

What is the best approach to achieve anesthesia of a hot tooth?

An Evidence Based Report

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Abstract

An evidence-based study of the literature aimed to examine a myriad of clinical approaches to successfully achieve anesthesia in teeth with irreversible pulpitis. The literature review compiled evidence from eight electronic bibliographic databases. Overall, 35 articles were reviewed. Of these, 10 were deemed relevant and were critically appraised according to a “Checklist to Assess Evidence of Efficacy of Therapy or Prevention”. Four of these ten studies did not meet the cut-off requirement, which was a checklist score of 11 and were therefore excluded. Six studies had a score greater than or equal to 11 and were thus, included. Collectively, the evidence provided in the included articles does not recommend or negate a specific treatment modality. Our clinical recommendations remain inconclusive albeit the standard inferior alveolar nerve block for the mandible and infiltration for the maxilla utilizing 2% lidocaine in the endodontic treatment of irreversible pulpitis.

Introduction

Although local anesthetics are highly effective in producing anesthesia in normal tissue, local anesthetics commonly fail in endodontic patients with inflamed tissue.¹ For instance, the inferior alveolar nerve (IAN) block is associated with a failure rate of 15% in patients with normal tissue², whereas IAN fails 44-81% of the time in patients with irreversible pulpitis.³ Similarly, it has been reported that the failure rate of a maxillary infiltration injection is as high as 30% in teeth with irreversible pulpitis.² Inability to achieve anesthesia in patients with irreversible pulpitis remains a significant barrier to successfully treating patients through endodontics.

Irreversible pulpitis is a clinical condition characterized by severe inflammation of the pulp.⁴ This condition stems from a variety of predisposing factors, including: reversible pulpitis, pulpal damage during operative procedures, or reduced pulpal blood flow due to trauma or orthodontic movement. The result is necrotic pulpal tissue as a result of impaired healing. Subsequently, treatment of teeth with signs and symptoms of irreversible pulpitis includes root canal treatment or extraction.

Several hypotheses have been proposed regarding the causes of local anesthetic failure in endodontic patients with irreversible pulpitis. It has been suggested that pulpal and periapical inflammation and infection can lower the tissue pH in the affected region limiting the ability of the local anesthetic to provide pain control⁵. Others have hypothesized that inflammation products enhance nerve conduction⁵. Unusual vasodilation caused by inflammation may also lead to systemic uptake of anesthetic solution from the local site of infiltration, thus, reducing its local effectiveness⁵.

It has been suggested that variations in the pharmacology of the local anesthetic, as well as variations in the technique used to administer the anesthetic can markedly affect the success of anesthesia in endodontic patients. For instance, Bigby et al., suggest that a supplemental intraosseous injection of 4% articaine improves the anesthetic efficacy of the IAN block in mandibular posterior teeth with irreversible pulpitis⁶. Another study by Cohen and others⁷ found that a supplemental periodontal ligamental injection with 2% lidocaine was 74% successful in achieving pain control in patients with irreversible pulpitis. Kanaa et al., on the other hand have found that 4% articaine with 1:100,000 epinephrine was more effective than 2 % lidocaine 1:100,000 epinephrine in achieving anesthesia in mandibular teeth⁸. Although several studies have explored a variety of approaches to improve the anesthetic efficacy in patients with irreversible pulpitis, an effective treatment approach is not well-established.

This literature review was undertaken to investigate the following general question: What is the best approach to achieve anaesthesia for a hot tooth? This general question was further refined to a more focused question: What combination of anaesthetic technique, local anaesthetic solution, and adjunctive medication will result in the greatest rate of anesthesia success of teeth with irreversible pulpitis? The null hypothesis was that there was no improvement in achieving anesthetic success in teeth with irreversible pulpitis when using approaches other than the standard techniques. The present review considered the IAN block and buccal infiltration with 2% lidocaine and epinephrine as standard anesthetic approaches for mandibular and maxillary teeth, respectively. Our aim was to review the strongest sources of evidence regarding the above-mentioned relationships.

