

REVIEW

Local Anesthesia in Pediatric Patients – a Review of Current and Alternative Methods, Devices and Techniques

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Painless treatment is an integral element of quality pediatric dental care. Recent progress in the field of local anesthesia has led to development of newer agents, delivery devices and also modification in injection techniques. Their aim is to allow the clinician a treatment approach associated with the improved pain control and reduced risk of adverse effect essential for pediatric patients. This article reviews available information on current and alternative means, methods and technologies for achieving local anesthesia in pediatric patients intended to minimize the pain associated with the procedure.

BACKGROUND

Pain management is a critical aspect of pediatric dental care. Fear associated with seeing and experiencing needle penetration, sensation of swelling soft tissues and prolonged numbness as well as allergic reactions to the anesthetic fluid, are the most common factors causing patients and dental clinicians to experience anxiety regarding the use of infiltration local anesthesia. Exploring new alternative and atraumatic methods will help improving the quality of care in pediatric dentistry.

Recent advances in the field of anesthetic agents, delivery devices and techniques for local anesthesia, allow the clinician a treatment approach associated with improved pain control, reduced injection pain and fewer adverse effects. The current progress has led to development of newer agents, refined equip-

ment and also modification in techniques. Their aim is to attain painless application, reduction of the area and duration of collateral soft-tissue anesthesia, as well as a prospect of rapid sensation recovery after manipulation.

This article reviews the available information on current and alternative means, methods and technologies for achieving local anesthesia in pediatric patients, intended for minimizing the pain associated with the procedure.

I. PHARMACOLOGICAL LOCAL PAIN MANAGEMENT

Chemically induced local anesthesia is achieved by creating a depot of an anesthetic agent in the tissues by a diffuse or vascular-diffuse mechanism. A classification of local anesthesia techniques has been developed lately based on this concept. The diffuse methods in it include topical, infiltration

and conduction anesthesia, while vascular-diffuse mechanism is observed in intraosseous, intraligamentary, intraseptal, and intrapulpal anesthesia. In this article, the recent advancements in local anesthesia are presented according to the induction mechanism of local anesthetic effect.

1. Diffuse local anesthesia

1.1. Topical anesthesia

a. Lidocaine patches

The lidocaine patch is a transoral delivery system of lidocaine via a mucoadhesive base attached to the oral mucosa. The anesthetic agent is absorbed by the mucosa and the reported onset of anesthetic effect is within 2 minutes of application and may last up to 30 minutes after removal.¹⁻³ Indications for use include superficial mucosal and gingival procedures, and topical analgesia before injectable local anesthesia.¹ Although the lidocaine patch is considered a good alternative to conventional topical agents by some authors^{2,4}, disadvantages include its high cost and poor adhesion to the oral mucosa⁵. Currently there is little and inconclusive scientific data available about its minimum effective dose, clinical efficiency and duration of action.

b. EMLA - cream

Mixtures of anesthetic agents aimed for topical anesthesia are called eutectic mixtures for local anesthesia (EMLA). Such formulations are considered to have lower melting points, which promotes easier absorption in the oral mucosa.⁶ Indications for use include procedures on the oral soft tissues causing minor pain. Following the introduction of EMLA cream, a 1:1 mixture of 2.5% prilocaine and 2.5% lidocaine, as topical anesthetic in dermatology², studies have been conducted to evaluate the safety and efficacy of administration to the oral mucosa. The use of EMLA in pediatric patients shows satisfactory results^{7,8}, although some authors report no significant difference between its efficacy and that of 5% lidocaine.⁹ Despite the various findings related to the potential of EMLA cream for use in dentistry, manufacturers do not recommend the use of cream on mucous membranes. Further studies are needed to determine the appropriate dose and duration of exposure in children to prevent the risk of overdosing and adverse effects.

c. Intranasal spray

This is a novel technique for achieving local anesthesia of maxillary teeth by infiltration of an anesthetic solution through the nostrils by a metered device⁵ (Fig. 1). It is hypothesized that the anesthetic solution diffuses through the nasal mucous walls

and affects the structures, involved in innervation of maxillary teeth.¹⁰ Its composition consists of a mixture of 3% tetracaine hydrochloride and 0.05% oxymetazoline. Besides its anesthetic properties, it also reduces the risk of bleeding due to the shrinkage of regional blood vessels without causing significant cardiovascular disturbance in healthy patients.¹¹ The method allows dental clinicians to perform conservative dental manipulations requiring pulpal anesthesia of maxillary frontal teeth, canines and premolars in adults and children weighing more than 40 kg.^{12,13} More studies on the effectiveness and safety of administration of the method for pediatric patients are necessary.



Figure 1. Kovanaze[®], St. Renatus - tetracaine HCL and oxymetazoline HCL in a metered device.

