Review Article

Advances in dental local anesthesia techniques and devices: An update

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ABSTRACT

Although local anesthesia remains the backbone of pain control in dentistry, researches are going to seek new and better means of managing the pain. Most of the researches are focused on improvement in the area of anesthetic agents, delivery devices and technique involved. Newer technologies have been developed that can assist the dentist in providing enhanced pain relief with reduced injection pain and fewer adverse effects. This overview will enlighten the practicing dentists regarding newer devices and methods of rendering pain control comparing these with the earlier used ones on the basis of research and clinical studies available.

Key words: Dental anesthesia, local anesthesia delivery device, local anesthesia delivery technique

Introduction

The most important skill required of all dental practitioners is the ability to provide safe and effective local anesthesia (LA). The injection of local anesthetic is perhaps the greatest source of patient fear[1,2] and inability to obtain adequate pain control with minimal discomfort remains a significant concern of dental practitioners.[3,4] The achievement of good local anesthesia requires knowledge of the agents being used, the neuroanatomy involved, and best techniques and devices available. The agents and anesthetic delivery equipments available today provide the practitioner an array of options to effectively manage the pain associated with dental procedures. This review focuses on the most recent developments in dental LA techniques and devices.

Local Anesthesia Delivery Devices

Although Cook invented the modern dental syringe nearly 150 years ago,[5] it is only recently that anesthetic delivery systems have seen major innovations. Although the traditional aspirating syringe still is the most common method by which local anesthetics are administered, newer technologies have been developed that can assist the dentist in providing enhanced pain relief with reduced injection pain and minimum adverse effects.

This section will discuss vibrotactile devices, computer-controlled local anesthetic delivery (CCLAD) systems, jet injectors, safety dental syringes and devices for Intra-Osseous (IO) anesthesia.

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Vibrotactile Devices

Some of the newer local anesthetic delivery systems aimed at easing the fear of the needle take advantage of the gate control theory of pain management,[6] which suggests that pain can be reduced by simultaneous activation of nerve fibers through the use of vibration. Inui and colleagues[7] have shown, however, that pain reduction due to non-noxious touch or vibration can result from tactile-induced pain inhibition within the cerebral cortex itself and that the inhibition occurs without any contribution at the spinal level, including descending inhibitory actions on spinal neurons.

VibraJect

It is a small battery-operated attachment that snaps on to the standard dental syringe. It delivers a high-frequency vibration to the needle that is strong enough for the patient to feel.[8] Researches evaluating the effectiveness of VibraJect, have shown mixed results. Nanitsos *et al.*,[9] and Blair[10] have recommended the use of VibraJect for painless injection. In contrast, Yoshikawa *et al.*,[11] found no significant pain reduction when VibraJect was applied with a conventional dental syringe. Saijo *et al.*,[12] evaluated the effectiveness of VibraJect in combination with an electrical injection device. They also found no statistically significant decrease in pain scores at needle insertion or anesthetic injection.

DentalVibe

Another system that uses vibration diversion based on the pain gate theory is recently introduced DentalVibe (BING Innovations LLC, Crystal Lake, IL, USA). It is a cordless, rechargeable, hand held device that delivers soothing, pulsed, percussive micro-oscillations to the site where an injection is being administered. Its U-shaped vibrating tip attached to a microprocessor-controlled Vibra-Pulse motor gently stimulates the sensory receptors at the injection site, effectively closing the neural pain gate, blocking the painful sensation of injections. It also lights the injection area and has an attachment to retract the lip or cheek.[13]

Accupal

The Accupal (Hot Springs, AR, USA) is a cordless device that uses both vibration and pressure to precondition the oral mucosa. Accupal provides pressure and vibrates the injection site 360° proximal to the needle penetration, which shuts the "pain gate," according to the manufacturer. After placing the device at the injection site and applying moderate pressure, the unit light up the area and begins to vibrate. The needle is placed through a hole in the head of the disposable tip, which is attached to the motor. It uses one AAA standard battery.[14]

Computer-controlled Local Anesthetic Delivery Systems

In the mid-1990s, work began on the development of local anesthetic delivery systems that incorporated computer technology to control the rate of flow of the anesthetic solution through the needle. This concept is now called computer-controlled local anesthetic delivery (CCLAD).[15] The first of these CCLAD devices, the Wand™ (Milestone Scientific, Inc., Livingston, N.J.), was introduced in 1997. Subsequent versions from same manufacturers were named Wand Plus and then CompuDent™, the current designation. In 2001, the Comfort Control Syringe (Dentsply International, York, PA, USA) was marketed as an alternative to the Wand. Examples of similar products include the QuickSleeper and SleeperOne devices (Dental Hi Tec, Cholet, France) and the Anaeject (Nippon Shika Yakuhin, Shimonoseki, Japan) and Ora Star (Showa Uyakuhin Kako, Tokyo, Japan) syringes.

