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Advances in Local Anesthesia Devices and Techniques -A Review

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Abstract:- Local anesthesia remains the cornerstone of pain control in dentistry, researchers are continually searching for new and more potent techniques. The majority of research efforts are focused on creating anesthetic medications, delivery mechanisms, and related procedures. For dentists to give better pain treatment with less unpleasant injections and adverse effects, newer technologies have been developed. Based on newly accessible research and clinical investigations, practicing dentists will learn about fresh pain-controlling instruments and strategies by contrasting them with those that were previously employed.

I. INTRODUCTION

Newer technology have been created to help dentists provide improved pain management with less painful injections and negative side effects.(1) The ability to administer local anesthetic safely and effectively is the most crucial competency required of all dental professionals (LA).(2,3) Perhaps the most common cause of patient anxiety is the local anesthetic injection, and dental professionals continue to have serious concerns about their patients' inability to get enough pain relief with the least amount of discomfort.(4,5)Understanding the drugs being utilized, the underlying neuroanatomy, and the best practises and devices on the market are necessary for producing effective local anesthetic. Today's agents and delivery systems for anesthetics give dentists a variety of alternatives for efficiently controlling the discomfort brought on by dental treatments. In this study, the most recent advancements in dental LA methods and equipment are highlighted.(6)

II. VIBROTACTILE DEVICES

In order to effectively manage anxiety in paediatric patients, vibrotactile devices like DentalVibe (DV) offer a new non-pharmacological method that might be available to clinicians. This method is associated with a reduction in injection pain. This well-powered, single-center experimental investigation used a split-mouth design for its randomised controlled trial.(7)This implies that simultaneous nerve fibre activation caused by vibration can alleviate pain. Inui and colleagues have demonstrated, however, that tactile-induced pain inhibition within the cerebral cortex itself can result in pain reduction caused by non-noxious touch or vibration, and that the inhibition occurs without any contribution at the spinal level, including descending inhibitory actions on spinal neurons.(8)

- *VIBRAJECT*

It is a tiny, battery-powered add-on that attaches to the typical dental syringe. It produces a high-frequency vibration to the needle that is potent enough for the patient to feel.(9) VibraJect efficacy studies have yielded conflicting findings. VibraJect has been advocated for usage by Blair(11) and Nanitsos et al.(10) for painless injection. Yoshikawa et al., however, showed no discernible pain relief when VibraJect was applied using a standard dental syringe.(12) The efficiency of VibraJect in conjunction with an electrical injection device was assessed by Saijo et al.(13) Additionally, they discovered no statistically significant reduction in pain levels at needle insertion or anesthetic injection.(figure-1)

Fig-1 vibraject

- *DENTAL VIBE*

Recently released DentalVibe is another another technology that employs vibration diversion based on the pain gate principle (BING Innovations LLC, Crystal Lake, IL, USA). It is a cordless, battery-operated hand-held device that emits calming, pulsing, percussive micro-oscillations at the injection site. The Vibra-Pulse device has a U-shaped vibrating tip that is connected to a microprocessor-controlled Vibra-Pulse motor. This motor gently stimulates the sensory receptors near the injection site, effectively closing the neural pain gate and obstructing the painful injection sensation. It contains an attachment to pull back the lip or cheek and also lights the injection site.(14) (figure-2)

Fig-2 Dental vibe

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➢ *ACCUPAL*

The cordless Accupal (Hot Springs, AR, USA) preconditions the mouth mucosa using both vibration and pressure. According to the company, Accupal applies pressure and vibrates the injection site 360 degrees proximal to the needle puncture, closing the "pain gate." The item lights up the region and starts to vibrate once you place it at the injection site and apply mild pressure. The head of the disposable tip, which is connected to the motor16, has a hole through which the needle is inserted. The patient's perception of pain is significantly diminished by using these vibrations.(15)(figure-3)