Materials and Methods

A comprehensive literature search was carried out using Ovid MEDLINE, Pubmed, Scopus, HealthStar (1986-2009), Cochrane, EMBASE (1996-2009) and Web of Science search engines. In order to critically analyze our research question, the “PICOC” criteria was utilized. The population base was restricted to human adults between 18-65 years of age presenting with irreversible pulpitis. The intervention was restricted to the following terms: local, technique and adjunctive medication. The control was determined as the inferior alveolar nerve block for the mandible and infiltration for maxilla, both with lidocaine. The outcome was defined as anesthesia, electric pulp test (EPT) and visual analogue scale (VAS). Finally, the critical appraisal, checklist scores and strength of the study (based on the Canadian Task Force grades of recommendation for specific clinical preventive actions) were determined. The PICOC outline served as the basis for a more comprehensive keyword list which then served as the basis of the search presented in Table 1. It should be noted that pain is a very difficult parameter to accurately measure; VAS is one of the most accurate and well documented measures of pain. VAS is defined as a horizontal line which is 100 mm in length, where patients are asked to rate their pain, with 0 being no pain, and 100 being very severe pain (Lindemann et al., 2008). Heft-Parker VAS is a modified VAS scale. It is defined as a horizontal line, 170 mm in length. This scale is broken down so 0 means no pain, 0-54mm is mild pain, 54mm-114mm is moderate pain, and 114mm and above is severe pain (Claffey et al., 2004).

Inclusion/Exclusion criteria: Following our comprehensive search, the resultant articles were imported into RefWorks. Originally 476 articles were imported into RefWorks, 293 of which were duplicates, leaving 183 articles at the title stage. A group of reviewers examined the 183 remaining articles and excluded non-human, non-English papers, articles pertaining to post

operative-pain related to pulpitis, clinical trials and reviews, and articles that did not pertain to either anesthetic drugs or techniques. Thirty five articles were chosen at this stage and were carried forward to the abstract stage. The following inclusion/exclusion criteria were used to select articles for the full copy stage: the abstract level article had to pertain to irreversible pulpitis and to either an anesthetic technique or drug. It was also required to be a Randomized Control Trial (RCT), Non-RCT or a Cohort study. It also had to include a comparison group, and articles were eliminated if it was mentioned in the abstract that the study was discontinued for various reasons. Nineteen articles were eliminated this way and the remaining sixteen articles were examined further at the full copy stage. At least two reviewers agreed on all the articles before they were eliminated. In case of any discrepancies, a third reviewer was consulted.

Study selection, data extraction and quality assessment: An evidence table was created in order to account for consistency of reviewers. The table consisted of citation, abstract, location where the study was conducted, type of study, mean age, female/male ratio, sample size, type of teeth, measurement of pain, technique, type of anesthesia, adjunctive medication including volume, control, assessment criteria, results, author conclusions, checklist score, strength of study design (Tables 2 and 3), and comments. The system developed by the Canadian Task Force grades of recommendation is simply a ranking system for the level of evidence ranging from Level I which is the strongest evidence level (as in RCT) to Level III which is the weakest (Opinions of respected authorities, based on clinical experience, descriptive studies or reports of expert committees). The checklist utilized was “Checklist to Assess Evidence of Efficacy of Therapy or Prevention”¹³. The checklist score was ranked out of 18. The checklist critically appraised the papers based on ethics, study design, reliability of results, methods used, and relevance to clinical settings.

Based on the evidence table (Table 4), articles were further excluded if they were not RCT or had a checklist score of less than 11 out of 18. Six articles were left after the full copy stage, these articles were then included in the final evidence table. The articles that were eliminated at this stage were then included in the rejection table (Table 4). It should be noted that we examined the reference lists of the selected manuscripts to ensure no relevant articles were missed in our search, this search did not result in any additional papers.

Results

After a thorough search of the available literature, 6 relevant studies were included in an evidence based table (Table 4). All of the studies were randomized controlled trials (RCT) conducted in a university setting (Table 4). While there was only one study conducted in India⁹, the rest of the trials were conducted in the United States^{6,10,11,14,15}. The participants mean age ranged from 29 to 37 years of age (Table 4). The male:female ratio was balanced in most of the trials, except for the study conducted by Claffey et al.¹¹ which had a male:female ratio of 25 /47. The sample size of the eight trials ranged from 20 to 72 participants (Table 4).