1.2. Infiltration anesthesia

a. Jet-injection

The jet-technology is also known as needleless injection (Fig. 2). It is based on the principle of using a mechanical energy source to generate pressure, allowing a thin stream of anesthetic fluid of sufficient strength to penetrate the soft tissues. It is assumed to have advantages over traditional infiltrative methods, presenting a rapid onset of soft tissue anesthesia, controlled delivery of anesthetic dose, obviation of intravascular injection and high patient acceptance in instances of needle-phobia. The absence of a needle in the manipulation suggests a positive psychological effect¹⁴, although results from clinical trials in children report preference of traditional infiltration over the jet-injector¹⁵. Limitations of the method include difficulty in positioning the device in the posterior region due to its size, contraindicated use for achieving nerve blocks, inadequate pulpal anesthesia and risk of small residual

hematomas.¹⁶ Conventional syringe infiltration has been found by some researchers to be more effective, acceptable, and preferred, compared with the needleless injection.^{8,15} There are very few controlled clinical studies involving pediatric patients. To date, the application of the jet-infiltration method in the dental practice is determined to be limited in comparison with classical infiltrative technique.



Figure 2. Med-Jet H-III – MIT, Canada – needle free injector.

b. Vibrotactile devices

The gate control theory of pain is a widely accepted concept of pain perception. In recent years, several innovative dental appliances have been developed on the basis of this theory - Accupal, DentalVibe (**Fig. 3**), Vibraject and others.⁵ Their concept is to reduce the pain of needle injection by applying pressure, vibration, micro-oscillations or a combination of them. The applied physical stimuli modify or interfere with pain signals by closing the neural gate of cerebral cortex, aimed to decrease the pain perception due to distraction. The number of clinical trials is insufficient to validate the method as effective in reducing injection pain, although some researchers report positive results.¹⁷⁻¹⁹

c. Modification in techniques - anterior middle superior alveolar (AMSA) and palatal approach to anterior superior alveolar (P-ASA) nerve blocks

These are two recently defined techniques for maxillary teeth analgesia without occurrence of



Figure 3. The DentalVibe® Comfort Injection System – a vibrotactile device, designed with the shape of cheek retractor and equipped with light for easier visualization of the operative field.

extraoral soft tissue anesthesia.²⁰ In childhood dental care this feature is critical due to the reduction of self-injury risk as a result of collateral lips and cheeks numbness, occurring with the use of traditional infiltration methods. With the introduction of computer-controlled anesthetic delivery systems, the use of these techniques provides a minimal level of discomfort to patients in childhood.²¹⁻²³ The AMSA nerve block achieves pulpal anesthesia of the maxillary incisors, canines and premolars on the side of the injection, while the P-ASA technique anesthetizes six frontal teeth, from canine to canine, as well as the palatal and labial gingiva, mucoperiosteum and bone covering these teeth.²⁰

The available studies regarding comparison of injection pain of AMSA and P-ASA nerve blocks application with CCLAD and traditional syringe are insufficient.²⁴ Further research is required for assessment of the effectiveness of both techniques, applied with traditional and computer-controlled anesthetic delivery systems.

2. Vascular-diffuse local anesthesia

a. Computer-controlled intraligamentary anesthesia

The computer-controlled local anesthetic delivery (CCLAD) systems present a technology for controlling the volume and flow rate of anesthetic solution through the needle. The STA (single tooth anesthesia) system is an intraligamentary CCLAD system with an additional function for dynamic pressure sensing, providing real time feedback to the practitioner (**Fig. 4**). The advantage is the rapid onset of profound pulpal anesthetic effect, with mild to moderate injection pain.²⁵ The prolonged duration of the anesthetic administration could be considered a drawback for pediatric patients. Safety precautions should be considered when intraligamentary anesthesia is applied on primary teeth close to developing permanent teeth, as some researchers report risk of enamel hypoplasia occurrence.²⁶

An increasing number of clinical trials demonstrate measurable benefits of the technology.^{25,27} The effectiveness of the system in comparison to conventional syringe infiltration, in reducing dental anxiety and injection pain in pediatric patients, is a subject of clinical research with controversial results.^{24,28-30}

b. Computer-assisted intraosseous anesthesia (CAIO)

Intraosseous anesthesia is considered to be a successful alternative to conventional anesthetic infiltration by some authors, as the anesthetic agent



Figure 4. The Wand® STA, Milestone Scientific – a computer controlled local anesthesia delivery system with dynamic pressure sensing DPS®.

is injected directly into the cancellous bone adjacent to the tooth required to be anesthetized.³¹ Computer-controlled intraosseous anesthesia delivered with constant velocity and pressure of the anesthetic solution, is found to reduce the injection pain and the time of onset of the anesthetic effect (**Fig. 5**). The following are predisposing factors for successful application in pediatric patients.^{5,32} Two main techniques of CAIO application are mentioned by authors - trans-septal and osteocentral infiltration. Consideration should be given to the location of



Figure 5. The Quicksleeper 5®, Dental Hi Tec – a system for computer controlled local anesthesia delivery, equipped with DHT needles enabling injection in the center of the spongy bone close to the apex.

permanent teeth germs when applying the method in primary dentition.