Wand/Compudent system

This system enabled operator to accurately manipulate needle placement with fingertip accuracy and deliver the LA with a foot-activated control. The lightweight handpiece is held in a pen-like grasp that provides the user with greater tactile sensation and control compared to a traditional syringe. The available flow rates of LA delivery are controlled by a computer and thus remain consistent from one injection to the next. The greater control over the syringe and the fixed flow rates of the LA drug are responsible for a significantly improved injection experience, as demonstrated in many clinical studies conducted with CCLAD devices in dentistry.[16-19] A growing number of clinical trials in medicine also demonstrate measurable benefits of CCLAD technology.[20,21]

Comfort control syringe

The Comfort Control Syringe differs from the Milestone products in that there is no foot pedal. It has two main components: A base unit and a syringe. Several functions of the unit- most importantly injection and aspiration- can be controlled directly from the syringe, possibly making its use easier to master for practitioners accustomed to the traditional manual syringe. The Comfort Control Syringe has five pre-programmed speeds for different injection techniques and can be used for all injection techniques. Although, use of the Comfort Control Syringe may be more perceptive than that of the CompuDent system in the sense that the injection is controlled by hand, the syringe is bulky and more cumbersome to use than the Wand handpiece.[22] A comparison between the traditional dental syringe and the Comfort Control Syringe revealed no meaningful differences in ease of administration, injection pain and efficacy, and acceptance by patients.[4]

Jet Injectors

Jet-injection technology is based on the principle of using a mechanical energy source to create a release of pressure sufficient to push a dose of liquid medication through a very small orifice, creating a thin column of fluid with enough force that it can penetrate soft tissue into the subcutaneous tissue without a needle. Jet injectors are believed to offer advantages over traditional needle injectors by being fast and easy to use, with little or no

pain, less tissue damage, and faster drug absorption at the injection site.[8] Controlled studies evaluating efficacy are lacking, and reports are primarily anecdotal. To date, the effectiveness of the technique in dentistry has been reported to be limited.[23]

Syrijet

The Syrijet Mark II (Keystone Industries [aka Mizzy], Cherry Hill, NJ, USA) has been on the market for nearly 40 years and has had some minor improvements over the years. Some good features of the device is that it accepts the standard 1.8 mL cartridges of LA solution (thereby ensuring sterility of the solution), permits the administration of a variable volume of solution from 0 to 0.2 mL, and is completely autoclavable.[22]

MED-JET H III

MED-JET (Medical International Technologies, Montreal, QC, Canada) has been launched in 2011 with the manufacturer's claim that medication being injected with the device is directed through a small orifice 7 times smaller than the smallest available needle in the world. This extremely small stream of liquid under pressure pierces and then the remainder of the dose will be dispersed into the desired layer of tissue. The system's uniqueness is its ability to utilize low pressure delivery methods without compromising accuracy, convenience and ease of use - while ensuring patient comfort, environmental safety and user affordability.[24]

Safety dental syringes

In recent years there has been a move toward the development and introduction of 'safety' syringes in both medicine and dentistry. Use of a safety syringe minimizes the risk of accidental needle-stick injury occurring to a dental health provider with a contaminated needle after the administration of LA. These syringes possess a sheath that 'locks' over the needle when it is removed from the patient's tissues preventing accidental needle stick.[25] Both OSHA and the CDC have recommended that health care personnel should adopt safer work practices and consider using medical devices with safety features. Subsequent to this several syringes appeared in market. Surveys reported wide user dissatisfaction with many of the safety devices, however.[8] Results of a review and bench tests indicate that the devices tested were no safer than traditional anesthetic needles.[26] Most have disappeared from the market. There is still a need for safety syringes that will protect providers from needle-stick injury, and some are available on the market.

Ultra Safety Plus XL syringe

The Ultra Safety Plus XL syringe (Septodont, Lancaster, PA, USA) has a sterile disposable protective shield that is fitted with a dental needle into which anesthetic carpules are placed. The plunger assembly is reusable and autoclavable. The Ultra Safety Plus XL syringe provides protection from the needle because the needle is covered both before and after injection, and the needle does not have to be disassembled prior to disposal, which further protects the worker who is cleaning the dental tray. Providers who used this type of syringe reported that there was more time required for changing anesthetic carpules.[8]

UltraSafe Syringe

The UltraSafe syringe (Safety Syringes Inc, Carlsbad, CA, USA) is a disposable syringe and needle with a transparent, plastic syringe barrel, which has a retractable needle sheath. Providers can view the carpule contents through the clear plastic syringe barrel; this is further helpful in aspiration and in viewing anesthetic content, and also protects the provider from injury because the needle is covered before and after injection. The difference between this type of syringe and the Ultra Safety Plus XL syringe is that in the UltraSafe syringe the entire assembly is disposable and is not autoclavable.

