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Review Article

Advances in local anaesthetic delivery system: A review

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ABSTRACT:
The most common reason for patients to avoid dental treatment is dental pain. Dental pain has always been an enigma for dentists as they are unaware of various techniques to manage dental pain. One of the most important procedures to manage dental pain is local anesthesia. Local anesthesia is necessary to reduce pain during dental treatments such as extractions, root canal treatments, flap surgeries etc. The important property of local anesthesia is that it produces loss of sensation without producing loss of consciousness. With advancement in dentistry, advancement in local anesthetic delivery systems have also been there. Many devices have been introduced that inject local anesthetic agents into tissues at set speed to reduce pain. Collectively these "PAINLESS ANAESTHETIC DEVICES", are termed as "COMPUTER- CONTROLLED LOCAL ANAESTHETIC DELIVERY" devices(CCLAD) .Other newer local anesthetic delivery systems aimed at easing the fear of the needle take advantage of the gate control theory of pain management are vibrotactile devices. These include vibraject, dental vibe, accupal etc. In recent years there has been a move toward the development and introduction of 'safety' syringes in both medicine and dentistry. These include UltraSafe syringe, HypoSafety syringe and SafetyWand. Recently some needle free injectors like INJEX30 system are also there which would greatly reduce the anxiety of the patient. This article will enlighten the practicing dentist 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.

Keywords: Pain, Dental fear, Anxiety, Local Anesthesia, Painless dentistry, CCLAD, INJEX 30.

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INTRODUCTION

According to International Association for study to pain "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage." Dental fear is the most common reason for patients to avoid visiting the dental professionals. Dental fear can occur due to many reasons including noise and vibration from tooth-cutting instrument such as dental hand pieces, smell of drugs and dental materials used in dentistry, pain during treatment, irrational fear of local anesthesia[1]. However patient fear and anxiety of pain caused by needle prick is more than pain caused by treatment itself. Survey has found that approximately 36% of the population is affected by dental fear or dental anxiety, with a further 12% suffering from extreme dental fear[2]. This fear can have serious repercussions in terms of individual's oral health and it considered to be a significant barrier to dental attendance resulting in poor attendance to the dental clinics and this leads to poor oral hygiene[3].

Although, local anesthesia remains backbone of pain control in dentistry, researches are going to seek new and better means of managing pain. Newer techniques have been developed that can assist the dentist in providing enhanced pain relief with reduced injection pain and fewer adverse effects. Conventional LA delivery system includes syringes, needle and cartridges. Syringe is the main component of local anesthetic armamentarium which is the vehicle for delivering local anesthetic agent into the tissues. Different types of syringes available including non-disposable, disposable, safety and computer controlled local anesthetic delivery system. Most commonly used are the disposable syringes which are available in different sizes with an assortment of needle gauges. These contain a luer lock screw on needle with no aspirating tip.

Needle is the vehicle that permits local anesthesic solution to travel from the dental cartridges into the tissues surrounding the needle tip. Problems with needles are pain on insertion, pain on withdrawl, breakage, accidental injury to the patient or dentist.
Dental cartridge is the glass cylinder which contain local anesthetic agent. Problems with these are extruded stopper, sticky stopper, rust on cap, leakage during injection, broken cartridges etc,.
Although the traditional aspirating syringes still is the most common method by which local anesthetic agent 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.
Various devices have been introduced including vibrotactile devices, computer-controlled local anesthetic delivery system, safety dental syringes, needle free injections.

VIBROTACTILE DEVICES
Newer techniques aimed at easing the fear of the needle take advantages of the gate control theory of pain management[4].These devices include VibraJect, Accupal, DentalVibe.

- **VibraJect:** This device works on gate control theory of pain management. This device is simply a battery operated attachment that snaps on to the standard dental syringe. It delivers high frequency vibration to the needle that is strong enough for patient to feel [5].

- **Dental Vibe:** It is a cordless, rechargeable hand held device that deliver soothing, pulsed, percussive micro-oscillations to the site where an injection is being administered. It includes ultra bright LED that help dentist to easily locate point of injection by which chances of second shot is reduced. Disposable comfort tips are single use and latex free available in both adult and child sizes. Breakthrough VibraPulse technology delivers unique soothing pulsed vibration to block pain and discomfort[6]

- **Accupal:** Battery operated cordless device uses both vibration and pressure to precondition the oral mucosa so that patient feels less pain which makes the patient less discomfort[7].

