included with a minimum follow-up of 12 h up to 7 days. Patients requiring root canal treatments irrespective of age, gender, and type of teeth were included in the study irrespective of pre-operative pain and status of the tooth. The comparison group was the measure of post-endodontic pain among participants with no apical filling at the same time intervals. Observational, case–control studies, case series, in vitro studies, and experiments done on laboratory animals were excluded from the study.

Data extraction and quality assessment

Studies were processed for data extraction only after fulfilling the inclusion criteria. Two authors separately extracted the required information and outcome data using guidelines published by Cochrane collaboration (16). The title and abstracts were screened to determine if studies should be retrieved in full. Retrieved articles were read before inclusion. Differences between the authors extracting data were resolved by discussion. A third person with subject expertise as-sisted in cases of lack of consensus. Data extracted from the studies included author, publication year, country of origin, inclusion criteria, pre-operative pain and symptoms, irrigation protocol, number of visits, and final outcome. The characteristics of the studies included (12,13,17-19) and excluded (20,21) from the meta-analysis are presented in Tables 2 and 3, respectively.

Quality was assessed according to Cochrane collaboration

Table 1. Population, intervention, comparison, and outcome (population intervention comparison outcome Format)

Aspect	Information
Population	Patients undergoing root canal treatment
Intervention	Maintenance of apical patency
Comparison	No maintenance of apical patency
Outcome	Post-endodontic pain in root canal treated teeth

Table 2. Characteristics of studies included in the meta-analysis

Author; Year	Study location	Study design	Number of participants (n)	Inclusion criteria	Preoperative status	Irrigation protocol	Visits	Outcome-post-endodontic pain
Arora et al.; 2016 (12)	India	RCT	68 I-32 C-33	18+years Permanent dentition (Mandibular teeth)	Pulpal necrosis and apical pain periodontitis with or without preoperative	NaOCl and EDTA	Multi visit	24 h, 2 d, 3 d, 4 d, 5 d, 7 d
Sharaan et al.; 2012 (13)	Egypt	RCT	80 I-40 C-40	14–60 years Permanent dentition	Pulpal necrosis and apical periodontitis with or without preoperative pain	NaOCl	Multi visit	6 h, 12 h, 24 h, 48 h
Yaylali et al.; 2018 (17)	Türkiye	RCT	320 I-160 C-159	21–45 years Permanent	Pulp necrosis and apical dentition periodontitis with no pre-operative pain	NaOCl and EDTA	Single visit	12 h, 24 h, 48 h, 3 d, 4 d, 5 d, 6 d, and 7 d
Ahmed et al.; 2018 (18)	Pakistan	RCT	200 I-100 C-100	Permanent dentition (Only Molars)	Pulpal necrosis and apical periodontitis with no preoperative pain	Saline wash	Multi visit	12 h, 24 h, 2 d, a nd 7 d
Garg et al.; 2018 (19)	India	Clinical study	80 I-40 C-40	Permanent dentition (Only Molars)	Vital and Non vital with or without preoperative pain	NaOCl and Saline	Single visit	1 h, 2 h, and 7 d

h: Hours; d: Days; NaOCl: Sod. Hypochlorite; EDTA: Chelating agent.

Table 3. Characteristics of studies excluded from the meta-analysis

Author; Year	Study location	Study design	Number of participants (n)	Inclusion criteria	Preoperative status	Irrigation protocol	Visits	Outcome-post-endodontic pain	Reason for exclusion
Arias et al.; 2009 (20)	Spain	Clinical study	300 I-115 C-121	Permanent teeth	Vital and non-vital teeth with or w/o operative pain	NaOCl	Single visit	Incidence, degree, and length of post-operative pain compared based on pre-operative pain, vitality status, and position of tooth.	Primary outcome measures dissimilar
Shubham et al.; 2021 (21)	Nepal	Clinical study	160 I-80 C-80	Permanent teeth	Vital and Non vital teeth with or w/o preoperative pain	NaOCl	Single or Multiple	Post-operative pain scores between patency and non-patency groups.	Primary outcome measures dissimilar

NaOCl: Sod. Hypochlorite.

