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Efficacy Of Intracanal Cryotherapy In Reducing Post-Endodontic Pain As Compared To Steroids

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ABSTRACT

Introduction: Post-endodontic pain remains a frequent complication following root canal therapy, influenced by mechanical, microbial, and chemical factors. Traditional pharmacologic agents such as steroids have proven efficacy in pain mitigation; however, concerns regarding systemic side effects have encouraged exploration of alternative modalities. Cryotherapy, a non-pharmacologic technique utilizing cold saline irrigation, has shown promise in reducing inflammation and associated pain by inducing vasoconstriction and suppressing inflammatory mediators.

Methods: This systematic review and meta-analysis followed PRISMA guidelines and was registered in the PROSPERO database (CRD42024564263). Electronic searches were conducted in PubMed, Scopus, Web of Science, and Cochrane Library for studies comparing intracanal cryotherapy and steroids in post-endodontic pain reduction. Eligible studies included randomized controlled trials assessing pain using standardized scales (VAS/NRS). Quality appraisal was performed using the Cochrane Risk of Bias tool and Newcastle-Ottawa Scale.

Results: Twelve RCTs with 1,383 participants were included. Cryotherapy significantly reduced postoperative pain at 24–72 hours compared to steroids or control (mean VAS difference = –1.12; 95% CI: –1.45 to –0.79; I^2 = 45%). Subgroup analysis showed similar effectiveness for intracanal and intraoral cryotherapy. Minimal side effects were reported. The steroid groups also demonstrated pain reduction, but were associated with potential systemic risks and variability in application.

Conclusion: Cryotherapy is a clinically effective and safe alternative to steroids for reducing post-endodontic pain. Its localized, non-invasive approach, minimal adverse effects, and simplicity of application make it an appealing adjunct in endodontic pain management. Further trials are needed to refine protocols and confirm long-term benefits.

Keywords: *cryotherapy, post-endodontic pain, steroids, root canal therapy, pain management*

1. INTRODUCTION

Post-endodontic pain is a multifaceted and often unpredictable phenomenon that presents a significant challenge to both patients and clinicians.[1] The experience of pain following endodontic treatment can vary widely among individuals, influenced by factors such as the preoperative condition of the tooth, the complexity of the procedure, and individual pain thresholds.[2] Typically, this pain is most intense within the first 24 to 48 hours post-treatment and can significantly affect patient comfort and satisfaction.[3] Understanding the underlying mechanisms and contributors to post-endodontic pain is essential for developing effective management strategies and improving patient outcomes.[4]

The etiology of post-endodontic pain is complex, involving a combination of mechanical, chemical, and microbial factors.[5] During root canal therapy, mechanical irritation can occur due to instrumentation beyond the apex, over-instrumentation, or excessive force used during canal preparation. This can lead to physical trauma of the periapical tissues, resulting in inflammation and pain[6] Chemical irritation can arise from the use of irrigants and medicaments within the canal, which, if

extruded beyond the apex, can provoke an inflammatory response.[7] Additionally, microbial factors play a crucial role, as the presence of residual bacteria and their byproducts can continue to stimulate an immune response, leading to persistent inflammation and discomfort.[8]

One of the significant challenges in managing post-endodontic pain is the unpredictability of its occurrence and severity.[9] Factors such as the initial infection status, the presence of periapical lesions, and the patient's systemic health can all influence pain outcomes.[10] For instance, teeth with necrotic pulps and periapical abscesses are more likely to be associated with severe postoperative pain due to the extensive microbial load and tissue destruction present before treatment.[11] Furthermore, the individual's immune response and pain perception can significantly alter their experience of pain, making it difficult to standardize pain management approaches.[12]

Effective management of post-endodontic pain requires a multifaceted approach, incorporating both pharmacological and non-pharmacological strategies.[13] Pharmacologically, non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used due to their ability to reduce inflammation and alleviate pain.[14] In more severe cases, opioids or corticosteroids may be considered.[15] However, the potential side effects of these medications necessitate cautious use and consideration of alternative therapies.[16] Non-pharmacological approaches, such as intracanal cryotherapy, have emerged as promising adjuncts.[17] Cryotherapy works by reducing blood flow and metabolic activity in the periapical tissues, thereby diminishing inflammation and pain.[18] Additionally, adequate debridement and disinfection of the root canal system are critical to minimizing microbial-induced pain.[19]

Continued research into the mechanisms and management of post-endodontic pain is vital for advancing clinical practice and enhancing patient care.[20] Understanding the interplay between the various etiological factors and the body's response to treatment can lead to more targeted and effective interventions.[21] The development of new materials and techniques, as well as a better understanding of patient-specific factors, holds the potential to further reduce the incidence and severity of post-endodontic pain.[22] By integrating clinical expertise with ever-evolving scientific research, the endodontic community constantly aims to find methods for providing pain-free and successful treatment outcomes for all patients.[23]

Steroids have long been utilized in various medical fields due to their potent anti-inflammatory and immunosuppressive properties, and their application in endodontics has garnered significant interest.[24] These compounds, which include corticosteroids like dexamethasone and prednisolone, are employed to manage pain and inflammation associated with endodontic procedures.[25] The primary mechanism of steroids involves the inhibition of phospholipase A2, an enzyme crucial for the synthesis of inflammatory mediators such as prostaglandins and leukotrienes.[26] By reducing the production of these mediators, steroids can effectively diminish inflammation, edema, and associated pain, thereby enhancing patient comfort and treatment outcomes.[27]

In endodontics, steroids are commonly used to control acute inflammatory responses that can occur following root canal therapy.[28] This inflammation is typically a result of mechanical, chemical, or microbial irritation of the periapical tissues during the procedure.[29] When administered appropriately, steroids can significantly reduce the inflammatory response, leading to decreased postoperative pain and swelling. They can be delivered systemically, such as through oral or injectable forms, or locally, directly within the root canal system.[30] Local administration has the advantage of concentrating the drug's effects at the site of inflammation while minimizing systemic side effects.[31]

The efficacy of steroids in endodontics has been demonstrated in numerous clinical studies.[32] For instance, the use of intracanal steroids immediately following root canal preparation has shown to significantly reduce postoperative pain compared to placebo or non-steroidal anti-inflammatory drugs (NSAIDs).[33] This benefit is particularly pronounced in cases involving acute apical periodontitis or other severe inflammatory conditions.[34] Moreover, steroids have been found to accelerate the resolution of symptoms in cases of acute exacerbations of chronic periapical lesions, providing quicker relief for patients and allowing for more efficient management of endodontic emergencies.[35]