II. NON-PHARMACOLOGICAL LOCAL PAIN MANAGEMENT

1. Laser analgesia

Laser analgesia is a non-invasive, non-thermogenic biomodulation of the dental pulp reactivity.³³ It is based on the concept that parallel with the ablative laser action, simultaneous low-level laser therapy (LLLT) can be observed.³⁴ This is not profound anesthesia (a complete lack of sensation), as the one achieved by infiltrative local anesthesia. Laser pulses alter the behavior of a neuronal cell membrane causing a temporary disruption of the Na-K pump.³⁵ This leads to loss of impulse conduction, and thus an analgesic effect is achieved.³⁶ The analgesic effect, together with the lack of contact and vibration in the manipulations, are prerequisites for accepting laser treatment as effective in reducing the anxiety associated with dental treatment in children and adolescents.³⁶⁻³⁸

2. Electronic dental anesthesia (EDA)

Electronic dental anesthesia (EDA) is a technique for achieving local anesthesia by the application of electrodes, providing transcutaneous electric nerve stimulation (TENS). It is mainly used as a supplementary method to conventional local anesthesia. The limitations of this method include increased salivary flow and an inability to use metal instruments freely.³⁹ Using TENS is found by some authors to have a positive impact on childhood behavior, reducing anxiety levels in needle-phobic patients.⁴⁰ Although EDA cannot replace injectable local anesthesia, it can be used to relieve pain during various minor dental procedures in pediatric patients, due to its analgesic and nonpharmacological physiological effect.³⁹⁻⁴¹

3. “Virtual anesthesia”

Pain management for routine interventions in childhood dental care is considered to be of critical importance. The most widely used behavioral techniques for relieving dental anxiety are verbal. The current progress in the field of virtual reality devices presents more engaging forms of distraction. Despite some limitations, researchers in this field have successfully demonstrated its feasibility and patient satisfaction because of decreasing pain associated with medical interventions.⁴² Controlled clinical trials, albeit a few, report subjective and objectively assessed reduction in pain perception and anxiety levels during dental procedures in pediatric patients.⁴³⁻⁴⁶ These preliminary results suggest that immersive VR may be a potentially viable adjunctive



Figure 6. Dental treatment with virtual reality distraction at the Department of Pediatric Dentistry, Medical University – Plovdiv. The device used is Noon VR, FXGear along with Iphone 7, Apple.

nonpharmacologic analgesia for procedural dental pain (**Fig. 6**). Virtual reality may also have analgesic potential⁴⁷, leading to new term creation - “virtual anesthesia”. Thus suggests that VR distraction may be a useful tool for dental clinicians and extensive research in this field is required to validate any efficacy of the method.

III. REVERSAL OF LOCAL ANESTHESIA

The prolonged duration of soft-tissue anesthesia is often an undesirable effect of infiltrative local anesthesia in dental patients. Self-induced soft-tissue trauma, a sensation of altered face appearance, impaired speech and eating are some of the post-operative side effects of local analgesia. These effects are more disturbing in pediatric patients. Various means for reversal of the local anesthetic action have been developed for a faster recovery from anesthesia. Phentolamine mesylate (OraVerse) is a short-acting alpha-adrenergic antagonist, leading to an increased clearance of local anesthetic solution from the injection site, reducing the duration of action. Since it is an antagonist to the vasoconstrictor and not to the anesthetic agent compound, it is mainly recommended for use in non-surgical treatment.⁴⁸ Controlled research reports high level of satisfaction of patients and dental practitioners.⁴⁸⁻⁵⁰ Despite its limitations, phentolamine mesylate is described as safe and effective means for reducing the duration of soft-tissue anesthesia induced by local anesthetic infiltration, and its associated functional deficits in adults and children after 6 years of age.⁵⁰

CONCLUSION

The safety and efficacy of the aforementioned products and techniques is a subject of current research studies. The integration of these advancements into the dental practice is still limited, due to their cost and low accessibility. Dental clinicians should be informed of the new developments in local anesthesia, as painless treatment is an integral element of quality dental care. In children and adolescents, it is an essential aspect of patient behavior management. The use of age-appropriate non-threatening terminology, distraction, topical anesthetics, as well as effective injection techniques, can serve to build up trust and promote dentist-patient relationship. The following is aimed to endorse positive dental health attitude throughout life.

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Местная анестезия при педиатрических пациентах - обзор текущих и альтернативных методов, механизмов и техник

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Безболезненное лечение является основным элементом качественной стоматологической помощи детям. Достижения последних лет в области улучшения местной анестезии привели к разработке новых агентов, механизмов применения, а также модификаций методов инъекций. Их цель - позволить клиницисту использовать подход к лечению для улучшения контроля боли и снижения риска побочных эффектов, которые имеют первостепенное значение для пациентов детского возраста. В этой статье представлен обзор доступной информации о существующих и альтернативных средствах, методах и технологиях применения местной анестезии для минимизации боли, связанной с процедурой.