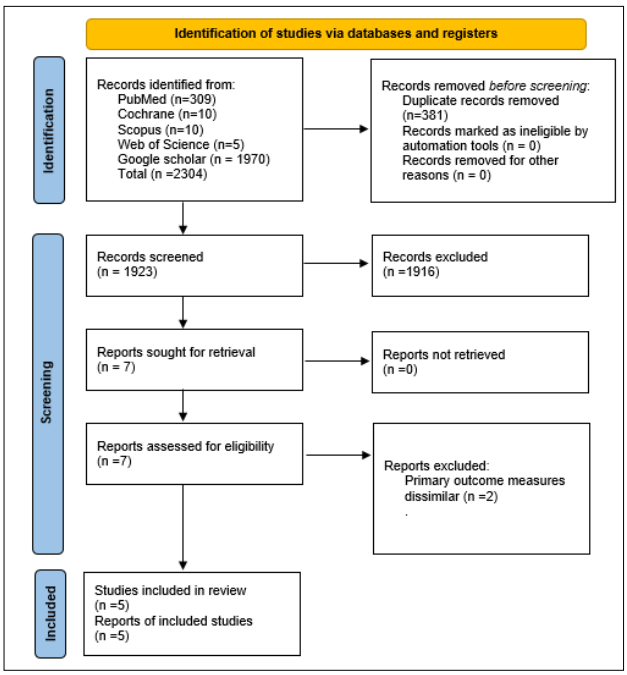


Fig. 1. Flow diagram of study selection process.

tools (22). Risk of bias was evaluated based on the following parameters: Randomization (sequence generation and allocation concealment), blinding, attrition, and other associated biases. The certainty of the evidence was determined using the grading of recommendations, assessment, development, and evaluations assessment (23). Grade assesses the quality of evidence taking into consideration the included studies, bias risk, consistency between studies, directness of the evidence, result precision, publication bias, magnitude of effect, and influence of plausible confounding factors.

Statistical Analysis

The meta-analysis was conducted using the Cochrane program review manager, Version 5. A random-effects model was used to assess the mean differences in post-endodontic pain for the two used techniques. Mean difference with 95% confidence interval was calculated to assess the difference in pain scale between participants where apical patency technique was performed versus the non-apical patency technique. Publication bias was not assessed as <10 studies were included in the analysis.

Results

Study Selection

The literature search yielded 2304 potentially relevant publications of which five were included in the review as presented in Fig. 1. Characteristics of the included and excluded studies are presented in Tables 2 and 3, respectively. A total of 372 patients with apical filling versus 372 with no apical filling were available for analysis at end of 24 and 48 h and 332 and 333 participants with and without apical patency maintenance were available for analysis at end of 7 days.

Quality Assessment

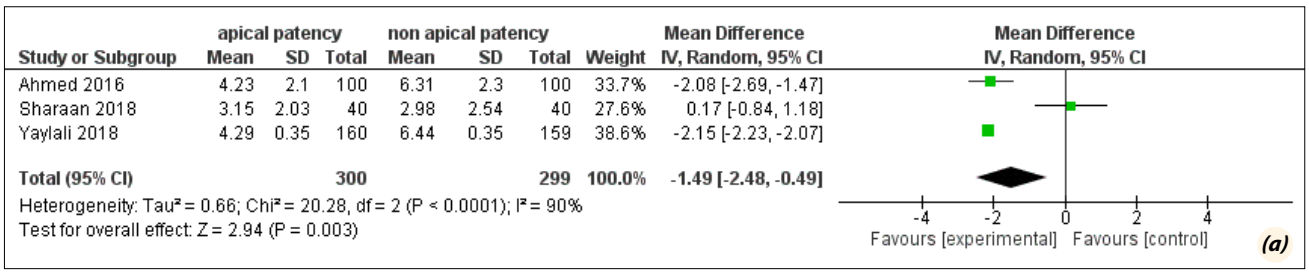
The quality of trials included in the study is presented in Table 4. All included studies were randomized with a low risk of bias. Attrition of few participants was reported by Arora et al., in 2016 and Yaylali et al., in 2018 (12,17). Other sources of bias included patients with pre-operative pain not included in studies by Arora et al., in 2016; Yaylali et al., in 2018; and Ahmed et al., in 2018 (12,17,18). Furthermore, most studies included only non-vital teeth, except Garg et al. (19) where both vital and non-vital teeth were chosen. The meta-analysis of randomized controlled trials evaluating the effect of apical patency on post-endodontic pain at 12 h (1/2 day), 24 h (1 day), 48 h (2 days), and 168 h (7 days) is presented in Fig. 2a-d.