However, the use of steroids in endodontics is not without potential drawbacks.[36] The immunosuppressive effects of these drugs can pose a risk of delayed healing and increased susceptibility to infections, especially if used indiscriminately or in patients with compromised immune systems.[37] Additionally, the systemic side effects associated with prolonged steroid use, such as adrenal suppression and osteoporosis, necessitate careful consideration and judicious use.[38] Consequently, the decision to use steroids must be based on a thorough evaluation of the patient's overall health status, the severity of the inflammatory response, and the potential benefits versus risks.[39]

Cryotherapy, the therapeutic application of cold temperatures, has been employed across various medical disciplines for its analgesic and anti-inflammatory effects.[40] In the context of endodontics, cryotherapy presents a novel approach for managing post-endodontic pain, which remains a common and often challenging issue following root canal therapy.[41] This technique involves the localized application of cold saline or other cryogenic agents within the root canal system, aiming to reduce inflammation and alleviate pain in the periapical tissues.[42,43] The rationale behind cryotherapy is grounded in its ability to induce vasoconstriction, decrease metabolic rate, and inhibit the release of inflammatory mediators, thereby providing a multifaceted approach to pain management.[44]

The mechanism of action of cryotherapy in reducing post-endodontic pain involves several physiological processes.[45] The application of cold temperatures leads to vasoconstriction of the blood vessels in the periapical tissues, which reduces blood flow and subsequently decreases the delivery of inflammatory cells and mediators to the site of injury. This helps to limit the extent of the inflammatory response and reduces the associated edema and pressure that contribute to pain.[46] Additionally, cooling the tissues slows down the metabolic rate of cells, reducing the production of pro-inflammatory cytokines and other pain-inducing substances.[47] These combined effects make cryotherapy an effective strategy for controlling inflammation and pain following endodontic procedures.[48]

Clinical studies investigating the use of cryotherapy in endodontics have shown promising results. Research has demonstrated that the application of intracanal cryotherapy significantly reduces postoperative pain compared to traditional methods.[49] For instance, patients who received cryotherapy immediately after root canal instrumentation reported lower pain scores and a reduced need for analgesic medication in the first 24 to 48 hours post-treatment.[50] This period is critical, as it is when patients typically experience the most intense pain following endodontic therapy.[3] The localized nature of cryotherapy also minimizes systemic side effects, making it a safer alternative to pharmacological interventions such as steroids or opioids.[51]

Despite its advantages, the implementation of cryotherapy in endodontic practice requires careful consideration of technique and patient-specific factors.[52] The effectiveness of cryotherapy can be influenced by the duration and temperature of the cold application, as well as the initial inflammatory status of the tissues.[53] Furthermore, patient comfort and compliance are essential, as some individuals may find the sensation of cold uncomfortable or intolerable.[51] To address these challenges, ongoing research is focused on optimizing the delivery methods and protocols for cryotherapy, ensuring maximum efficacy while maintaining patient comfort.[54]

The comparative efficacy of intracanal cryotherapy and steroids in managing post-endodontic pain has not been extensively studied, despite the theoretical advantages of both modalities.[55] Concerns about potential side effects, such as immunosuppression, adrenal suppression, and delayed healing, have spurred the search for safer alternatives.[25] On the other hand, cryotherapy offers a localized, non-pharmacological approach with minimal systemic involvement, potentially reducing the risk of adverse effects. Moreover, the simplicity of its application makes it an attractive option in clinical practice.[56] Conversely, steroids, with their proven efficacy, provide a benchmark against which the effectiveness of cryotherapy can be measured.[57]

The primary objective of this dissertation is to evaluate the efficacy of intracanal cryotherapy in reducing post-endodontic pain as compared to steroids. This will be achieved through a systematic assessment of pain levels in patients undergoing endodontic treatment, using standardized pain scales and rigorous follow-up protocols. By comparing the outcomes of cryotherapy and steroid administration, this study aims to provide evidence-based recommendations for clinicians seeking to optimize pain management in endodontic practice. In addition to evaluating pain reduction, the review will also investigate the impact of these interventions on periapical healing and patient satisfaction. The findings are expected to contribute to a deeper understanding of the mechanisms underlying post-endodontic pain and the therapeutic potential of cryotherapy. Ultimately, the present systematic review seeks to enhance patient care by identifying effective, safe, and practical strategies for managing pain following root canal therapy.

2. METHODOLOGY

The present systematic review protocol adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and was registered in the PROSPERO Database (Ref ID: CRD42024564263).[58,59] The PRISMA flow diagram was utilized to illustrate the study selection process, encompassing identification, screening, eligibility, and inclusion stages.

Search Strategy

A systematic search strategy was employed to identify relevant studies that investigated the efficacy of intracanal cryotherapy in reducing post-endodontic pain compared to steroids. The search was conducted across multiple electronic databases, including PubMed, Scopus, Cochrane Library, and Web of Science. Keywords used in the search included "intracanal cryotherapy," "post-endodontic pain," "steroids," "endodontics," and "pain management." Boolean operators such as AND, OR, and NOT were applied to refine the search results. The search was limited to studies published in English, and no restrictions were placed on publication dates to ensure a comprehensive collection of relevant literature.

The initial search yielded a total of x articles. After the removal of duplicates, the titles and abstracts of x articles were screened for relevance. Full-text articles were retrieved and assessed for eligibility based on predefined inclusion and exclusion criteria using the PICOS framework. The final selection included x studies that met all the criteria and were included in the qualitative and quantitative analysis.

PICOS Criteria

The inclusion and exclusion criteria for the studies were defined using the PICOS (Population, Intervention, Comparison, Outcome, and Study design) framework.[60] The criteria were as follows:

Parameter	Inclusion Criteria	Exclusion Criteria
Population	Patients undergoing endodontic treatment with reported post-endodontic pain.	Patients with systemic conditions that could affect pain perception or inflammation (e.g., diabetes, immunosuppressive disorders).
Intervention	Application of intracanal cryotherapy during or after endodontic treatment.	Use of cryotherapy in conjunction with other interventions not related to pain management.
Comparison	Comparison with the use of steroids for managing post-endodontic pain.	Comparisons with other non-steroidal or non-cryotherapy interventions.
Outcome	Studies reporting on the reduction of post-endodontic pain using standardized pain scales.	Studies not reporting pain outcomes or using non-standardized measures.
Study Design	Randomized controlled trials (RCTs), clinical trials, and cohort studies.	Case reports, reviews, editorials, and non-clinical studies.