Fig -3 Accupal

➢ *COMPUTER CONTROLLED LOCAL ANESTHETIC DELIVERY SYSTEM*

The development of local anesthetic delivery devices that used computer technology to regulate the anesthetic solution's rate of flow through the needle started in the middle of the 1990s. The term computer-controlled local anesthetic delivery now refers to this idea (CCLAD). [16] The WandTM (Milestone Scientific, Inc., Livingston, N.J.), the first of these CCLAD devices, was released in 1997. The names Wand Plus and then CompuDentTM were given to later iterations by the same makers. As a replacement for the Wand, the Comfort Control Syringe (Dentsply International, York, PA, USA) was introduced in 2001. The QuickSleeper and SleeperOne devices from Dental Hi Tec in Cholet, France, as well as the Anaeject and Ora Star syringes from Nippon Shika Yakuhin in Shimonoseki, Japan, and Showa Uyakuhin Kako in Tokyo, Japan, are a few examples of comparable products.(6)

➢ *WAND/COMPUDENT SYSTEM*

This device allowed the operator to deliver the LA using a foot-activated control while manipulating needle placement with fingertip accuracy.(16,17)In comparison to a conventional syringe, the lightweight handpiece is held in a pen-like grip, giving the user more tactile sensation and control.(18,19)Computer-controlled available flow rates for LA administration ensure consistency from one injection to the next. (20)Numerous clinical investigations using CCLAD devices in dentistry have shown that the increased syringe control and the regulated LA medication flow rates result in a noticeably better injection experience. Additionally, an increasing number of medical clinical investigations show that CCLAD technology has quantifiable advantages.(21,22)figure-4

Fig-4 wand system

➢ *COMFORT CONTROLLED SYRINGE*

As opposed to Milestone products, the Comfort Control Syringe does not have a foot pedal. Syringe and base unit make up its two primary parts. The unit's ability to be operated directly from the syringe for a number of purposes, most notably injection and aspiration, may make it simpler for practitioners used to the conventional manual syringe to learn how to use. The Comfort Control Syringe may be used with all injection techniques and has five speeds that are pre-programmed for different injection procedures. The Comfort Control Syringe may be more intuitive to use than the CompuDent system because the injection is controlled manually, but it is bulkier and more difficult to use than the Wand handpiece.(23)There were no appreciable differences between the conventional dental syringe and the Comfort Control Syringe in terms of ease of administration, injection pain and efficacy, and patient approval.(5) figure 5,figure -6

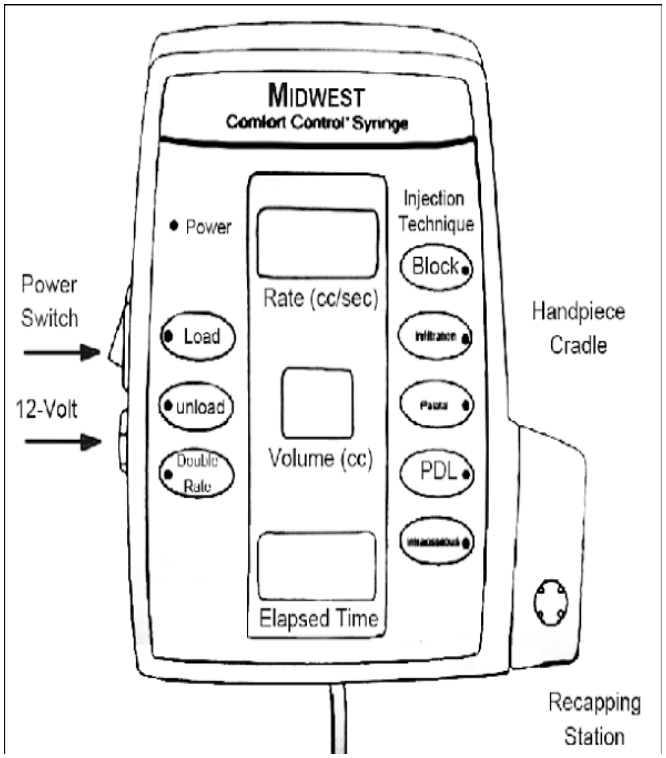

Fig -5 comfort controlled syringe

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Fig -6 comfort controlled syringe instrument

