Review Article

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Intrapulpal anesthesia in endodontics: an updated literature review

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Effective pain management is crucial for the successful performance of various endodontic procedures. Painless treatments are made possible by anesthetizing the tooth to be treated using various nerve-block techniques. However, certain circumstances necessitate supplemental anesthetic techniques to achieve profound anesthesia, especially in situations involving a "hot tooth" in which intrapulpal anesthesia (IPA) is employed. IPA is a technique that involves the injection of an anesthetic solution directly into the pulp tissue and is often utilized as the last resort when all other anesthetic techniques have been unsuccessful in achieving complete pulpal anesthesia. This review focuses on the IPA procedure and the factors that influence its success. Additionally, the advantages, limitations, disadvantages, and future directions of IPA are discussed.

Keywords: Hot Tooth; Intrapulpal Anesthesia; Local Anesthesia; Pain Management; Supplemental Anesthetic Technique.

INTRODUCTION

Effective pain management is crucial when performing endodontic therapy, since it decreases the patient's anxiety and improves comfort, thereby allowing the clinician to focus on treatment without interruptions. Delivering painless treatments to patients increases their satisfaction and the probability of obtaining referrals, thus enhancing clinical practice overall [1]. Pharmacological agents, such as local anesthetics and analgesic drugs, are used to alleviate pain during and after endodontic procedures. Local anesthetics continue to be the most widely employed drugs during endodontic procedures [2].

Various local anesthetic techniques are employed to anesthetize the tooth, enabling the clinician to perform endodontic therapy [3]. However, achieving profound anesthesia depends on the dental arch to be anesthetized, the tooth's pulpal status, the chosen anesthetic technique, the type and amount of anesthetic solution used, and the patient's anxiety levels [4,5]. Previous research indicates that it is more challenging to anesthetize the mandibular teeth than the maxillary teeth due to anatomical variability, increased bone density of the mandible, and

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additional nerve innervations [6].

The inferior alveolar nerve block (IANB) is frequently used to anesthetize the mandibular teeth, with success rates varying considerably, often between 80% and 85%, and decreasing further to 25–48% in cases where the tooth is diagnosed with symptomatic irreversible pulpitis [7,8]. Employing supplemental anesthetic techniques, such as intraligamentary, intraosseous, and interseptal anesthesia, in conjunction with IANB, is beneficial in attaining adequate anesthesia. However, achieving complete anesthesia becomes exceptionally challenging in "hot tooth" situations [9,10]. The potential causes for the inability to induce anesthesia in hot tooth situations are as follows.

a) Decreased pH levels: Inflamed tissues often exhibit decreased pH levels as postulated in the “pH theory”. Low pH reduces the ability of the anesthetic's base form to penetrate nerve sheaths and membranes, typically leading to insufficient anesthesia [11].

b) Altered nerve properties: Inflamed nerves usually exhibit altered resting potential and reduced excitability, making anesthetics less effective at blocking nerve impulses [12].

c) Reduced neural sensitivity: A reduction in neural sensitivity may result from the existence of anesthetic-resistant tetrodotoxin sodium channel receptors and sodium channel upregulation, which occur in cases of irreversible pulpitis, leading to increased expression levels of sodium channels within the dental pulp and eventually, reducing nerve sensitivity to anesthetics [13].

Intrapulpal anesthesia (IPA) is considered a last resort for achieving adequate anesthesia in an affected tooth that has failed to respond to conventional and other supplemental anesthetic techniques. IPA requires the direct injection of the anesthetic solution into the exposed pulp under adequate pressure and it has been found to be extremely useful for managing "hot tooth" conditions. It is necessary for approximately 5 to 10% of patients to attain complete anesthesia, allowing clinicians to extirpate the pulp and proceed comfortably with the treatment [14]. This review examines the IPA procedure in endodontics, highlighting its benefits, drawbacks, and limitations. It intends to enhance our understanding of IPA and the factors influencing its success when performing endodontic therapy.

METHODS

The two principal authors performed an extensive literature search using the PubMed and Medline databases as the primary sources for identifying relevant publications. The search was performed using MEsH terms related to IPA, encompassing "Intrapulpal Anaesthesia," "Intrapulpal Injections," "Pulpal Anaesthesia," "Supplemental Anaesthetic Techniques," and "Local Anesthesia." The search terms were combined using the Boolean operators "OR" and "AND." The search was restricted to articles published between 1966 and February 2024 to ensure a broad selection of publications containing the most up-to-date information on the current topic. The search yielded 235 articles.