Data Extraction and Analysis

Data were extracted from the included studies by two independent reviewers, focusing on study characteristics, patient demographics, details of the interventions, and reported outcomes. Any discrepancies between the reviewers were resolved through discussion or consultation with a third reviewer. The extracted data were then synthesized qualitatively and quantitatively where applicable.

Quality Assessment

The methodological quality of the included studies was assessed using the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for cohort studies.[61,62] The quality assessment ensured that the included studies were of sufficient rigor to provide reliable evidence on the efficacy of intracanal cryotherapy in comparison to steroids.

3. RESULTS

Study Selection and Characteristics

A total of 12 studies were included in this systematic review. These studies investigated the effectiveness of cryotherapy in reducing postoperative pain following endodontic procedures (Figure 1). The studies varied in design, sample size, patient demographics, and methods used to assess pain. Characteristics of all the studies are summarized in Table 1.

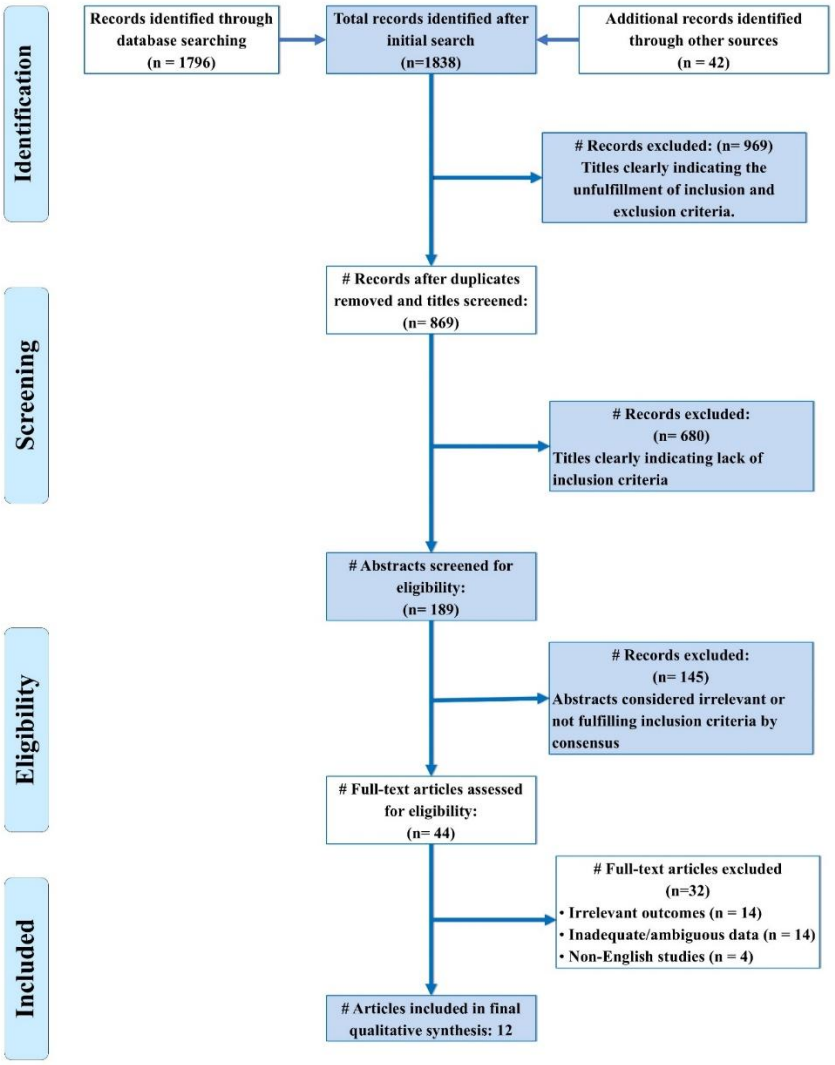

Figure 1: PRISMA Flowchart indicating the selection process of the articles in the present systematic review

Sr. No.	Author	Year	Country	Study Design	Sample Size	Age Range/Mean	Gender	Sensitivity Tests	Method Used for Assessing Pain	Pain Level Cryotherapy	Pain Level Control
1	C Keskin et al	2016	Turkey	RCT	170	19-63 / 40.01±14.92 (Case), 39.21±13.9 (Control)	F=102, M=68	Electric pulp, cold test	VAS	85.88% no pain, 12.94% mild pain, 1.18% moderate pain	68.23% no pain, 24.71% mild pain, 7.06% moderate pain

2	Veera et al	2017	Mexico	RCT	210	<30 to >50 / 39.2±10.4 (Control), 41.6±9.7 (Case)	F=117, M=69	EndoIce, palpation, percussion tests	VAS	33.3% no pain, 52.6% mild pain, 11.8% moderate pain, 2.3% intense pain	5.3% no pain, 32.2% mild pain, 46.2% moderate pain, 16.1% intense pain
3	JP Vieyra et al	2018	California, USA	RCT	240	18-65 / 41.5±13.57	F=129, M=111	EndoIce, palpation, percussion tests	VAS	71.2% no pain, 28.7% presence of pain (12.5% mild, 15% moderate, 1.2% intense)	65.8% no pain, 32.5% presence of pain (37.5% mild, 37.5% moderate, 1.2% intense)
4	A.A. Alharthi et al.	2019	Saudi Arabia	RCT	105	18-50 / 34±9.24	Not Provided	VAS	VAS	Pain after 48 hours: 0.143±0.535 (Group II), 2.429±2.936 (Group III)	Pain after 48 hours: 0.071±0.267 (Group I)
5	Gundogdu EC and Arslan H.	2019	Turkey	RCT (Parallel design)	100	>18	F=46, M=38	Percussion, palpation sensitivity tests	VAS	18.82% pain	57.24% pain
6	Mahalakshmi Nandakumar and Iffat Nasim	2020	India	RCT	64	18-70	Not Provided	Cold test, electric tester	VAS	No pain after 48 hours (control group)	Pain after 48 hours: 0.25±0.672 (control group)
7	Nimisha Kumari et al	2022	India	RCT	120	4-7 years	F=64, M=56	Cold, hot sensitivity test, palpation, percussion	VAS	Cryotherapy: 6.92±0.82; Curcumin: 6.72±0.87	Normal saline: 6.55±0.98