➢ *JET INJECTORS*

The idea behind jet-injection technology is to use a mechanical energy source to generate a pressure release that is strong enough to force a dose of liquid medication through a very small orifice, creating a thin column of fluid with enough force to penetrate soft tissue into the subcutaneous tissue without the use of a needle.(9) The usage of jet injectors is thought to be quicker and simpler than traditional needle injectors, with little to no discomfort, reduced tissue damage, and quicker medication absorption at the injection site. Controlled research assessing effectiveness is lacking, and the majority of claims are anecdotal. The technique's minimal efficacy in dentistry has reportedly been reported thus far.(24) figure-7,figure-8

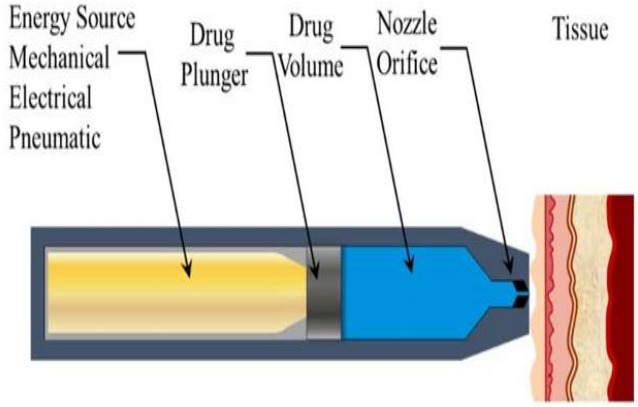

Fig -7 jet injector

Fig -8 how to use jet injector

➢ *SYRIJET*

Nearly 40 years after its release, the Syrijet Mark II (Keystone Industries [aka Mizzy], Cherry Hill, NJ, USA) has undergone a few modest upgrades. The device has certain useful features, such as the ability to administer a variable volume of solution between 0 and 0.2 mL, complete autoclavability, and acceptance of the standard 1.8 mL LA solution cartridges (ensuring sterility of the solution)(23).

It avoids needless patient discomfort and needle fear while saving time and effort.For successful operations and surgeries in the upper and lower anterior regions, as well as for all procedures on deciduous teeth, Syrijet ensures dependable anesthetic(15).figure-9

Fig -9 syrijet

➢ *MED-JET H 3*

The producer of the MED-JET (Medical International Technologies, Montreal, QC, Canada) claims that the device's tiny opening allows medication to be injected seven times more precisely than with the smallest needle currently on the market(9). The remainder of the dose will be distributed into the desired layer of tissue when this incredibly tiny stream of liquid under pressure has pierced it. Its capacity to use low pressure delivery techniques without sacrificing precision, convenience, and usability while assuring patient comfort, environmental safety, and user affordability is what makes the system special(21).figure-10

Fig -10Med-jetH3

➢ *SAFETY DENTAL SYRINGES*

Dental syringes that are safe In both medicine and dentistry, there has been a trend in recent years toward the creation and adoption of "safety" syringes. The danger of an unintentional needle-stick injury to a dental healthcare professional after the administration of LA is reduced by using a safety syringe(19). The sheath on these syringes "locks" over the needle when it is taken out of the patient's tissues, eliminating unintentional needle sticks(25). Health care workers should adopt safer working habits and think about adopting medical devices with safety features, according to both the CDC and OSHA. Several syringes thereafter started to come on the market. However, user surveys revealed widespread unhappiness with several of the safety devices(19.

