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REVIEWS

INTRALIGAMENTARY ANESTHESIA: BIOLOGICAL BASIS, TECHNIQUES, AND CLINICAL APPLICATIONS. A NARRATIVE REVIEW

Vesela Hristova

Department of Conservative Dentistry and Oral Pathology, Faculty of Dental Medicine, Medical University of Varna, Bulgaria

ABSTRACT

Intraligamentary anesthesia (ILA), also known as periodontal ligament injection, is a local anesthetic technique used as an alternative or supplementary approach in dental practice for both maxillary and mandibular procedures. The technique involves the administration of a small volume of local anesthetic solution into the periodontal ligament space, allowing diffusion of the anesthetic agent into the surrounding cancellous bone and neural structures. This mechanism provides a rapid onset of anesthesia with minimal soft tissue numbness and reduced systemic exposure. Clinical and experimental evidence suggests that ILA can provide anesthetic efficacy comparable to conventional nerve block techniques in selected clinical situations, including restorative procedures and tooth extractions in pediatric and adult patients. The use of computer-controlled local anesthetic delivery systems has further improved the precision and patient comfort of ILA by regulating flow rate and injection pressure despite its advantages. Intraligamentary anesthesia remains a technique-sensitive procedure with potential limitations related to operator skill and injection pressure. When performed according to established clinical protocols, it is considered a safe and effective method with a low incidence of adverse effects. This study aims to analyze the anatomical, pharmacological, and clinical aspects of ILA, focusing on its indications, techniques, advantages, limitations, and safety considerations within contemporary dental practice.

Keywords: *intraligamentary anesthesia, periodontal ligament injection, local anesthesia, computer-controlled delivery systems, dental pain management*

Address for correspondence:
Vesela Hristova
Faculty of Dental Medicine
Medical University of Varna
84 Tzar Osvoboditel Blvd
9002 Varna, Bulgaria
e-mail: vesseladobreva@abv.bg

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INTRODUCTION

Pain control is a fundamental component of dental treatment and plays a critical role in patient comfort, cooperation, and overall treatment success. Local anesthesia remains the most commonly used method for pain management in dentistry, enabling clinicians to perform a wide range of diagnostic and therapeutic procedures effectively (1,2,3). De-

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spite continuous advancements in anesthetic agents and delivery techniques, achieving predictable and profound anesthesia—particularly in the mandibular region—continues to represent a clinical challenge (4,5,6). Conventional local anesthetic techniques, such as infiltration anesthesia and inferior alveolar nerve block, are widely accepted as standard approaches in daily dental practice. However, these techniques may be associated with several limitations, including delayed onset, incomplete anesthesia, prolonged soft tissue numbness, and an increased risk of nerve-related complications (7,8,9). In addition, fear of injections and dental anxiety remain significant barriers to dental care and are frequently cited as major reasons for avoidance or postponement of treatment (10,11,12). Intraligamentary anesthesia (ILA), also known as periodontal ligament injection, was introduced as an alternative local anesthetic technique designed to overcome some of these limitations. The method involves the injection of a small volume of local anesthetic solution under pressure into the periodontal ligament space. This allowing diffusion of the anesthetic agent into the adjacent cancellous bone and terminal nerve fibers (13,14,15). Due to its intraosseous mechanism of action, ILA provides a rapid onset of pulpal anesthesia while minimizing unwanted soft tissue numbness (16,17,18).

The technique was first described in the early twentieth century; however, its widespread clinical adoption was initially limited by inadequate delivery systems and concerns regarding potential periodontal tissue damage (19,20). The subsequent development of pressure-controlled syringes and, more recently, computer-controlled local anesthetic delivery systems has significantly improved injection precision, pressure regulation, and patient comfort (21,22,23). These technological advances have renewed interest in ILA, particularly in pediatric dentistry and in patients with increased dental anxiety (24,25,26). Recent randomized clinical trials and comparative studies have demonstrated that ILA may achieve anesthetic efficacy comparable to inferior alveolar nerve block in selected clinical situations (27,28,29). The limited duration of anesthesia and reduced soft tissue involvement further contribute to a lower incidence of postoperative complications such as accidental lip or tongue biting, especially in children (30,31).

Despite these advantages, ILA remains a technique-sensitive procedure. Improper needle placement or excessive injection pressure may result in postoperative discomfort or transient periodontal tissue irritation (32,33). Therefore, thorough knowledge of the underlying anatomical, pharmacological, and technical principles concerning ILA is essential to ensure its safe and effective clinical application.

AIM

The aim of this study is to analyze the clinical role of ILA in modern dental practice, with emphasis on its indications, techniques, advantages, limitations, and safety profile in comparison with conventional local anesthetic approaches.

MATERIALS AND METHODS

We examined the PubMed, Scopus and Web of Science archives for relevant literature on the subject. Every article under examination was released between 1981 and 2023. The keywords used for this search included: intraligamentary anesthesia, periodontal ligament injection, local anesthesia, and their combinations.

RESULTS

Anatomical and Pharmacological Basis

The periodontal ligament is a specialized connective tissue situated between the cementum and the alveolar bone, characterized by rich vascularization and dense innervation. It contains mechanoreceptors and nociceptive fibers responsible for transmitting pain during dental procedures (34,35). These anatomical features allow the periodontal ligament to function as an effective pathway for the diffusion of local anesthetic agents into the adjacent cancellous bone (36).