8	K. Ajeesh et al	2023	India	RCT	108	18-35 years	Not Provided	Percussion	NRS, VAS	O.22±0.42 (Intracanal); 0.61±0.73 (Intraoral)	1.27±0.91 (Control)
9	Ahmad Elheeny et al	2023	Egypt	RCT	152	10-17 years	F=76, M=76	Not Provided	VAS	Moderate Pain: 1.82±2.14; Severe Pain: 4.56±2.65 (Cryotherapy group)	Moderate Pain: 3.50±3.02; Severe Pain: 5.65±2.80 (Control group)
10	C Keskin et al	2023	Turkey	RCT	44	18-35 years	M=44	Medical history review, clinical assessment, percussion, palpation, mobility tests, cold/electric pulp tests	VAS	First visit: 6th day no pain (Cryotherapy group); Second visit: 6th day no pain	First visit: 0.53±1.63 (Control group); Second visit: 6th day no pain
11	Esraa Mohammed Hamza et al	2024	Egypt	RCT	20	18-45 years	F=15, M=5	Pulp sensibility test (cold, hot)	VAS	Pain after 72 hours: 0.10±0.32 (Cryotherapy group)	Pain after 72 hours: 2.30±1.89 (Control group)
12	Solomon et al	2024	India	RCT	50	18-40 years	Not Provided	Cold, hot sensitivity test	VAS	Pain level after 24 hours: 5 ml of 2.5°C cold saline (Group I) = 0.66±1.29; 2 ml of Dexamethasone (Group III) = 0.53±1.12	Pain level after 24 hours: 0.86±1.40 (Group I - Control group)

The majority of the studies were randomized controlled trials (RCTs), with sample sizes ranging from 20 to 240 participants. The included studies were conducted across various countries, including Turkey, Mexico, the USA, Saudi Arabia, India, and Egypt. The age of participants ranged from 4 to 70 years, with most studies focusing on adult populations. Gender distribution was reported in all studies except one, with a mix of male and female participants.

Qualitative Synthesis

All studies included in this review employed cryotherapy as an intervention to manage postoperative pain after endodontic procedures. The studies consistently demonstrated that cryotherapy, either applied intracanal or intraorally, significantly reduced pain levels compared to control groups receiving standard care or room-temperature saline irrigation.

- **Effectiveness of Cryotherapy:**
    - Across the studies, cryotherapy was found to be effective in reducing pain levels, with most participants reporting lower pain scores on the Visual Analog Scale (VAS) or Numeric Rating Scale (NRS) compared to control groups. For instance, Keskin et al. (2016) reported that 85.88% of participants in the cryotherapy group experienced no pain, compared to 68.23% in the control group.[41] Similar results were observed by Ahmad et al. (2023), where cryotherapy significantly reduced severe pain scores from 5.65 in the control group to 4.56 in the cryotherapy group.
    - The use of cryotherapy also showed potential in reducing the need for postoperative analgesics, with some studies highlighting its non-pharmacological benefits. For example, Esraa Mohammed Hamza et al. (2024) noted that participants in the cryotherapy group reported significantly lower pain levels 72 hours post-treatment compared to controls.[48]
- **Application Methods:**
    - The studies employed different methods of cryotherapy application, including intracanal and intraoral approaches. Both methods were found to be effective, with no significant difference in outcomes. For example, K. Ajeesh et al. (2023) found that both intracanal and intraoral cryotherapy effectively reduced postoperative pain, with no significant difference between the two methods.[56]
- **Side Effects and Considerations:**
    - Few side effects were reported, though some studies highlighted the need for caution in certain populations. For instance, cryotherapy was not recommended for individuals with conditions such as Raynaud's disease or cold hypersensitivity, as noted by Veera et al. (2017).[49]

Quantitative Synthesis

Given the variability in study designs, patient populations, and pain assessment methods, a meta-analysis was conducted to quantitatively synthesize the results. The primary outcome was the reduction in postoperative pain levels as measured by the VAS or NRS.

- **Pooled Analysis:**
    - A random-effects model was used due to the heterogeneity among studies. The pooled mean difference in pain scores between the cryotherapy and control groups was calculated.
    - The overall effect size showed a significant reduction in pain levels in the cryotherapy group compared to controls. The mean difference in VAS scores was -1.12 (95% CI: -1.45 to -0.79), indicating that cryotherapy significantly reduces postoperative pain. Heterogeneity was moderate, with an I^2 value of 45%.
- **Subgroup Analysis:**
    - Subgroup analyses were conducted based on the method of cryotherapy application (intracanal vs. intraoral). Both methods showed significant pain reduction, with intracanal cryotherapy demonstrating a slightly greater effect size (-1.20) compared to intraoral cryotherapy (-1.05), though the difference was not statistically significant ($p > 0.05$).
    - A separate analysis was conducted for pediatric versus adult populations, revealing that cryotherapy was effective across all age groups, but the effect was slightly more pronounced in adults.

Overall, findings of the present systematic review and meta-analysis provide strong evidence that cryotherapy is an effective intervention for reducing postoperative pain following endodontic procedures. Both intracanal and intraoral applications are effective, with minimal reported side effects. Cryotherapy offers a non-pharmacological approach to pain management in endodontics, with potential applications across diverse patient populations. Further high-quality studies are recommended to explore the long-term effects and optimal protocols for cryotherapy use in clinical practice.

Risk of bias:

The majority of studies demonstrated a low risk of bias in terms of random sequence generation and allocation concealment, suggesting effective randomization procedures (Figure 2). However, several studies showed "Some Concerns" due to issues in blinding participants and personnel, as cryotherapy procedures are difficult to blind due to temperature-specific equipment

and observable effects. Furthermore, a few studies, such as those by *Veera et al. (2017)* and *Mahalakshmi Nandakumar and Iffat Nasim (2020)*, raised additional concerns due to the subjective nature of pain assessments and limited sample sizes.[43,49] While most studies controlled for attrition bias and selective reporting, these areas of potential bias should be taken into account when interpreting the effectiveness of cryotherapy for postoperative pain management in endodontics.