The inclusion criteria encompassed studies published exclusively in English that examined i) the employed technique; ii) the factors influencing success, such as the size of the pulpal exposure, the gauge of the needle employed, the type and volume of anesthetic solution used, and the pressure employed to perform IPA; and iii) the advantages, disadvantages, and limitations of IPA in the context of endodontic treatment. Case reports and abstracts were omitted from the analysis.

The primary and secondary authors meticulously examined the articles that met the inclusion criteria. After acquiring the full texts of the selected papers, a careful examination of the reference lists therein was performed using Google Scholar to incorporate additional relevant research papers that the initial search might have missed. Any discrepancies or conflicts regarding the technique, advantages, disadvantages, and factors affecting the success described in the chosen publications were handled through author discussions until a unanimous consensus was reached. Thirty-four articles were included in the present literature review.

IPA PROCEDURE

IPA is performed as follows:

a) The patient is first educated about and prepared for the potential discomfort associated with the IPA technique, emphasizing that the discomfort will only be momentary, lasting only a few seconds. The majority of patients are willing to tolerate a brief period of pain when they are informed that profound anesthesia is to follow [11].

b) The tooth is isolated, and the existing restoration is removed. After visually locating the pulp chamber, access is gained using a high-speed, small round bur at the highest pulp horn in the area with thinner dentin. The patient is reassured as they will feel a sharp, momentary pain. Any bleeding is managed by applying a cotton pellet soaked in a local anesthetic solution. This small portion of the exposed pulp chamber is the target area and provides sufficient space to insert a 27-, 30-, or 31-gauge needle [8,15].

c) A topical anesthetic gel is applied to the exposed pulp and rubbed for approximately 1 min to let the gel penetrate, which may assist in reducing the pain when the needle is inserted into the exposed pulp [16].

d) The patient is always informed before insertion of the needle into the exposed pulp tissue. A 90-degree bend is placed on the needle to facilitate insertion. For the greatest effectiveness, pressure is applied with the opposite index finger or thumb to the area until resistance is felt. Subsequently, approximately 0.2–0.3 mL of anesthetic solution is administered with sufficient pressure to achieve pulpal anesthesia [17,18,19].

MECHANISM OF ACTION

The precise mechanism by which IPA acts continues to be discussed. Nevertheless, there are two proposed mechanisms through which IPA achieves profound anesthesia.

a) Direct nerve inhibition: Since the anesthetic solution is directly injected into the pulp, it functions by obstructing nerve impulses. The local anesthetic agent binds to sodium channels within the membranes of nerve cells, thereby inhibiting the entry of sodium ions crucial for transmitting nerve signals. Consequently, this direct application enables prompt and precise administration of anesthesia to the afflicted tooth, resulting in instant pain alleviation during endodontic operations by affecting the nerve fibers temporarily to convey pain signals [18,20].

b) Direct neural damage: IPA works by applying pressure to introduce an anesthetic solution into the pulp before pulpal extirpation. The anesthesia is significantly influenced by the pressure exerted on the pulp by the solution. The anesthesia is profound and rapid when administering the injections and achieving significant resistance. The exact method by which pressure might induce anesthesia is not fully understood. Nevertheless, it is hypothesized that continuous pressure may result in the degeneration of nerve fibers in numerous cases, resulting in adequate anesthesia. Further research should investigate the mechanism by which IPA works to gain a more comprehensive understanding [19,21,22].

FACTORS AFFECTING THE SUCCESS OF IPA

1. Size of the pulpal exposure

The pulpal exposure should be as small as possible, allowing the insertion of the needle deep into the pulp, thereby enhancing the chances of attaining high pressure within the chamber, resulting in direct pulpal damage and complete anesthesia. Hence, anesthetic success is influenced by the size of the exposed pulp, with smaller exposures increasing the likelihood of achieving profound anesthesia [8,19].

