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# Recent Advances in Local Anesthesia: A Review

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## Abstract

Although local anaesthetics are the primary analgesic used in dentistry, they are also the foundation for pain management during a variety of routine and intricate dental procedures. Nevertheless, contemporary research is increasingly looking for novel and more efficient ways to modify analgesia in order to enhance clinical results and patient satisfaction. The development of better anaesthetic medications with enhanced safety and efficacy profiles, the creation of novel and improved delivery systems that enable more accurate and comfortable administration and the investigation of alternate strategies that could supplement or improve conventional methods are the main areas of the present academic activity. Modern dental technologies now give doctors the ability to give patients good pain management by making injections less painful, lowering patient anxiety, and avoiding bad physical or mental effects. The goal of all of these improvements is to make dental care more bearable and acceptable for a wider range of patients. This literature review organizes the current body of evidence in a way that helps dental professionals learn how to use modern local anaesthetics, different technical methods, and other treatments effectively. By assembling together all the existing literature that is out there, the intention is to help professionals find ways to make dental care less painful, more efficient and more comfortable for patients.

**Keywords:** Dentistry, Local Anesthesia, Pain Management, Recent Trends,

## Introduction

According to the definition of the International Association to Study Pain (IASP), pain is an unpleasant experience of sensation and emotion linked to actual or potential tissue injury or expressed in terms of tissue injury (1). Clinicians, healthcare providers and even the public health authorities have extensively supported this definition and it has been adapted by a number of governmental and non-governmental organizations such as the world health organization (WHO) (1). Various definitions have been formulated, such as Monheim defines pain as unpleasant emotional perception typically aroused by a noxious stimulus and propagated through a specialized neural network to the Central Nervous System (CNS) where it is perceived as such pain (2).

The delivery of local anesthetic is essential to the modern dentistry. The dentists have a range of tools and procedures to attain local anesthesia. Even though this is, patients often complain of significant anxiety and distress when subjected to dental interventions despite the supposed mitigatory function of local anesthetic in reducing the perception of pain. This means that the dental practice needs to be effectively managed through analgesics (3). The present range of local anesthetic agents to use on the maxillary and mandibular extremes are adequate in the majority of clinical cases. They are used in invasive dental practice, such as surgery, deep scaling and root planning, cavity preparation, and the requisite pulp therapy. The exception being the routine check-ups, scaling, oral prophylaxis, and fluoride application, local anesthetic is administered in most dental procedures, depending on the pain threshold and anxiety level of the individual (4).

Numerous approaches have been promoted in order to minimise the pain that comes with the use of local anaesthetic agents. They include the use of different anaesthetic gels, distraction, warming of anaesthetic agents, slowing of the rate of injection and buffering of local anaesthetic solutions. This review aims at giving reliable and evidence-based



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details to dentists with regards to modern local anesthetics, alternative methods, and techniques of pain management during administration of anesthetics so as to promote patient comfort (5, 6). This review involves an integrative approach, looking at both the pharmacological effects of new anesthetics and the pros and cons of other pain treatment methods.

Articaine and Centbucridine are the comparatively new agents which have proven their effectiveness which can be compared, and even better, with lignocaine (7). Articaine is an amide based local anesthetic with an ester side chain which is metabolised by tissue esterases and a thiophene ring in place of the benzene backbone. It has a long half-life and is excreted at a long rate. Its metabolism in the liver and blood is greatly mediated by plasma esterases (8). Articaine has a greater duration of action and a faster onset than lignocaine which leads to a greater success rate. It is about 1.5 times stronger than other agents and is linked with a lower systemic poisoning (9). Similar to prilocaine, articaine is involved in the occurrence of neuropathies and methemoglobinemia. Both the agents are linked to a higher occurrence of paresthesia especially of the lingual nerve, which shows a higher neurotoxic potential as compared to lidocaine. Interestingly, the use of articaine, particularly as an infra-orbital nerve block, has been associated with ocular complications, which is believed to be caused by its high tissue diffusion (3).

Centbucridine is a derivative of quinolones, synthesized in 1983 at the Centre for Drug Research, Lucknow, India and has local anesthetic effects as well as antihistaminic and vasoconstrictive effects. It is useful in spinal anesthesia, nerve block as well as infiltration procedures at a concentration of 0.5 per cent. Its anesthetic effect is 4-5-fold more potent than 2% lignocaine. Its use in management of dental pain although widely applied in ophthalmology and other medical disciplines is little explored. Gune and Katre have described Centbucridine to be used as an alternative in patients between 12 and 14 year of age with hypersensitivity, cardiac and thyroid conditions where vasoconstrictors should be avoided (10).