During ILA, the anesthetic solution is delivered under controlled pressure into the periodontal ligament space, from where it penetrates the cribriform plate and reaches the medullary bone spaces (37). This intraosseous diffusion enables rapid anesthetization of terminal nerve endings supplying the dental pulp, resulting in a fast onset of pulpal anesthesia (38). Pharmacologically, commonly used agents for

ILA include lidocaine and articaine, frequently combined with vasoconstrictors such as epinephrine to prolong anesthetic action and reduce systemic absorption (39). The small volume of solution required minimizes the risk of systemic toxicity while maintaining adequate anesthetic depth (40). The limited duration of anesthesia and absence of extensive soft tissue numbness are characteristic advantages of this technique. It makes it suitable for short dental procedures and pediatric patients (41).

Techniques of Intraligamentary Anesthesia

Intraligamentary anesthesia is performed by injecting a small volume of local anesthetic solution directly into the periodontal ligament space under controlled pressure. The injection is typically administered at the mesiobuccal and distobuccal aspects of the tooth. The needle is positioned at a shallow angle to the long axis of the root to ensure accurate placement within the ligament (42). Conventional ILA can be delivered using standard dental syringes or specially designed high-pressure syringes, which allow the clinician to generate sufficient pressure for effective diffusion of the anesthetic solution (43). However, excessive pressure may increase the risk of tissue trauma or postoperative discomfort, emphasizing the importance of controlled injection technique (22). The introduction of computer-controlled local anesthetic delivery systems (CCLADS) has significantly improved the precision and comfort of ILA. These systems regulate the flow rate and pressure of the anesthetic solution, reducing pain during injection and enhancing patient acceptance, particularly in pediatric and anxious patients (44). The volume of anesthetic solution required for ILA is minimal, usually not exceeding 0.2 mL per root. Slow administration is essential to allow adequate diffusion and to minimize discomfort (45). Proper needle stabilization and avoidance of repeated punctures are critical to achieving consistent anesthetic success (46).

Advantages and Limitations of Intraligamentary Anesthesia

Intraligamentary anesthesia offers several clinical advantages that make it a valuable alternative to conventional local anesthetic techniques. One of its primary benefits is the rapid onset of pulpal anesthesia combined with minimal soft tissue numbness. This significantly reduces the risk of postoperative soft tissue injury (47). The technique requires a small volume of anesthetic solution, resulting in decreased systemic exposure and a lower likelihood of toxic reactions. This feature is particularly beneficial in pediatric dentistry and in medically compromised patients (48). Additionally, ILA can be effectively used in cases where conventional nerve blocks are contraindicated or have failed (49). However, ILA is highly technique-sensitive. Inadequate needle positioning, insufficient pressure, or anatomical variations in the periodontal ligament may lead to reduced anesthetic success. Excessive injection pressure has been associated with postoperative discomfort and transient periodontal tissue irritation (50).

DISCUSSION

Achieving predictable and deep analgesia in dental practice remains a major challenge, especially in the mandibular region. Conventional inferior alveolar nerve block (IANB) is considered the standard approach, but its failure rate is clinically significant by Kaufman et al. (12) and Wong & Jacobsen (31). This failure is often due to anatomical variations, accessory innervation, or local tissue acidosis in cases of acute inflammation (22). In this context, ILA is emerging as a valuable alternative and complementary method, the advantages, limitations, and clinical safety of which require detailed analysis. The question of whether ILA can completely replace conventional methods has been the subject of long-standing debate. Early studies by Walton & Abbott (10) and Smith et al. (11) identified intraligamentary injection as a reliable method with a rapid onset, but reported that the duration of pulpal anesthesia was shorter compared to IANB. Modern clinical studies have shown similar results. Youssef et al. (5) and Orafi et al. (4) demonstrated in randomized controlled trials that in the extraction of lower molars, ILA provides a therapeutic effect comparable to that of IANB, but with the advantage of no prolonged soft tissue numbness.

The available evidence supports ILA as a reliable adjunct or alternative to traditional anesthetic techniques when applied correctly. Its effectiveness depends largely on operator skill, appropriate case selection, and the use of controlled delivery systems. In teeth with irreversible pulpitis, standard IANB often does not provide complete comfort due to al-

tered sodium channel expression and tissue hyperemia (13). Coggins et al. (20) and Kanaa et al. (32) demonstrated that the administration of ILA immediately after a failed IANB dramatically increased the success rate of subsequent endodontic treatment. In terms of volume, the clinical trials of Aggarwal et al. (24) emphasized that the volume of additional injected solution should be strictly controlled; increasing the dose above the recommended rates (about 0.2 mL per root) did not significantly increase the success rate, but increased the risk of postoperative discomfort.

The introduction of computer-controlled local anesthetic delivery systems (CCLADS, e.g., The Wand) has completely changed the predictability of the technique. Clinical studies by Elbay et al. (2) and Helmy et al. (3) have shown that CCLADS adjusts flow rate and pressure in real time, taking into account tissue resistance. Nevertheless, further standardized clinical studies are needed to establish optimal protocols and long-term effects on periodontal tissues (51).

CONCLUSION

Intraligamentary anesthesia is an effective adjunctive technique in modern dental practice, characterized by rapid onset and localized anesthetic action. Its limited soft tissue involvement and favorable safety profile make it particularly useful when conventional anesthetic techniques are insufficient. Although it cannot replace traditional methods in all clinical situations, ILA enhances anesthetic success when applied appropriately. Proper technique, careful case selection, and adequate operator training are essential for achieving predictable and comfortable clinical outcomes.

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