Nanitos et al[8], and Blair[9] have recommended the use of Vibraject for painless injection. Yoshikawa et al[10], found no significant pain reduction when Vibraject was applied with a conventional dental syringe. Sajio et al[11], asses the worth of the effectiveness of Vibraject in combination with an electrical injection device. They found no such significant result that were claimed by manufacturing companies.

COMPUTER CONTROLLED LOCAL ANESTHETIC DELIVERY SYSTEMS
During the late 1880s, physician Sigmund Freud, Carl Koller, and William Halsted were pursuing a common area of clinical research: the development of the drug benzoyl-methyl ecognine more commonly known today as cocaine, for medical use and for application as the first local anesthetic[12]. However Freud and Koller were the first to notice the anesthetic effect of cocaine, it was Hastled who introduced cocaine as a local anesthetic in dentistry[12]. Hastled demonstrated interstitial

injection aqueous cocaine using hypodermic syringe resulting in effective nerve block of the inferior alveolar nerve, and that a small amount of anesthetic solution injected into the trunk of a sensory and motor function from the terminal nerve branches. This discovery was as a starting point for local pain control in both Dentistry and Medicine. In 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 system including Wand, Comfort control syringes [13]. Originally called THE WAND (later renamed The CompuDent/Wand; Milestone Scientific, Inc., Livingston NJ)[13].

WAND/ COMPUDENT SYSTEM

Regardless of careful local anesthetic procedures, dental local anesthesia can cause pain for various reasons which include soft tissue damage during penetration of oral mucosa, pressure from spread of anesthetic solution, temperature of anesthetic solution, low Ph of anesthetic solution and pain from drug [14]. In order to reduce such pain WAND system was introduced which reduces dental fear. Wand system is single tooth anesthesia system represents a significant advance in C-CLAD technology. It enabled operator to accurately manipulate needle placement with finger tip accuracy. The lightweight headpiece is held in a pen-like grasp. In addition to this, disposable hand pieces weighing less than 10g were introduced which increases tactile control and improves dexterity during injection. The available flow rates of LA delivery are controlled by a computer and thus remain consistent from one injection to the next. Though this system is very much beneficial but due to its single tooth anesthesia system it can't be used in multiple tooth extraction or multiple tooth treatment cases.

COMFORT CONTROL SYRINGE

Comfort control syringe is an electronic pre-programmed computerized local anesthetic injection device. The CCS comprises a main control unit, a syringe and needle hand-piece, ultra tubing connecting the control unit to the syringe and needle hand piece. The CCS has five pre-programmed speeds for different injection techniques and can be used for all types of injections. There is no foot control present like in WAND system[14].

There are various functions of the unit however most important are the injection and aspiration can be controlled directly from the syringe, making its use easier to master for practitioners. The comfort control syringes has five pre-programmed speeds for different injection techniques and it can be used for all the injection techniques. In spite the fact that comfort control syringes may be more insightful than that of CompuDent system in the sense that the injection is controlled by hand, the syringe is heavy and more inconvenient to use than Wand headpiece. Comparison between traditional dental syringe and the Comfort Control syringes revealed no such difference in ease of administration, injection pain and acceptance by patient[15].

SAFETY DENTAL SYRINGES

Despite of advantages of above systems explained, however they may cause needle stick injuries. To overcome this disadvantage, many studies were done and safety dental syringes were introduced. As the name depicts the meaning of the system, these syringes posses a sheath that locks over the needle when it is removed from the patient's tissues preventing accidental needle stick. Both OSHA and CDC recommend that health workers should adopt safer health practices[5]. Afterwards many syringes were introduced in the market, but many were disappeared due to no significant advantages. Still there is a need for safety dental syringes which can protect the user from needle stick injuries, for this reason some are available in the market. These syringes includes ultrasafe, safetywand, ultra safety plus XL, HypoSafety syringes. These syringes are sterile, for single use, self-aspirating system specially designed to prevent needle stick injuries, no recapping necessary.