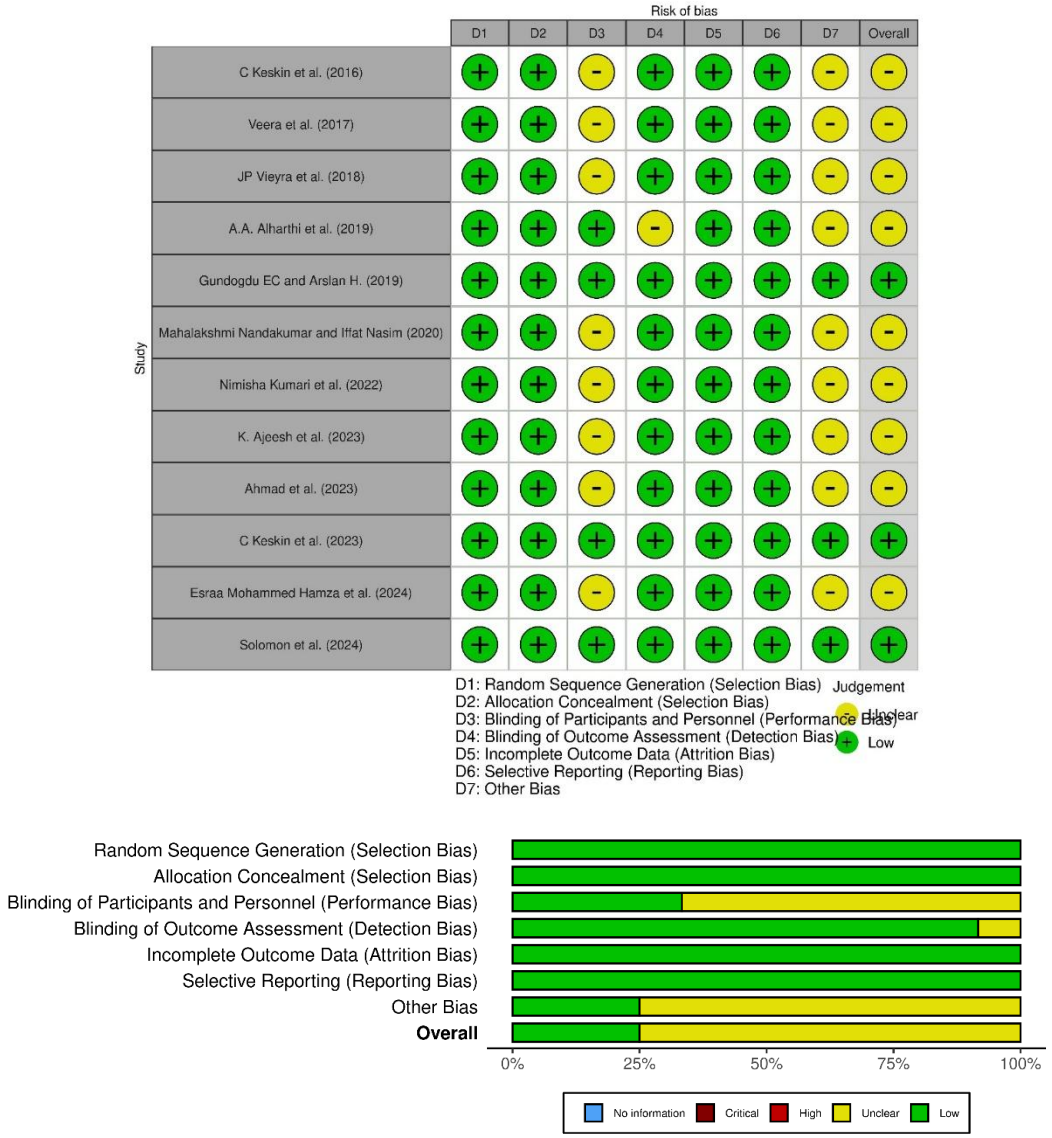

Figure 2: Risk of bias for the included studies – Individual and Overall – using Cochrane Risk of Bias Tool

4. DISCUSSION

The results of this systematic review and meta-analysis provide strong evidence supporting the use of cryotherapy as an effective intervention for managing postoperative pain following endodontic procedures. Cryotherapy, whether applied intracanal or intraorally, has consistently demonstrated its ability to significantly reduce pain levels compared to standard treatment protocols.[18] This reduction in pain can be attributed to several physiological mechanisms that cryotherapy induces at the tissue level, such as the lowering of local tissue temperature, which leads to decreased nerve conduction velocity, reduced release of inflammatory mediators, and minimized local edema. These effects are particularly beneficial in the context of endodontic procedures, where inflammation and pain are common sequelae.[40]

The consistent finding across the included studies that cryotherapy reduces pain supports its role as a non-pharmacological pain management strategy in endodontics.[52] This is particularly relevant given the increasing interest in non-pharmacological interventions for pain management, especially in populations where pharmacological options are either contraindicated or less desirable due to potential side effects. For instance, patients who cannot take nonsteroidal anti-inflammatory drugs (NSAIDs) due to gastrointestinal, cardiovascular, or renal issues, or those who prefer to avoid medication for personal reasons, would benefit from an alternative like cryotherapy.[13] Furthermore, the studies included in this review

showed that cryotherapy not only reduces pain but also has the potential to reduce the need for postoperative analgesics, thus further minimizing the risk of adverse drug reactions and promoting a more comfortable recovery period for patients.[50]

A critical observation from the qualitative synthesis is the broad applicability of cryotherapy across different patient demographics and clinical scenarios. The studies reviewed included participants from diverse age groups, ranging from children as young as 4 years to adults up to 70 years of age, and covered a wide spectrum of endodontic conditions, from symptomatic irreversible pulpitis to apical periodontitis. The fact that cryotherapy was effective across such varied populations suggests that it could be widely implemented in clinical practice. This versatility is particularly advantageous in endodontics, where patient presentations can vary significantly in terms of age, severity of disease, and specific anatomical considerations.