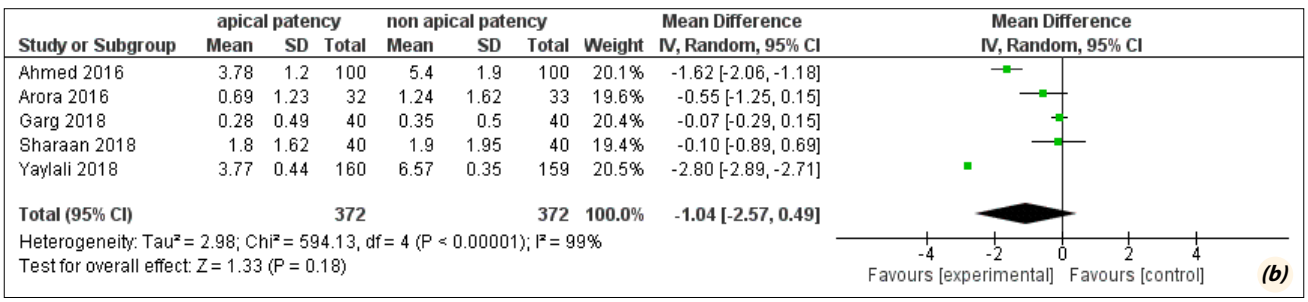
Data Synthesis

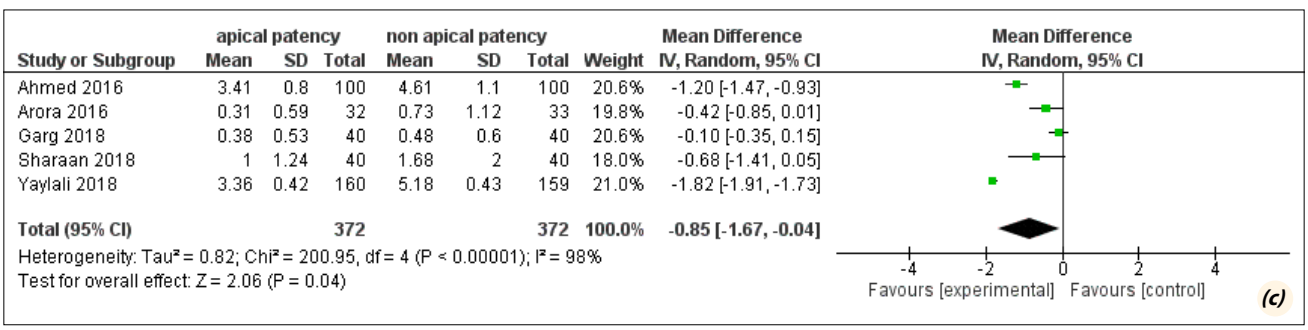
The technique of maintaining apical patency as per pooled data analysis was associated with lesser post-endodontic pain at all the time intervals with a statistically significant difference at 12 h and 2 days. At 12 h, the recorded studies reflected a statistically significant difference between the two interventions (MD = −1.49; 95% CI, −2.48–−0.49; p = 0.003). All the trials concluded that post-endodontic pain at 12 h was significantly lesser with the apical patency technique. At 24 h, the study outputs determined statistically non-significant results (MD = −1.04; 95% CI, −2.57–−0.49; p = 0.18). The forest plot illustrates that post-endodontic pain was lesser at 24 h with the apical patency technique as compared to the non-apical patency technique. However, the differences were non-significant. After 2 days, the overall pain had reduced in both the groups as compared to the first 12 h. However, there was a statistically significant difference between the post-endodontic pain felt by patients in the apical patency technique versus the non-apical patency technique after 2 days (MD = −0.85; 95% CI, −1.67–−0.04; p = 0.04). Outputs of four studies were plotted at 7 days (MD = −0.02; 95% CI, −0.07–0.04; p = 0.48). All studies favored the apical patency technique; however, the differences were non-significant. A high to moderate level of heterogeneity was noted.