➢ *ULTRASAFE SYRINGE*

The UltraSafe syringe is an inexpensive disposable syringe and needle with a retractable needle sheath and a clear plastic syringe barrel (Safety Syringes Inc, Carlsbad)(1). The clear plastic syringe barrel allows the provider to see the contents of the carpule, which is also useful for aspiration and viewing the anesthetic content(4). This also helps to prevent injury to the provider because the needle is covered before and after injection.The entire assembly of the UltraSafe syringe is disposable and cannot be autoclaved(14). Figure-11

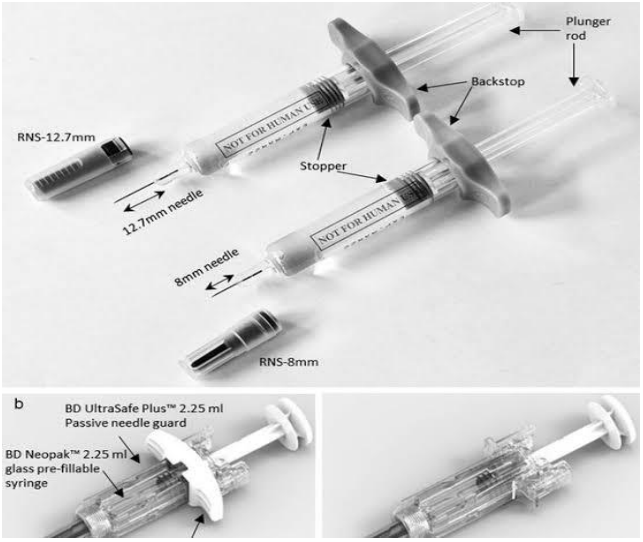

Fig-11 ultrasafe syringe

➢ *HYPO SAFETY SYRINGE*

A clear disposable plastic syringe and needle are included in the HypoSafety syringe. Following the injection, the needle can be pulled back into the syringe's barrel(22). The needle is thus protected both before and after injection, reducing the possibility of providers becoming hurt by needle sticks. With this kind of syringe, the dentist faces the challenge of being unable to re-expose the safety shield in order to administer a second injection if the needle has been bent(3). This can cause the procedure to take longer and will necessitate the use of a second syringe in the event that a bent needle technique has been used(16).figure-12

Fig-12 hypeo safety syringe

➢ *SAFETY WAND*

The CompuDent system's SafetyWand has been created in response to the Needlestick Safety and Prevention Act(5). The safety system has a pen-like grip that provides the most tactile control possible and an auto-retracting design that shields the needle when not in use. As the shield is controlled with just one hand and is lighter than a conventional syringe, it appears to be safer to use(26,5,22). The product's maker, Milestone Scientific Inc. of Livingston, New Jersey, USA, asserts that it is the first patent-pending injection device to be fully in compliance with OSHA rules under the federal Needlestick Safety Act(15,12).

➢ *REV VAC SAFETY SYRINGE*

The RevVac safety syringe functions in a manner similar to that of a regular conventional syringe. There is no need for further instruction, knowledge, or techniques(27). It operates on the straight forward premise that when the plunger is retracted and pressed, a powerful vacuum is produced. An additional push on the plunger breaks the seal, and the needle retracts into the plunger once all of the medicine has been injected and the plunger has reached the

bottom and the syringe cannot be used again. The FDA has approved the RevVac Safety Syringe(20).figure-13

Fig-13 rev vac safety syringe

➢ *INTRAOSSEOUS INJECTION*

The goal of intraosseous anesthesia is to pierce buccal gingiva and bone close to the tooth to be sedated in order to inject local anesthetic solution into the cancellous bone near to the apex of the tooth. It can be used as a primary strategy to prevent patients from developing numb lips or tongues after surgery or as a supplement to mandibular nerve blocks to increase deep pulpal anesthesia(20,22)Figure-14 This has the restriction that it can only be utilized as an additional anesthetic choice for deep pulpal anesthesia(15).