In case of significant exposure to the pulp chamber, the clinician should consider flooding the pulp chamber with an adequate anesthetic solution for 1 min before inserting the needle. Pulpal anesthesia can then be achieved by one of the following techniques.

i) The "stoppering technique" refers to a procedure adopted to ensure that adequate pressure develops during the delivery of IPA. The approach involves using a stopper, such as a cotton pellet or a gutta-percha point, to generate backpressure and ensure efficient deposition of the anesthetic solution into the pulp chamber [23]. Suresh N et al., in a study conducted to evaluate pain perception following various needle gauges during IPA, used the stoppering technique, wherein the cotton pellet was placed over the exposed pulp chamber after the needle was inserted into the pulp chamber. This backpressure, which is essential for facilitating the distribution of the anesthetic solution within the pulp chamber, contributes to the efficacy of the IPA procedure [8].

ii) A 31-gauge needle is inserted deeply into the canal until resistance is felt, after which approximately 0.2 to 0.3 mL of anesthesia is injected into each canal [8,19].

2. Gauge of the needle

The extent of pain experienced during IPA is influenced by factors such as the design of the needle, the gauge of the needle used to administer the solution into the pulp tissue, the depth at which the needle is inserted, and the characteristics of the tissue into which the anesthetic solution is injected. Of these factors, the gauge of the needle used for IPA significantly influences the perception of pain during the injection procedure. A 31-gauge needle produces substantially less pain perception and discomfort during IP injection in comparison to a 27-gauge needle, since the outer and inner diameter of a 31-gauge needle is smaller than that of a 27-gauge needle, resulting in contact with a smaller area of pulp tissue and fewer type A nerve fibers being triggered during insertion. In addition, the flow rate of the solution deposited using a 31-gauge needle is comparatively less because of the smaller bore diameter, which creates less interstitial pressure during the deposition of the anesthetic solution. Therefore, using thinner needles can help manage difficult clinical situations, such as highly anxious patients, thereby increasing the patient's comfort during IPA [8,18].

3. Type and volume of anesthetic solution

Different anesthetic drugs have been employed in dentistry to anesthetize the teeth and ensure painless treatments. Commonly used local anesthetics in endodontic treatments include lidocaine with 1:100,000 adrenaline, articaine, mepivacaine, bupivacaine, and prilocaine. Two percent lidocaine with 1:100,000 is still widely used as an anesthetic agent for nerve blocks and IPA in both adults and pediatric patients [9,24]. Articaine is a recently developed anesthetic that has enhanced efficacy for pulpal anesthesia due to its unique chemical structure, allowing it to penetrate more effectively into the nerves that need to be anesthetized [25]. Mepivacaine and bupivacaine are categorized as long-acting anesthetics [26]; however, their efficacy and durability when employed for IPA requires further evaluation. Overall, using different anesthetic drugs in dentistry enables effective treatment without discomfort. Among these options, lidocaine is most commonly used for IPA owing to its established efficiency, with minimal side effects [18,24].

VanGheluwe conducted a comparative study to assess the efficacy of 2% lidocaine with 1:100,000 epinephrine and sterile saline solution at inducing anesthesia. The results indicated that the effective induction of IPA is independent of the solution used, suggesting similar levels of efficacy across both solutions [27]. Additionally, Birchfield and Rosenburg found no substantial disparity in the induced local anesthesia between a sterile normal saline solution and 2% lidocaine with 1:50,000 epinephrine. Therefore, when choosing a solution for inducing IPA, both local anesthetic and sterile saline solutions can be considered equally effective [19].

The volume of local anesthetic solution utilized for IPA is critical in guaranteeing adequate anesthesia, managing pressure build-up, and enhancing patient comfort during endodontic treatments. The amount of anesthetic solution is proportional to the level of anesthesia achieved and plays a significant role in sufficiently saturating the pulp tissue with the anesthetic solution by promoting better penetration and generating suitable pressure to enhance the efficacy of pulpal anesthesia. However, the factor that ultimately decides the effectiveness of IPA is the pressure exerted during IPA administration [7,8,15,18,19].

4. Pressure

Pressure plays a pivotal role in the successful execution of IPA. An average pressure of approximately 170 psi is typically required [22]. The delivery of the anesthetic solution with substantial backpressure induces profound and rapid anesthesia. The requisite pressure varies depending on the dimensions and layout of the pulp chamber and the canal being injected [27]. In essence, the precise pressure needed for each injection may vary depending on specific circumstances and requires clinicians to rely on their expertise.