Study Outcome

Apical patency maintenance was associated with lower post-endodontic pain at all the studied time intervals. The







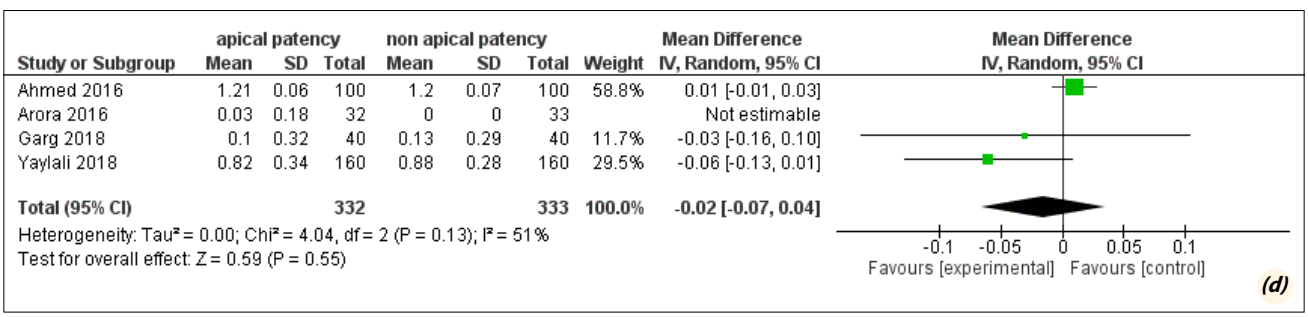


Fig. 2. **(a)** Forest plot of post-endodontic pain between apical patency (experimental) and non-apical-patency group (control) at 12 h/½day. **(b)** Forest plot of post-endodontic pain between apical patency (experimental) and non-apical-patency group (control) at 24 h/1 day. **(c)** Forest plot of post-endodontic pain between apical patency (experimental) and non-apical-patency group (control) at 48 h/2 days. **(d)** Forest plot of post-endodontic pain between apical patency (experimental) and non-apical-patency group (control) at 168 h/7 days.

level of evidence for this association was moderate to low. The level of evidence obtained for the significant association between maintenance of apical patency and lower post-endodontic pain at 12 h and 2 days was moderate. The certainty of the evidence of no association between apical patency maintenance and post-endodontic pain was low (Table 5).

Discussion

This meta-analysis presents evidence for a reduced post-endodontic pain when the technique of apical patency is used for performing a root canal treatment either with single or multi-visit endodontics. All the trials favored the apical patency technique, even though the difference was non-significant at 24 h. Post-operative pain, within 12 h and after a span of 2 days, using the apical patency technique was significantly lower. After 7 days, pain values had reduced in both the techniques considerably compared to the values at 12 h.

Few researchers believe that maintenance of apical patency causes displacement of debris and irritate the periodontal ligament (12). Siqueira (7), in 2003, concluded that

Table 4. Quality assessment of trials included in the meta-analysis

Author; Year	Sequence generation	Allocation concealment	Blinding	Attrition (outcome data)	Other sources of bias
Yaylali et al.; 2018 (17)	Low	Low	Low	Low (loss of one sample in control group)	High (Patients with pre-operative pain not included)
Garg et al.; 2018 (19)	Low	Low	Unclear	Low	Low
Sharaan et al.; 2012 (13)	Low	Low	Unclear	Low	Low
Ahmed et al.; 2018 (18)	Low	Low	Low	Low	High (Patients with pre-operative pain not included)
Arora et al.; 2016 (12)	Low	Low	Low	Low (loss of 2 samples in experimental and 1 in control group)	High (Patients with pre-operative pain not included)