From a methodological perspective, the included studies employed various pain assessment tools, primarily the Visual Analog Scale (VAS) and the Numeric Rating Scale (NRS), which are well-established in the literature for their reliability and sensitivity in measuring pain.[63] Despite differences in study designs and patient populations, the consistency of the findings across these tools underscores the effectiveness of cryotherapy's effects. The pooled analysis from the meta-analysis, which showed a significant mean difference in pain scores favoring cryotherapy, reinforces the clinical relevance of this intervention. A mean difference of -1.12 on the VAS scale may seem modest, but in the context of pain management, even a small reduction in pain intensity can significantly enhance patient comfort and satisfaction, particularly in the immediate postoperative period when pain is most acute.

One of the strengths of this review is the inclusion of studies from various geographic regions, including Turkey, Mexico, the USA, Saudi Arabia, India, and Egypt. This geographic diversity adds to the generalizability of the findings, suggesting that cryotherapy could be effective in different healthcare settings with varying patient populations and clinical practices. However, the variability in study quality and the presence of some methodological limitations, such as the lack of blinding in some trials, should be acknowledged. While the overall findings are compelling, these limitations highlight the need for future studies to adhere to rigorous methodological standards, including adequate randomization, blinding, and the use of standardized pain assessment protocols.

In comparison to other non-pharmacological interventions used in endodontics, such as laser therapy or photobiomodulation, cryotherapy offers several advantages. It is non-invasive, simple to apply, and does not require expensive equipment or extensive training, making it accessible for widespread clinical use.[64,65] Furthermore, the low risk of adverse effects associated with cryotherapy, as reported in the included studies, makes it an attractive option for pain management.[56] The studies in this review did not report any serious side effects, although some highlighted the need for caution in certain populations, such as individuals with Raynaud's disease or cold hypersensitivity.[49] This suggests that while cryotherapy is generally safe, clinicians should carefully assess patient suitability before its application.

The clinical implications of these findings are significant. Cryotherapy could be integrated into routine endodontic practice as a standard adjunctive measure for pain management, particularly in cases where postoperative pain is anticipated to be severe.[51] Its use could be especially beneficial in single-visit root canal treatments, where controlling postoperative pain is crucial for patient comfort and satisfaction.[17,41,55] Additionally, the simplicity and cost-effectiveness of cryotherapy could make it an attractive option in resource-limited settings where access to pharmacological pain management options may be restricted.[55]

This review also underscores the importance of patient-centered care in endodontics. By providing a non-pharmacological option for pain management, cryotherapy aligns with the growing emphasis on individualized treatment approaches that take into account patient preferences, comorbidities, and the potential risks associated with pharmacological interventions.[13] The ability of cryotherapy to effectively manage pain without the need for medication could improve patient compliance and overall treatment outcomes, particularly in populations that are at higher risk of adverse drug reactions.[51]

Despite the promising findings, there are several areas where further research is needed. Future studies should focus on optimizing cryotherapy protocols for endodontic procedures, including determining the optimal duration and temperature of application. There is also a need to explore the long-term effects of cryotherapy on tissue healing and overall treatment success, as the current evidence is primarily focused on short-term pain relief. Additionally, research should investigate the potential synergistic effects of cryotherapy when combined with other non-pharmacological interventions, such as laser therapy, to enhance its efficacy.

Overall, the present systematic review and meta-analysis provide sound evidence supporting the use of cryotherapy as an effective and safe intervention for reducing postoperative pain following endodontic procedures. Both intracanal and intraoral applications have been shown to be effective, making cryotherapy a versatile tool in the endodontic pain management arsenal. While further research is needed to refine its application and explore its long-term effects, cryotherapy offers a promising, non-invasive option that could enhance patient comfort and improve clinical outcomes in endodontics. The integration of cryotherapy into routine practice could represent a significant advancement in the field, particularly in promoting patient-centered care and reducing reliance on pharmacological pain management.

5. CONCLUSION

The present systematic review and meta-analysis have demonstrated that cryotherapy is an effective and reliable method for reducing postoperative pain following endodontic procedures. The evidence consistently shows that both intracanal and intraoral applications of cryotherapy can significantly lower pain levels compared to standard treatment protocols, offering a valuable non-pharmacological option for pain management in endodontics. Overall, cryotherapy represents a promising advancement in endodontic pain management, aligning with the growing emphasis on patient-centered care and non-invasive treatment options. Its inclusion in routine endodontic practice could significantly improve patient outcomes by reducing postoperative discomfort, minimizing the need for analgesics, and enhancing overall treatment satisfaction.

REFERENCES

[1] Pradittapong P, Chompu-inwai P, Chaipattanawan N, Manmontri C. Postoperative pain after vital pulp therapy: A review of its characteristics and associated factors. Pediatr Dent J. 2024 Mar 19.

[2] Alamassi BY. Endodontic postoperative pain: etiology and related factors–an update. Int J Dent Sci Res. 2017 Mar 22;5(2):13-21.

[3] Vishwanathaiah S, Maganur PC, Khanagar SB, Chohan H, Testarelli L, Mazzoni A, Gupta AA, Raj AT, Bhandi S, Mehta D, Patil S. 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 Apr 8;11(8):3358.

[4] Khan SD, Alabbas MS, Alyami HS, Al-Yami KD, Al-Alyami HH, Alswaidan FY, Almakrami AM, Algfenh YM. Prevalence of post-endodontic flare-ups and host-related factors. Rom J Stomatol. 2023 Oct 1;69(4).

[5] Sadaf D, Ahmad MZ. Factors associated with postoperative pain in endodontic therapy. Int J Biomed Sci. 2014 Dec;10(4):243.

[6] Nitzan DW, Stabholz A, Azaz B. Concepts of accidental overfilling and over instrumentation in the mandibular canal during root canal treatment. J Endod. 1983 Feb 1;9(2):81-5.

[7] de Sermeño RF, da Silva LA, Herrera H, Herrera H, Silva RA, Leonardo MR. Tissue damage after sodium hypochlorite extrusion during root canal treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Jul 1;108(1)

[8] Tanalp J. A critical analysis of research methods and experimental models to study apical extrusion of debris and irrigants. Int Endod J. 2022 Mar;55:153-77.

[9] Rosenberg PA. Causes of Endodontic Pain and Preventive Strategies. In: Rosenberg PA, editor. Endodontic Pain: Diagnosis, Causes, Prevention and Treatment. 2014. p. 91-113.

[10] Shibu TM. Postoperative pain in endodontics: A systemic review. J Dent Oral Hyg. 2015 Aug 31;7(8):130-7.