Five of the six RCT trials specifically investigated mandibular posterior teeth^{6,10,11,14,15}, while Srinivasan et al. looked at maxillary posterior teeth only⁹. In order to assess the pre- and post-intervention pain, four studies employed the Heft Parker VAS scale^{6,10,11,14} whereas Srinivasan et al. used the VAS scale⁹, while Remmers et al. used the electric pulp test¹⁵. Three studies employed interventions that altered the pharmacological component of the control anaesthetic approach^{6,9,11}, while keeping the technique (maxillary buccal infiltration or mandibular IAN block) constant. Lindemann et al. investigated the analgesic effect of triazolam as an adjunctive medication to the standard IAN block¹⁰, while Remmers et al. and Kennedy et al. compared the standard IAN block to the intraflow intraosseous injection and the bidirectional needle rotation technique using computer assisted Wand II, respectively^{15,14}. None of the 6 studies observed significant differences in achieving anesthetic success between intervention and control (Table 4). All 6 studies received a research design rating of I and a recommendation grade of I for specific clinical preventive actions (Table 4). None of these studies achieved a

checklist score lower than 11 out of the possible 18 with Remmers et al. and Srinivasan et al. ranking with the highest with a score of fourteen^{15,9}.

The studies conducted by Remmers et al. and Srinivasan et al. were superior to the remaining studies when strength of evidence was considered^{15,9}. These two studies employed statistical tests aimed at reducing the influence of confounding variables on the results. Barring the experimental intervention, all groups were treated equally for the duration of each study. Furthermore, Remmers et al. also determined whether a patient experienced complications at the end of the procedure and at follow-up appointments¹⁴ while Srinivasan et al., reported a treatment effect large enough to be clinically significant⁹.

Altogether, Remmers et al. and Srinivasan et al. tested two different experimental interventions to determine their ability to induce adequate anesthesia in patients with irreversible pulpitis. Srinivasan et al. investigated the anesthetic efficacy of articaine, and found 4% articaine to be significantly better than 2% lidocaine with respect to obtaining anesthesia in the first molar. On the other hand Remmers et al. reported that Intraflow intraosseous injection significantly reduces anesthesia onset when compared to the standard IAN block, however, no significant differences were found when overall anesthetic success was considered.

The remaining four studies failed to obtain a high rank when the studies were evaluated using the “Checklist to assess evidence of efficacy of therapy or prevention.” The reasons for this failure varied between the studies. Overall, shortcomings included: unbalanced ratio of males to females, different rates of injection between intervention and control groups, inadequate consideration of adverse effects including abnormal heart rate and sedation, and lack of “blinding” of all patients, health workers, and study personnel.

Discussion

Evidence collected from this literature review has determined that the best way to achieve anesthesia in patients with irreversible pulpitis remains undetermined. Though there have been several recommendations in each of the aforementioned studies, the overall perspective remains unclear. The major contribution of this likely stems from the fact that the relevant pathways that lead up to the sensation of pain in each patient or a group of patients are unique and have not been elaborated both anatomically and functionally. In addition, the psychological component of the perception of pain along with dental anxiety in some patients makes it a daunting task for the operator to provide a “painless” experience.

Due to this lack of a clear understanding in the sensation of pain, any evaluation of pain is limited. Subsequently, any treatment modality to eradicate that pain to achieve anesthesia also becomes limited. Many studies have relied on qualitative measures such as the VAS to measure pain. However, there has been some doubt placed on this approach therefore compromising the validity of the VAS test. It has been stated that the McGill Pain Questionnaire is a more robust measure of pain and should be the method of choice. On the contrary, it is important to point out that neither method has been exemplified as being absolute in evaluating anesthesia in patients undergoing endodontic treatment. Nevertheless, these evaluation methods rely on the subjectivity of the patient’s reportings towards the nature of their pain. Currently, there is no one method that evaluates the patients’ pain in an objective manner.