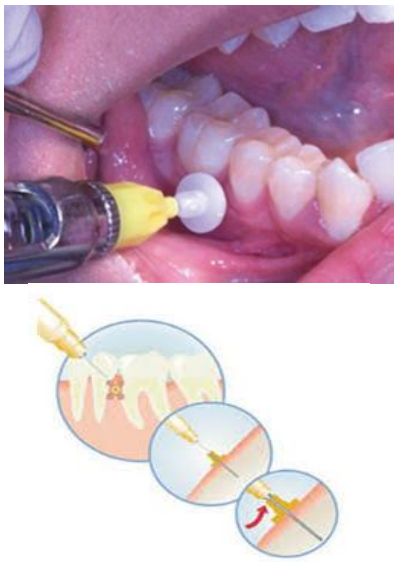

Fig-14 intraosseous injection

III. DEVICES FOR INTRAOSSEOUS ANAESTHESIA

➢ *STABIDENT*

An ordinary dental anesthetic syringe for the needle and a slow-speed handpiece with a latch contra-angle for the perforator. When activated, a solid wire measuring 27 gauge with a bevel end punches a small hole through the cortical plate(6). The main drawback of the device is that a puncture must be made in the linked gingiva distal to the tooth to be anesthetized in a fairly visible and accessible position. It can be quite challenging to detect the perforation site with the anesthetic needle if the penetration zone is situated in alveolar mucosa that moves after the perforator is removed(18,15).figure-15

Fig-15 stabident

➢ *X-TIP*

Because the Stab Dent System finds it difficult to detect the perforation hole(15), the X Tip resolves this issue by creating a pilot drill that allows a 27-gauge needle to pass through. The original drill remains in situ, preventing the need to look for the newly made hole before inserting the anesthesia. Males have reported experiencing higher post-operative pain with the X Tip, which may be related to increased heat production during perforation due to the X Tip's bigger drill and guide sleeve diameters (17,19). It functions in regions without associated gingiva or without obvious access(4,20).figure-16

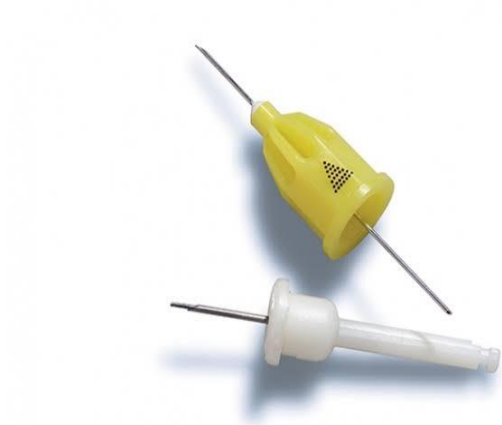

Fig -16 x tip

➢ *INTRA FLOW*

The Intra Flow device is simply a dental handpiece with an integrated injectable mechanism. The main benefit of the Intra Flow anesthetic system is that the perforation site does not need to be moved in order to enter the penetration zone, provide an injection, and then withdraw anesthesia(1,23). This one-step procedure may be useful in penetration zones that are challenging to see or reach, including the second and occasionally the first molar regions, or in areas where there is horizontal bone loss or a small band of connected gingiva in the intended penetration zone(6,15). In comparison to 9 of 15 participants who had an inferior alveolar nerve, one recent study indicated that Intra Flow reliably anesthetized the posterior mandibular teeth in 13 of 15 subjects(5,12).figure - 17

Fig-17 intraflow

IV. LOCAL ANESTHESIA TECHNIQUES

- *ANTERIOR MIDDLE SUPERIOR ALVEOLAR AND PALATAL APPROACH-ANTERIOR SUPERIOR ALVEOLAR NERVE BLOCK*

Due to the low level of patient discomfort caused by CCLAD, both methods have become fairly popular. The maxillary incisors, canines, and premolars on the injection side are pulpally anesthetized by the AMSA nerve block.(28,29)

The intraoral mucosa of the five anesthetized teeth as well as the entire hard palate on that side have been given soft tissue anesthesia. Importantly, with the AMSA, no extraoral anesthetic forms, which benefits the patient (from a functional and aesthetic standpoint) as well as the doctor during cosmetic treatments (no drooping of the upper lip).(29)The six anterior teeth, which are canine to canine bilaterally, the palatal and labial gingiva, the mucoperiosteum, and the bone covering these teeth are all given pulpal analgesia via the palatal approach-anterior superior alveolar nerve block. There is no extraoral collateral anesthesia, as noted with the AMSA.(30) figure-18