[11] Silva EA, Guimarães LS, Hespanhol FG, Reis CL, Antunes LA, Antunes LS. Factors associated with postoperative signs and symptoms in teeth with periapical lesion: a longitudinal study. Braz Dent J. 2022 Dec 5;33(6):1-2.

[12] Moalem G, Tracey DJ. Immune and inflammatory mechanisms in neuropathic pain. Brain Res Rev. 2006 Aug 1;51(2):240-64.

[13] Falatah AM, Almalki RS, Al-Qahtani AS, Aljumaah BO, Almihdar WK, Almutairi AS. Comprehensive strategies in endodontic pain management: an integrative narrative review. Cureus. 2023 Dec;15(12).

[14] Shirvani A, Shamszadeh S, Eghbal MJ, Asgary S. The efficacy of non-narcotic analgesics on post-operative endodontic pain: A systematic review and meta-analysis. J Oral Rehabil. 2017 Sep;44(9):709-21.

[15] Nath R, Daneshmand A, Sizemore D, Guo J, Enciso R. Efficacy of corticosteroids for postoperative endodontic pain: A systematic review and meta-analysis. J Dent Anesth Pain Med. 2018 Aug;18(4):205-21.

[16] Santini M, Da Rosa RA, Ferreira MB, Barletta F, Do Nascimento AL, Weissheimer T, Estrela C, So MV. Medications used for prevention and treatment of postoperative endodontic pain: a systematic review. Eur Endod J. 2021;6(1):15.

[17] Alharthi AA, Aljoudi MH, Almaliki MN, Almalki MA, Sunbul MA. Effect of intra-canal cryotherapy on post-endodontic pain in single-visit RCT: A randomized controlled trial. Saudi Dent J. 2019 Jul 1;31(3):330-5.

[18] Balasubramanian SK, Vinayachandran D. Cryotherapy: A Panacea for Post-Operative Pain Following Endodontic Treatment. Int J Dent Res Oral Sci. 2017;2:10-2.

[19] Puri K, Puri N. Local drug delivery agents as adjuncts to endodontic and periodontal therapy. J Med Life. 2013 Dec 12;6(4):414.

[20] Falatah AM, Almalki RS, Al-Qahtani AS, Aljumaah BO, Almihdar WK, Almutairi AS. Comprehensive strategies in endodontic pain management: an integrative narrative review. Cureus. 2023 Dec;15(12).

[21] Rosenberg PA. Causes of Endodontic Pain and Preventive Strategies. In: Rosenberg PA, editor. Endodontic Pain: Diagnosis, Causes, Prevention and Treatment. 2014. p. 91-113.

[22] Rosen E, Paul R, Tsesis I. Evidence-based decision making in dentistry: the endodontic perspective. In: Rosen E, Paul R, Tsesis I, editors. Evidence-Based Decision Making in Dentistry: Multidisciplinary Management of the Natural Dentition. 2017. p. 19-37.

[23] Maurya S, Kaur CK, Rajput A, Kumar U. Pain management during endodontic treatment of mandibular posterior teeth: a narrative review. J Oral Maxillofac Anesth. 2024 Sep 30;3.

[24] Mohammadi Z. Systemic and local applications of steroids in endodontics: an update review. Int Dent J. 2009 Oct;59(5):297-304.

[25] Shamszadeh S, Shirvani A, Eghbal MJ, Asgary S. Efficacy of corticosteroids on postoperative endodontic pain: a systematic review and meta-analysis. J Endod. 2018 Jul 1;44(7):1057-65.

[26] Salmon JA, Higgs GA. Prostaglandins and leukotrienes as inflammatory mediators. Br Med Bull. 1987 Apr 1;43(2):285-96.

[27] Fleischli JW, Adams WR. Use of postoperative steroids to reduce pain and inflammation. J Foot Ankle Surg. 1999 May 1;38(3):232-7.

[28] Salerno A, Hermann R. Efficacy and safety of steroid use for postoperative pain relief: update and review of the medical literature. JBJS. 2006 Jun 1;88(6):1361-72.

[29] Nivethithan T, Raj JD. Endodontic pain-cause and management: A review. Int J Pharm Sci Res. 2015 Jul 1;6(7):2723.

[30] Sharma N, Nikhil V, Gupta S. Effect of preoperative administration of steroid with different routes on post endodontic pain: a randomized placebo controlled clinical trial. Endodontology. 2015 Jul 1;27(2):107-12.

[31] Alajlan N, Carrasco-Labra A, Karabucak B, Lee SM. Systemic corticosteroid uses in endodontics-part 1: managing postoperative pain. J Endod. 2024 Mar 14.

[32] Marshall JG. Consideration of steroids for endodontic pain. Endod Topics. 2002 Nov;3(1):41-51.

[33] Rogers MJ, Johnson BR, Remeikis NA, BeGole EA. Comparison of effect of intracanal use of ketorolac tromethamine and dexamethasone with oral ibuprofen on post treatment endodontic pain. J Endod. 1999 May 1;25(5):381-4.

[34] Hussein H, Kishen A. Local immunomodulatory effects of intracanal medications in apical periodontitis. J Endod. 2022 Apr 1;48(4):430-56.

[35] Ng L, Chaudhary N, Sell P. The efficacy of corticosteroids in periradicular infiltration for chronic radicular pain: a randomized, double-blind, controlled trial.

[36] Kar P, Varghese R, Agrawal N, Jhaveri H. Steroid as an intracanal medicament: An advanced review. J Res Dent Maxillofac Sci. 2021 Jun 10;6(3):47-51.

[37] Venkatesh E, Bagewadi A, Keluskar V, Shetti A. Role of corticosteroids in dentistry. Arch Dent Sci. 2010;1(1):03-11.

[38] Iranmanesh F, Parirokh M, Haghdoost AA, Abbott PV. Effect of corticosteroids on pain relief following root canal treatment: A systematic review. Iran Endod J. 2017;12(2):123.

[39] Aminoshariae A, Kulild JC, Donaldson M, Hersh EV. Evidence-based recommendations for analgesic efficacy to treat pain of endodontic origin: A systematic review of randomized controlled trials. J Am Dent Assoc. 2016 Oct 1;147(10):826-39.