HypoSafety Syringe

The HypoSafety syringe (Dentsply MPL Technologies, Susquehanna, PA, USA) is a translucent disposable plastic syringe and needle combination. The needle can be retracted into the barrel of the syringe after the injection. Therefore, the needle is covered before and after injection, which will minimize the chance of needle-stick injury for providers. The obstacle with this type of syringe is that the dentist is not able to re-expose the safety shield in order to administer a second injection if the needle has been bent; this can therefore delay the procedure and will require use of a second syringe in the case of a bent needle technique having been used.

SafetyWand™

In response to the Needlestick Safety and Prevention Act, the SafetyWand has been developed for use with the CompuDent system. The safety system has a pen-like grasp that allows maximum tactile control and an auto-retracting design that shields the needle when not in use. It is lighter than a traditional syringe, and the shield is operated with one hand, apparently making it safer to use. The manufacturer (Milestone Scientific Inc, Livingston, NJ, USA) claims that it is the first patented injection device to be fully compliant with OSHA regulations under the federal Needlestick Safety Act.[27]

RevVac™ safety syringe

The RevVac safety syringe operates the same as a standard conventional syringe. No additional training, skills, or procedures are necessary. It works on a simple

concept; where retracting and pressing the plunger creates a robust vacuum at the time of use. When the plunger reaches the bottom, after all medicine is administered, a further push on the plunger breaks the seal, and the needle retracts into the plunger. The syringe cannot be reused. The RevVac™ Safety Syringe is FDA Cleared.[28]

Devices for intra-osseous anesthesia

Several systems have been developed to achieve IO anesthesia. Although, significant differences exist among them, they all aim to inject local anesthetic solution into the cancellous bone adjacent to the apex of the tooth. These systems are: Stabident (Fairfax Dental, Miami, Florida), X-tip (Dentsply International Inc, Tulsa, OK, USA), and IntraFlow (Pro-Dex Incorporated, Santa Ana, CA, USA).

Stabident

Numerous studies have shown the Stabident system to be safe and effective when used as directed.[29] The advantages of the product are that it is relatively inexpensive and can be used with equipment already existing in a dental office: A slow-speed hand piece with a latch contra-angle for the perforator and a standard dental anesthetic syringe for the needle. The main disadvantage of the device is that the perforation needs to be made in a reasonably accessible and visible location in the attached gingiva distal to the tooth to be anesthetized. If the penetration zone is located in alveolar mucosa that moves once the perforator is withdrawn, it can be extremely difficult to locate the perforation site with the anesthetic needle.[22]

X-Tip

In view of above difficulty of Stabident system to locate the perforation hole, the X-Tip solves this problem by making the pilot drill itself a hollow tube through which a 27-gauge needle can pass. The initial drill stays in place, allowing the anesthetic to be placed without hunting for the hole that was just created. The X-Tip has been reported to have more post-operative pain in males, 1 to 3 days after the procedure, which may be contributed to by increased heat formation during perforation because of the X-Tip's wider diameter of the drill and guide sleeve.[30] The manufacturer (Dentsply International Inc, Tulsa, OK, USA) has discontinued making of X-Tip now.[22]

IntraFlow

The IntraFlow (Pro-Dex Medical Devices, Irvine, CA, USA) device is essentially a dental handpiece equipped with an injection system built into the body. The biggest advantage of the IntraFlow anesthesia system is that it allows entry into the penetration zone, injection, and withdrawal in one continuous step, without the need to relocate the perforation site. This single-step method can be helpful in penetration zones that are difficult to visualize or access, such as the second and sometimes the first molar areas, or where there is horizontal bone loss or a limited band of attached gingiva in the desired penetration zone. One recent study found IntraFlow to provide reliable anesthesia of posterior mandibular teeth in 13 of 15 subjects, compared to 9 of 15 with an inferior alveolar nerve block.[31] Disadvantages of the IntraFlow are start-up and maintenance costs, and that the device can occasionally leak anesthetic, especially if not assembled properly.[8]

Local Anesthesia Techniques

Anterior middle superior alveolar and palatal approach-anterior superior alveolar nerve block

CCLAD has made both techniques quite popular, as the level of patient discomfort is minimal. The AMSA nerve block provides pulpal anesthesia to the maxillary incisors, canines and premolars on the side of injection.[32,33] Soft tissue anesthesia is achieved for the entire hard palate on both that side and the intraoral mucosa of the five anesthetized teeth. Significantly, no extraoral anesthesia develops with the AMSA, a benefit to both the patient (functionally and esthetically) and the doctor during cosmetic procedures (no drooping of the upper lip).[33]