ADVANTAGES OF IPA

a) The onset of IPA is immediate, and it is highly successful in achieving profound anesthesia when the operator employs the appropriate technique [17].

b) IPA requires no special armamentarium, unlike the other supplemental anesthetic techniques, such as intraligamentary and intraosseous anesthesia [11].

c) Systemic effects are non-existent or negligible, since the volume of the anesthetic solution employed is minimal [9].

LIMITATIONS AND DISADVANTAGES OF IPA

a) IP anesthesia has a relatively brief duration of effect, often lasting approximately 15–20 min. The clinician must work quickly and efficiently to complete the required treatment within this short period to guarantee the patient's comfort [11,23].

b) IPA cannot be used as a primary injection and is considered to be the most painful injection. Introducing the needle into the pulp tissue activates type A nerve fibers, producing an initial sharp sensation. Additionally, injecting a local anesthetic solution increases the interstitial tissue pressure by expanding type A and C fibers. Hence, the cumulative effect of increased interstitial pressure and direct nerve damage directly triggers the nerve fibers, causing intense pain and significant patient discomfort [8,28]. However, one of two techniques can be employed to reduce the pain. First, a small amount of 20% topical benzocaine gel, combined with hyaluronidase, can be applied before IP injection into the exposed pulp. Hyaluronidase is an enzyme that hydrolyses hyaluronic acid, the main component of connective tissue. It promotes drug diffusion into the pulpal connective tissue, resulting in mild-to-moderate anesthesia of the exposed superficial pulpal tissue [16]. Second, a 31-gauge needle with a short length of approximately 6 mm can be employed. A 31-gauge needle is preferred over thicker needles for the injection technique, because its small diameter enables deeper penetration into the pulp chamber [8,29].

c) Clinicians are required to be mindful of interactions between endodontic irrigants and anesthetic solutions. Sodium hypochlorite, a commonly employed irrigation solution for dissolving pulp tissue in endodontics, interacts with local anesthetic solutions, such as lidocaine hydrochloride (with or without adrenaline), and may contribute to the formation of the toxic precipitate, 2,6-xylidine, which is a known carcinogen. However, clinicians neglect this crucial interaction because only a small volume of local anesthetic solution is required [30].

d) IPA has challenges in some instances. While IPA is recommended for teeth with vital pulps, it is contraindicated for cases with partial pulp necrosis. In such cases, the apical extrusions of the anesthetic solution, necrotic debris, and pulp tissue may evoke an inflammatory reaction in the periapical area [31]. Additionally, in cases of teeth with significant canal calcification or severe uncontrollable bleeding, the clinician may fail to achieve profound pulpal anesthesia, even after administering IPA [32].

FUTURE DIRECTIONS

IPA is a sophisticated technique that can achieve complete anesthesia. However, additional research is necessary to compare the effectiveness of IPA with other supplemental anesthesia techniques commonly used in endodontics by utilizing different anesthetic solutions and modern instruments used for administering anesthesia. Comparative studies with significant sample numbers and rigorous procedures may yield robust information concerning the efficacy, pain control, and patient satisfaction achieved when using IPA [9].

IPA, being one of the most painful methods of anesthesia, necessitates future research to focus on topical anesthetic gels or sprays with advanced formulations and the invention and adaption of fine needles to minimize the discomfort experienced during its administration [8,33].

In brief, the future of IPA in endodontics shows excellent prospects. By employing inventive methods, customized strategies, enhanced anesthetic solutions, and cutting-edge needles, and with collaborative efforts across multiple disciplines, IPA can continue to advance, offering patients better comfort, with reduced anxiety, and offering dental professionals superior treatment outcomes [34].

CONCLUSIONS

IPA is an invaluable supplemental anesthetic technique that is utilized as a last resort to achieve complete pulpal anesthesia when all other anesthetic techniques have been unsuccessful. Obtaining informed consent from the patient and employing precise techniques, with careful clinical judgment, during the administration of IPA is crucial to attaining a success rate of 100%. While it is undeniable that IPA has numerous benefits, it is essential to recognize its limitations and drawbacks to ensure its careful and safe application. Investigating new research fields, such as the development of innovative anesthetic agents and fine needles, can enhance precision and reduce pain perception during administration, thereby enhancing the predictability of IPA. In summary, IPA represents a cornerstone in endodontics, enabling pain management, particularly in situations involving hot teeth, and facilitating efficient pain control.

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