Even though most clinical situations work well with regular local anesthetics, they do have some drawbacks. Concerns about systemic toxicity, neurotoxicity, and patient-specific contra-indications make it impossible to use existing agents on everyone. Additionally, numerous adjunctive pain reduction techniques are sensitive to technique and heavily dependent on the operator's skill, potentially restricting their consistent efficacy in standard clinical environments.

# Review of Literature

## Alternative Practices

### Electric Dental Anesthesia

This is a non-pharmacological method that uses transcutaneous electrical nerve stimulation (TENS) to provide therapeutic electric currents. The lack of syringes reduces the anxiety of children and promotes compliance, which makes it appropriate to use with the children patients. Adults TENS is also used in analgesia during procedures such as rubber dam placement, cavity preparation, pulp capping, endodontic treatment, preparation of prosthetic teeth, oral prophylaxis, extractions and in reducing the pain of local anesthetic injections (8).

TENS (Transcutaneous Electrical Nerve Stimulation) has various applications in dentistry and pain management. In pediatric patients, its use helps alleviate the fear associated with syringes, promoting positive behaviors and reducing anxiety. In adults, TENS aids in pain management during procedures such as rubber dam placements, cavity preparations, pulp capping, endodontic surgeries, prosthetic tooth preparations, oral prophylaxis, and extractions, as well as in preventing injection pain (11). It is also beneficial in treating chronic pain conditions like temporomandibular joint syndrome, trigeminal neuralgia, and post-herpetic neuralgia. Furthermore, TENS can improve salivary flow in xerostomic patients by stimulating the skin-overlying parotid gland. However, there are contraindications to its use. It is not recommended for patients who are fearful, uncooperative, disabled, or mentally impaired. Additionally, TENS should not be used in patients with cardiac pacemakers due to the potential for interference, or in those with a history of aneurysm, stroke, or transient ischemia due to the risk of increasing peripheral blood flow. It is also contraindicated in individuals prone to seizures, as TENS pulses may trigger them, and during pregnancy, as it lacks FDA approval and poses unknown risks (12). The

mechanism of action behind TENS is explained by two primary theories. The Gate Control Theory, proposed by Melzack and Wall (1965), suggests that pain signals traveling through small, unmyelinated C fibers are inhibited when large, myelinated A fibers are simultaneously activated. This results in the reduction of pain transmission through the substantia gelatinosa in the dorsal horn of the spinal cord, which serves as a gate regulating sensory input (13).

**Cryoanesthesia**

Cryoanalgesia uses ice or cryogenic sprays to locally cool tissues thus stopping neuronal pain signalling. Topical cooling stimulates myelinated A-fibres, whereby, it activates pain-inhibitory mechanisms and causes neuropraxia through the reduction of the nociceptor thresholds and conductance. Hindocha et al. found that 5 per cent lidocaine gel when applied at the time of needle insertion provides similar effects as the use of topical cold that has been applied before insertion (8). The topical anesthetic remains effective a number of minutes after its application. Bose et al. have revealed that precooling soft tissues are beneficial to alleviate discomfort on infiltrations in children and enable anesthesia (14). Cryoanesthetic agents are crushed ice, cubed ice as well as refrigerant sprays (14).

**Iontophoresis**

Iontophoresis is a procedure which increases the transdermal concentration of topically applied drugs by using a low-strength electric current, which is used to increase the permeability of charged drug molecules through the skin (15).

Drugs in positively charged forms like lignocaine and adrenaline can be induced to enter tissues at the impact of an electric field. The device consists of two electrodes which are attached to an electrical circuit. One of the electrodes is located above the tooth to be treated and the other is located on the skin on the wrist, low voltage of direct current (03-mA) is then introduced into the tooth using the iontophoretic device which flows through the skin, the skin connective tissue, and then through the same pathway to reach the electrode on the return electrode. The same way the electric current follows the same path so do the ions of the drug. The procedure could develop 20-60 better drug penetration compared with topical application (16).

## Recent Developments in the Field of Local Anesthesia Delivery Devices

Some modern tools to attenuate needle anxiety act on the concept in the gate-control theory of pain management, which holds that pain may be reduced by simultaneously stimulating peripheral nerve fibres by vibration. Inui et al. however showed that pain suppression is produced by tactile input and the process is mediated by non-noxious touch or vibration and does not depend on the input to the spinal cord, such as descending inhibitory influences on spinal neurons (17).

**VibraJect**

The vibrating dental local anesthetic is VibraJect, which has been recently launched. It oscillates the injection needle at a high rate that is felt by the patient.