repeated passing of small patency files through the apex can cause an acute apical inflammatory response . The mechanical instrumentation causes extrusion of infected debris causing post-operative pain. Holland et al. (24), in 2005, assessed periapical healing after maintaining apical patency during instrumentation. It was seen that non-maintenance of apical patency showed better healing (25). If large instruments are used to maintain apical patency, they can hamper the outcome of endodontic therapy by causing post-operative pain and discomfort (26-27). Other researchers are of the opinion that the apical patency technique improves the delivery of irrigants to the apical third. In the case of necrotic pulp, apical patency may help remove bacteria present around the apical foramen. According to Buchnan, in 1989, the risk of loss of working length is minimized with the apical patency technique. Theoretically, the risk of procedural accidents also reduces due to a reduction in debris accumulation in the apical area consequently, reducing post-operative pain. This technique eliminates microorganisms that could jeopardize the treatment outcome. In case of incomplete elimination in the apical part of the canal, apical patency can disturb the environment and promote an imbalance that may be favorable for host defense mechanisms (27). Considering the rich collateral circulation and healing capability of attachment apparatus, establishing and maintaining apical patency are non-harmful biological events (13). The present meta-analysis provides evidence for the association of apical patency technique with reduced post-endodontic pain, with a moderate certainty of evidence.

A visual analog scale model was used to assess pain in all the included studies. It is one of the most commonly used models in measuring pain severity (28). Despite the scale used, differences in variability of pain threshold among individuals may affect the response. Providing painless endodontic treatment remains one of the prime concerns of endodontists globally. Various precautions are taken at every stage during and postendodontically to minimize the amount of pain experienced by the patient. The intensity of pain may be influenced by various factors such as periapical radiolucency, specific bacterial species in the root canal, tooth type, pre-operative pain, and pulp status.

Variations in the reported incidence of pain in the studies analyzed may also be due to differences in selection criteria of the tooth, patients, and experience or qualification of the dentist (13). None of the studies included in the meta-analysis mentioned or calibrated/standardized the clinicians/operators to the actual patency procedure. This could be a major flaw and could impact variability and bias. Maxillary and mandibular teeth were selected by Yaylali et al. (17), in 2018, as molar teeth have a higher tendency for post-operative pain . Arora et al., 2016 and Ahmed et al., in 2018, selected only mandibular molars (12,18). The complex structure of molar teeth and the difficulty of root canal treatment in the posterior region might contribute to higher post-operative pain (29). The other authors chose all anterior and posterior teeth with pulpal and periapical pathosis. However, none of the studies considered the complexity of the root apex regardless of the tooth type and presence of apical deltas, lateral canals, and multiple foramina. Despite all the technological advances, sometimes, it is clinically impossible to reach the apical foramen. Even in cases where apical patency is obtained, other anatomical variations can harbor bacteria with a potential to induce or maintain a periradicular disease and cause post-endodontic pain following root canal procedure (30, 31).

Patients with pre-operative pain were excluded as pre-operative pain is an important factor that affects the severity of post-operative pain and created a bias in study outcomes. However, Sharaan and Aboul-Enein. (13), in 2012, and Garg et al. (19), in 2017, also recorded teeth

with pre-operative pain. Two studies performed single visit endodontics whereas three other studies performed multi-visit or two visit endodontic treatments. Single-visit with reciproc single file was performed in a study by Yaylali et al., in 2018 (17). Garg et al. (19), in 2017, performed a single-visit with hero shapers . Meta-analysis performed by Schwendicke and Göstemeyer. (30), in 2016, concluded that there is a possible risk of flare-ups after single-visit treatment but no possible risk of pain between single or multi-visit treatment . A study was done by Albashaireh and Alnegrish, in 1998, reported contradictory results showing higher post-operative pain with single-visit treatment (32).

A small number of studies does not give us precise results and invariably account for high heterogeneity. This along with study protocol not being registered is few of the limitations of the study. The included trials contain variable factors which might account for high heterogeneity between studies. Choosing similar teeth and standardizing the number of visits can reduce the heterogeneity. However, this review yet confirms a reduced post-endodontic pain associated with apical patency technique with a moderate certainty of evidence. We would recommend conducting further clinical trials so that research evidence can be substantiated further.

Conclusion

Apical patency maintenance was significantly associated with lower post-endodontic pain at 12 and 24 h intervals in root canal treated teeth in permanent dentition. This meta-analysis presents evidence for reduced post-endodontic pain when the technique of apical patency is used.

Authorship Contributions: Concept: N.S; A.S; Supervision: A.S.; Literature Search: N.S; A.S; A.P.; Writing: N.S; A.S; A.P; P.S.; Critical Revision: N.S; A.S; A.P; P.S.

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