Fig-18AMSA

- *PERIODONTAL LIGAMENT INJECTION*

When a single tooth in the mandible needs to be anesthetized, another injection technique known as the intraligamentary injection (ILI), or periodontal ligament injection, has proven to be quite helpful.(31) Only localized soft tissue anesthesia develops after the PDL injection delivers pulpal anesthetic for the tooth. There is no extraoral or lingual numbness present when injected in the jaw, unlike with a conventional inferior alveolar nerve block. The inability to precisely locate the needle implantation position (inside or at the PDL entrance) and the potential for LA solution leaking into the patient's mouth are drawbacks. When using a typical syringe, high pressure must be applied in order to inject the LA into the dense oral tissues at the PDL injection site. As a result, many patients have expressed their discomfort with the PDL injection.(32,33,34) Figure-19

Fig-19 pdl injection

➢ *SINGLE TOOTH ANESTHESIA*

Single Tooth Anesthesia (STATM), a new product from the makers of the first CCLAD, the Wand, was unveiled in 2006. STA uses dynamic pressure-sensing (DPS) technology, which permits continuous, real-time monitoring of the exit pressure of the local anesthetic solution throughout all stages of the medication's delivery.(35) Originally intended for use in epidural regional anesthesia in medicine.(36,37) In order to get over the issues with PDL injection, STA applies a DPS modification to dentistry,(38) and makes injections of AMSA and P-ASA simpler. Any conventional intraoral injection method can be used with the device. The STA contains a training mode that orally explains how to use the device, as well as multi-cartridge and auto-cartridge retraction functions, in contrast to earlier models. A greater amount of LA can be supplied with better comfort and less tissue injury than with conventional syringes or PDL pressure devices since the pressure of the LA is strictly regulated by the STA system.(39)figure-20

Fig-20 single tooth anesthesia

➢ *REVERSING LOCAL ANESTHESIA*

Long-lasting lingual and facial numbness is a frequent unintended side effect of intraoral local anesthetic. Numerous dental patients claim that prolonged soft tissue anesthetic impairs their ability to speak normally. Self-inflicted wounds can happen.The FDA authorized OraVerse (phentolamine mesylate; Novalar Pharmaceuticals Inc, San Diego, CA, USA) in May 2009 for the treatment of functional deficits brought on by soft tissue anesthesia following the use of a local dental anesthetic.(40)In adults and children as young as six years old, phentolamine appears to be secure and efficient in shortening the recovery period following soft tissue local anesthetics.(41,42,43)A positive safety profile in kids as young as 4 years old is supported by scant data.(44)A recent study looked into OraVerse usage patterns, dentist assessments, and patient evaluations. Data were gathered from 51 dentists who reported on 390 patients ranging in age from 4 to 90. Patients noted improved dental experiences (84%) and a reduction in the amount of time they had oral numbness (92%). Patients overall indicated that 83% would suggest the drug to friends and 79% would choose OraVerse in the future. Dentists stated that the drug exceeded expectations (82%), met needs (86%), differentiated their practices (55%), built their practices (45%), and enhanced scheduling (29%). High levels of patient and dentist satisfaction were observed.(45)figure-21

Table: Durations of Common Forms of Local Anesthetics

Local Anesthetic Formulation	Expected duration of PULPAL anesthesia (minutes)	Expected duration of SOFT TISSUE anesthesia (minutes)	Category (based on pulpal anesthesia)
Lidocaine 2%	5 – 10	30 – 45	Short
Prilocaine 4%	10 – 15 (infiltration) 40 – 60 (nerve block)	60 – 120 (infiltration) 120 – 240 (nerve block)	Short Intermediate
Mepivacaine 3%	20 – 40	90 – 120	Short
Lidocaine 2% + epinephrine	60	180 – 300	Intermediate
Mepivacaine 2% + levonordefrin	60	180 – 300	Intermediate
Articaine 4% + epinephrine	60	180 – 300	Intermediate
Prilocaine 4% + epinephrine	60 – 90	180 – 480	Intermediate
Bupivacaine 0.5% + epinephrine	90 – 180 (nerve block)	240 – 720 (minutes)	Long