**Buzzy System**

This product consists of two parts, the vibration unit mounted on the body and removable cold-conducting wings, and its outward shape is similar to a bee. It operates on the basis of the gate control theory and the descending inhibitory systems. Particularly, it is the induced vibration that is suggested to suppress A-delta and C afferent pain-receptive fibers and, thus, decrease sensations of nociceptors. On the contrary, prolonged application of cold stimulates C nociceptive fibers and inhibits A-delta messages as long as it is applied near the nociceptive location. Suohu et al. prove that the unpleasant experience and anxiety of children during the administration of local anesthetic near the tooth (which is required to make invasive dental treatment) can be alleviated with the Buzzy system, which produces external cold and vibration (18).

Recent advancements in local anesthesia have focused not only on pharmacological innovation but also on alternative delivery systems aimed at reducing pain, anxiety, and injection-related complications. These include needle-free technologies, jet injectors, intraosseous delivery systems, and computer-controlled local anesthetic delivery (CCLAD). While these modalities demonstrate promise, a critical appraisal of their clinical effectiveness, limitations, and feasibility is necessary.

# Discussion

## Quick Sleeper

This is used where anesthetic solution is given with constant pressure and velocity to reduce the unpleasant feeling of injection. The system is made up of a handpiece and a control module. The foot pedal sends signals, through Bluetooth, to the main control box. When the circuit is completed, the handpiece drills and injects the anesthetic into intrabony/ cancellous bone tissues, thus achieving a maximum effect in anesthetic usage. (17). Smal-Faugeron et al. argue that with the QuickSleeper. technology, the dental practitioners will be able to treat young patients and adolescents easily because the technology lowers patient discomfort and anxiety (19).

## Tetracaine/Oxymetazoline Spray in the Nose

The long-acting water-soluble ester tetracaine is a local anesthetic which is five or eight times stronger than cocaine when used topically. The plasma pseudocholinesterase breaks down tetracaine; its injections and topical application are used at the concentrations of 0.15 and 2 per cent of the metabolized material, respectively. In nasopharyngeal and nasal environment, it is common to use tetracaine before surgical and exploratory measures are taken (20). After the initial 0.2 of 0.2mL sprayed on the ipsilateral nostril after every four minutes, a third spray was made in case of necessity. The overall success rate of pulpal anesthesia using the agent to provide restorative treatments in maxillary incisors, canines and premolars was 88% with a confidence interval of 95% (21).

In cases where a single tooth of the mandible only needs to be anaesthetized, intra-ligamentary injection (ILI), also known as the periodontal ligament injection, has been a very effective method. Localized soft-tissue anesthesia only takes place after the PDL injection causes pulpal analgesia. A jaw injection does not result in any extra-oral or lingual numbness as does a conventional inferior alveolar nerve block. The possibility of leakage of the local anesthetic solution into the oral cavity of the patient and the challenge of defining the accurate site of needle insertion (in or at the PDL entry) limits this. High pressure is needed to inject the local anesthetic by the conventional syringe into the dense tissues of the mouth at the PDL injection site (22).

# Conclusion

Local anesthesia is still a key part of modern dentistry because it lets dentists do a wide range of diagnostic, preventive, and therapeutic procedures while keeping patients comfortable and the procedures running smoothly. Even though traditional methods are still very effective and widely used in everyday clinical settings, recent developments in drugs, new delivery systems, and non-drug adjuncts have greatly increased the tools available to dentists. When looked at closely, these newer methods show clear improvements in patient comfort, faster onset of anesthesia, and a big drop in anxiety and fear related to dental treatment. However, they are often not used as much because they cost more, take longer to do, and require more technical knowledge and training. So, a combined approach that carefully mixes tried-and-true local anesthetic methods with carefully chosen new technologies seems to be the best, most practical, and most clinically effective way to do every day dental work. In the future, research should focus more on looking at the long-term clinical outcomes and patient-reported experiences of these newer treatments, as well as how cost-effective they are in different clinical settings. There should also be more focus on creating standardized training protocols and clinical guidelines. This would make it easier to safely, logically, and widely use new anesthetic technologies in routine dental care while keeping the quality and results consistent.

## Abbreviations

CNS: Central Nervous System, IASP: International Association for the Study of Pain, TENS: Transcutaneous Electrical Nerve Stimulation, WHO: World Health Organization.

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Zaki Sayyed: Conceptualization, literature review, writing of the manuscript, Yashmin Parveen: methodology, data analysis, writing of the manuscript, Firdous Jahan Sayed: writing of the manuscript, reviewing and editing, Syed Faraz Ali: literature review, reviewing and editing, Saad Maknojia: data analysis, reviewing and editing, Khan Tarannum Ayyub: reviewing the manuscript, supervision.

## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

## Declaration of Artificial Intelligence (AI) Assistance

The authors confirm that the research, writing, and analysis were conducted by the listed authors. AI assistance was not involved in any part of the writing or review process.

## Ethics Approval

This manuscript does not contain any studies with human or animal subjects, as it is a narrative review based on existing literature.

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