The palatal approach-anterior superior alveolar nerve block provides pulpal anesthesia to the six anterior teeth - canine to canine bilaterally, as well as the palatal and labial gingiva and mucoperiosteum and bone overlying these teeth. As noted with the AMSA, there is no collateral anesthesia extraorally.[34]

Periodontal ligament injection

Another injection technique, the periodontal ligament injection, also known as the intraligamentary injection (ILI) has been extremely useful when anesthesia of a single tooth in the mandible is required.[35] The PDL injection provides pulpal anesthesia to the tooth, with only localized soft tissue anesthesia developing. When administered in the mandible, there is no associated extraoral or lingual anesthesia like traditional inferior alveolar nerve block. Disadvantages are difficulty in locating the precise site for needle placement (within or at the entrance to the PDL), the chances of leakage of bitter-tasting LA solution into the patient's mouth. When the traditional syringe is used, the application of high pressure is needed to deliver the LA into the dense oral tissues at the PDL injection site. This has resulted in many patients complaining that the PDL injection was painful.[36-38]

Single-tooth anesthesia

In 2006, the manufacturers of the original CCLAD, the Wand, introduced a new device, Single Tooth Anesthesia (STA™). STA incorporates dynamic pressure-sensing (DPS) technology that provides a constant monitoring of the exit pressure of the local anesthetic solution in real time during all phases of the drug's administration.[39] Originally designed for use in medicine in epidural regional anesthesia,[40,41] STA utilizes an adaptation of DPS to dentistry as a means of overcoming the problems associated with PDL injection,[42] and simplifies AMSA and P-ASA injections. The system can be utilized for all traditional intraoral injection techniques. Unlike earlier variants, the STA includes a training mode that verbally explains how to use the device, and multi-cartridge and auto-cartridge retraction features. Since the pressure of the LA is strictly regulated by the STA system, a greater volume of LA can be administered with increased comfort and less tissue damage than seen with traditional syringes or PDL pressure devices.[43]

Reversing local anesthesia

Prolonged facial and lingual anesthesia is an often unnecessary and unwanted consequence of intraoral local anesthesia. Many dental patients report that prolonged soft tissue anesthesia interferes with normal oral function. Self-inflicted injuries can occur.

In May 2009, The FDA approved OraVerse (phentolamine mesylate; Novalar Pharmaceuticals Inc, San Diego, CA, USA) for the reversal of soft tissue anesthesia and the associated functional deficits resulting from a local dental anesthetic.[44] Phentolamine seems to be safe and effective in reducing soft tissue local anesthetic recovery time in adults and children as young as 6 years.[45-47] Limited data support a favorable safety profile in children as young as 4 years.[48] A recent study[49] investigated the pattern of use, dentist evaluation, and patient assessment of OraVerse. Data were collected from 51 dentists reporting on 390 patients 4 to 90 years of age. Patients reported reduced duration of oral numbness (92%) and improved dental experiences (84%) after use. A total of 83% of patients said they would recommend the medication to others and 79% said they would opt for OraVerse in the future. Dentists reported that the medication addressed an existing need (86%), met expectations (82%), was a practice differentiator (55%) and a practice builder (45%), and improved scheduling (29%). Both patient and dentist satisfaction rates were high.

Ph buffering of local anesthesia

Recent technical advances have made it practical to alkalinize dental anesthetic cartridges at chairside immediately prior to injection. Alkalinization hastens the onset of analgesia and reduces injection pain, making the science of buffering local anesthetic worthy of consideration by dentists interested in anesthesia that is more rapid, more efficient, and more predictable, as well as being more comfortable for the patient. Clinical recommendations for practitioners are to buffer cartridge immediately before delivering the injection and to buffer each injection.[50]

Future trends

An area of future interest is the possibility of development of newer improved devices and techniques for achieving profound anesthesia. A nasal spray[51] has shown to anesthetize maxillary anterior six teeth is set to be tested in an FDA Phase 3 trial, which will assess the spray's effectiveness compared to the current "gold standard" treatment - painful anesthesia injections. Syringe micro vibrator (SMV),[52] a new device being introduced in dentistry to alleviate pain and anxiety of intraoral injections.

Local anesthetics have made a great advancement in dentistry and have changed patients' perspectives of dental procedures to a great extent. There is still room for the improvement of painless techniques in administrating local anesthetics. It is important for clinicians to be familiar with all the local anesthesia devices and techniques available for dental procedures to best exploit them.

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