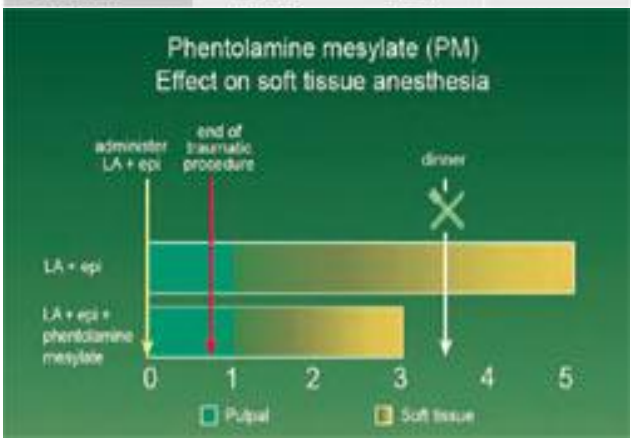

Fig-21 reversing LA table

➢ *PH BUFFERING OF LOCAL ANESTHESIA*

Alkalinizing dental anesthetic cartridges at chairside just before injection has become feasible thanks to recent technical advancements. Dentists interested in local anesthesia that is more rapid, more efficient, and more predictable, as well as being more comfortable for the patient, should give the science of buffering local anesthetic some thought. Alkalinization also lessens injection pain. Practitioners are advised by clinical guidelines to buffer each injection and the cartridge just before administering them.(46) figure-22

Fig-22 ph buffering LA

➢ *FUTURE TRENDS*

The potential for the creation of newer, better tools and methods for establishing profound anesthesia is a topic of future attention. In an FDA Phase 3 trial, a nasal spray (47)that has been demonstrated to anesthetize the six front teeth of the maxilla will be compared to the painful anesthetic injections that are currently the "gold standard" of care. A novel dental tool called the Syringe Micro Vibrator (SMV)(48) is being offered to reduce the discomfort and anxiety associated with intraoral injections.Local anesthetics have greatly improved dentistry and significantly altered patients' perceptions of dental operations. The use of painless methods to administer local anesthetics can yet be improved. To fully benefit from all local anesthetic devices and techniques available for dental operations, physicians must be knowledgeable about them.Figure-23

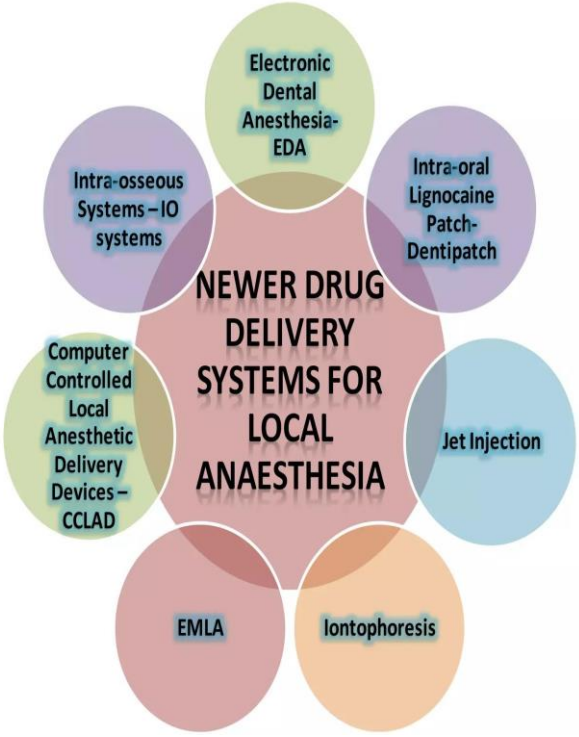

Fig-23 future trends

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