Future studies investigating the ability of anesthetic drugs and techniques to induce adequate anesthesia in patients with irreversible pulpitis should adhere to specific study design criteria. In particular, it is recommended that future studies be designed as double-blind

randomized control trials with controls for all confounders such as age, sex, and initial pain level. It is important to note that immediately prior to treatment, an electric pulp test should also be carried-out. The patient's heart rate should be recorded prior to treatment, as well as during anesthetic solution deposition, and post-deposition. If the patient feels pain during the endodontic treatment, the practitioner should discontinue the treatment, record the extent to which the affected tooth was penetrated before the patient experienced pain, and ask the patient to record his/her pain using VAS of the McGill Pain Questionnaire. Finally, it is crucial to record the presence or absence of side effects for all patients at the end of a given procedure and at follow-up appointments, including abnormal heart rate, post-operative sensitivity, and sedation.

This literature review reveals a general lack of experimental interventions that improve anesthetic success in patients with irreversible pulpitis. As reported by Srinivasan et al. compared to 2% lidocaine, 4% articaine significantly increases the anesthetic efficacy in maxillary first molars. Articaine however, should be used cautiously by clinicians due to its several side effects⁹. Furthermore, Remmers et al., have shown a temporal reduction in the onset of anesthesia using Intraflow intraosseus injections in the mandible. The usage of this Intraflow intraosseus injection needs to be studied more elaborately in order to establish its effectiveness.

In conclusion, additional studies that validly and reliably measure interventions and outcomes, while controlling for other relevant variables, should be carried-out in order to improve our understanding of anesthetic success in patients with irreversible pulpitis.

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Appendix 1

I. List of articles excluded and reasons for exclusion

Articles	Reason for exclusion
Goldberg and others 2008; Mikessell and others 2005; Willett and others 2008.	Did not pertain to irreversible pulpitis
Gallatin and others 2000	Focused on pre-operative pain management
Mellor and others 2007	Clinical trial was not completed
Modaresi and others 2008	Non-human (cats) study
Moroz and others 1991; Nagle and others 2000	Did not pertain to anaesthesia, just analgesia
Newcombe 2005	Not a study but a commentary
Bigby and others 2006; Khan and others 2007; McCartney and others 2007; Mickel and others 2006; Nusstein and others 1998, 2003, 2005; Parente and others 1998; Reisman and others 1997; Stabile and others 2007.	Not a randomized controlled trial
Elsharawy and others 2007; Uhle and others 1997	The golden standard was not used as a control
Modaresi and others 2006; Reisman and others 1997 Rosenberg and others 2007; Sherman and others 2008	Checklist score did not meet the scoring cut-off of 11/18
Tortamano and others 2009; Walton and others 1992.	Unable to access or retrieve article from known search engines or U of T holdings.
Meechan 2002; Weathers 1999	Not a study but a review

Appendix 2

II. References of articles excluded and reasons for exclusion:

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Checklist to Assess Evidence of Efficacy of Therapy or Prevention

Citation: _____

1. Was the study ethical? _____

2. Was a strong design used to assess efficacy? _____

3. Were outcomes (benefits and harms) validly and reliably measured? _____

4. Were interventions validly and reliably measured? _____

5. What were the results? _____

Was the treatment effect large enough to be clinically important? _____ Was the estimate of the treatment effect beyond chance and relatively precise? If the findings were “no difference” was the power of the study 80% or better _____

6. Are the results of the study valid? _____

• Was the assignment of patients to treatments randomised? • Were all patients who entered the trial properly accounted for and attributed at its conclusion? i) Was loss to follow-up less than 20% and balanced between test and controls ii) Were patients analysed in the groups to which they were randomised? • Was the study of sufficient duration? • Were patients, health workers, and study personnel “blind” to treatment? • Were the groups similar at the start of the trial? • Aside from the experimental intervention, were the groups treated equally? • Was care received outside the study identified and controlled for _____

7. Will the results help in caring for your patients? Were all clinically important outcomes considered? Are the likely benefits of treatment worth the potential harms and costs? _____

Adapted from:

Fletcher, Fletcher and Wagner. Clinical epidemiology – the essentials. 3rd ed. 1996, and Sackett et al. Evidence-based medicine: how to practice and teach EBM. 1997