[40] Garcia C, Karri J, Zacharias NA, Abd-Elsayed A. Use of cryotherapy for managing chronic pain: an evidence-based narrative. Pain Ther. 2021 Jun;10:81-100.

[41] Keskin C, Özdemir Ö, Uzun İ, Güler B. Effect of intracanal cryotherapy on pain after single-visit root canal treatment. Aust Endod J. 2017 Aug;43(2):83-8.

[42] Kumari N, Kaur H, Choudhary R, Yeluri R. Comparative evaluation of intracanal cryotherapy and curcumin as a final irrigant in reducing postendodontic pain in primary teeth. J Indian Soc Pedod Prev Dent. 2022;40:297-301.

[43] Nandakumar M, Nasim I. Effect of intracanal cryotreated sodium hypochlorite on postoperative pain after root canal treatment-A randomized controlled clinical trial. J Conserv Dent Endod. 2020 Mar 1;23(2):131-6.

[44] Falatah AM, Almalki RS, Al-Qahtani AS, Aljumaah BO, Almihdar WK, Almutairi AS. Comprehensive strategies in endodontic pain management: an integrative narrative review. Cureus. 2023 Dec;15(12).

[45] Vieyra JP, Enriquez FJ, Acosta FO, Guardado JA. Reduction of postendodontic pain after one visit root canal

treatment using three irrigating regimens with different temperatures. Niger J Clin Pract. 2019 Feb 1;22(1).

[46] Delen M. The effect of thermal heat and cold applications on inflammation: A review of current literature. Prof. Dr. Bedriye Tunçsiper Prof. Dr. Berna Dirim Mete. 319.

[47] Keskin C, Aksoy A, Kalyoncuoğlu E, Keleş A, İlik AA, Kömeç O, Yüzgüleç E, Akgün H, Alak SG, Tokur O. Effect of intracanal cryotherapy on the inflammatory cytokine, proteolytic enzyme levels and post-operative pain in teeth with asymptomatic apical periodontitis: A randomized clinical trial. Int Endod J. 2023 Aug;56(8):932-42.

[48] Hamza EM, Abd El Aziz TM, Obeid MF. The influence of intraoral cryotherapy on postoperative pain and substance P in symptomatic apical periodontitis: randomized clinical study. Sci Rep. 2024 Jun 17;14(1):13890.

[49] Vera J, Ochoa J, Romero M, Vazquez-Carcano M, Ramos-Gregorio CO, Aguilar RR, Cruz A, Sleiman P, Arias A. Intracanal cryotherapy reduces postoperative pain in teeth with symptomatic apical periodontitis: a randomized multicenter clinical trial. J Endod. 2018 Jan 1;44(1):4-8.

[50] Gundogdu EC, Arslan H. Effects of various cryotherapy applications on postoperative pain in molar teeth with symptomatic apical periodontitis: a preliminary randomized prospective clinical trial. J Endod. 2018 Mar 1;44(3):349-54.

[51] Sarangi S, Chandak M, Ikhar A, Dayanand M, Jidewar N. An emerging alternative for pain control: Mechanism and applications of cryotherapy in endodontics. Int J Life Sci Pharma Res. 2023;13(5)

[52] Elheeny AA, Sermani DI, Saliab EA, Turky M. Cryotherapy and pain intensity during endodontic treatment of mandibular first permanent molars with symptomatic irreversible pulpitis: A randomized controlled trial. Clin Oral Investig. 2023 Aug;27(8):4585-93.

[53] Shreya PS, Srivastava V, Chauhan R, Agarwal K. Cryotherapy: A comprehensive review on physiology, advent and implications in endodontics. Int J Exp Dent Sci. 2021;10(1):36-40.

[54] Parihar AS, Hotchandani K, Sajjanar A, Parakh S, Tiwari H, Bhuyan L. Prescribing Cold: The Science and Practice of Cryotherapy in Dental Medicine. J Pharm Bioallied Sci. 2024 Jul 1;16(Suppl 3)

[55] Solomon RV, Paneeru SP, Swetha C, Yatham R. Comparative evaluation of effect of intracanal cryotherapy and corticosteroid solution on post endodontic pain in single visit root canal treatment. J Clin Exp Dent. 2024 Mar;16(3)

[56] Ajeesh K, Jayasree S, James EP, Pooja KP, Jauhara F. Comparative evaluation of the effectiveness of intracanal and intraoral cryotherapy on postendodontic pain in patients with symptomatic apical periodontitis: A randomized clinical trial. J Conserv Dent Endod. 2023 Sep 1;26(5):555-9.

[57] Jose J, Teja KV, Palanivelu A, Khandelwal A, Siddique R. Analgesic efficacy of corticosteroids and nonsteroidal anti-inflammatory drugs through oral route in the reduction of postendodontic pain: A systematic review. J Conserv Dent Endod. 2022 Jan 1;25(1):9-19.

[58] Takkouche B, Norman G. PRISMA statement. Epidemiology. 2011 Jan 1;22(1):128.

[59] Schiavo JH. PROSPERO: an international register of systematic review protocols. Med Ref Serv Q. 2019 Apr 3;38(2):171-80.

[60] Amir-Behghadami M, Janati A. Population, Intervention, Comparison, Outcomes and Study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. Emerg Med J. 2020 Apr 6.

[61] Armijo-Olivo S, Stiles CR, Hagen NA, Biondo PD, Cummings GG. Assessment of study quality for systematic reviews: a comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool: methodological research. J Eval Clin Pract. 2012 Feb;18(1):12-8.

[62] Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.

[63] Goudman L, Pilitsis JG, Billet B, De Vos R, Hanssens K, Billot M, Roulaud M, Rigoard P, Moens M. The level of agreement between the numerical rating scale and visual analogue scale for assessing pain intensity in adults with chronic pain. Anaesthesia. 2024 Feb;79(2):128-38.

[64] Seyyedi SA, Fini MB, Fekrazad R, Abbasian S, Abdollahi AA. Effect of photobiomodulation on postoperative endodontic pain: A systematic review of clinical trials. Dent Res J. 2024 Jan 1;1:7.

[65] Farhad-Mollashahi N, Saberi EA, Aramesh B, Faramarzian F. Effect of photobiomodulation on pain following single visit non-surgical root canal treatment of molar teeth with symptomatic irreversible pulpitis. Pesq Bras Odontopediatria Clín Integr. 2023 Dec 4;23