ULTRASAFE

Disposable syringes and needle with transparent, plastic syringes barrel, which has a retractable needle sheet. The difference between the ultrasafe and the Ultra Safety Plus XL syringe is that in the Ultrasafe syringe the entire assembly is disposable and is not autoclavable[14].

SAFETY WAND

Has pen like grasp that allows maximum tactile control and an auto-retracting design that shields the needle when not in used. It is lighter than than the traditional syringe, and the shield is operated with one hand, apparently making it safer to use[16].

ULTRA SAFETY PLUS XL SYRINGES

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 needle is covered before and after injection and there is no need to disassemble prior to disposal , so these needles are beneficial in view of safety.

HYPOSAFETY SYRINGES

The hyposafety syringe (Dentsply MPL technologies, Susquehanna, PA,USA) is a translucent disposable plastic syringe and needle combination[14].

The main problem with this type of syringe is its expensive cost.

Syringes and hypodermic needle have been used to administer the drugs to the body for more than 1550 years. However, the technical advancements and bioengineering capabilities have led to the emergence of various “newer” active enhancements, designed so as to circumvent the barrier function of the stratum corneum which is the superficial layer of epidermis. Needle free injectors are the novel way of transfer of medicine through the skin without breaching the integrity of the skin, or even piercing it[17].

Needle free injector INJEX30 were specially designed for pediatric patients. Dentist can do all procedures of pediatric patient like pulpectomy, pulpotomy, extraction etc.

But now days it’s more used in adult patients also because they have more fear of needles.

NEEDLE FREE INJECTORS

Needle free injection system was first described by Marshall Lokhart in 1936. In 1940 professor Higson and his team develop high pressure guns[18]. INJEX30 is a stainless steel device for delivery of anesthetic agent from 0.3ml ampoules and sterile disposable silicone cushioning caps through a micro nozzle in the ampoule into the gum at a consistent pressure by the means of intergrated springs[18].

WHERE IT WILL WORK

In adults dentists can do RCT in Maxilla by putting only one shot bucally in molar to molar region. And for extraction in same area one more shot in palatal region. Dentist can do RCT in mandible by putting only one shot bucally premolar to premolar region

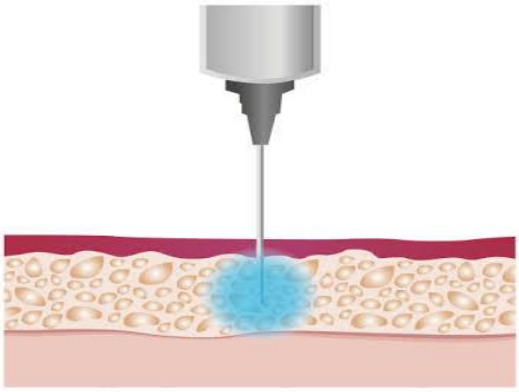
and for extraction in same region one more shot will be required in lingual region.

MECHANISM OF ACTION

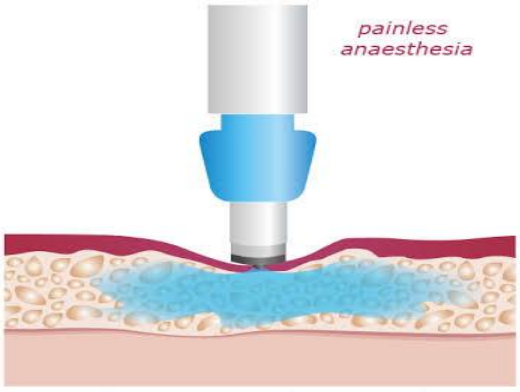
As the plunger on the traditional needle and syringe depressed a spiracle pool of medication called a bolus forms at the tip of needle. Needle free injections rely instead on pressure stream of medication itself to penetrate the skin. As the fluid stream forces itself through tissue it follows the path of least resistance, resulting in a wide dispersed spider web like distribution of medication[18].

The whole process of delivering the injection takes place in less than 1/3 of a second. It occurs in three stages:

1. Peak pressure stage: It is optimal pressure required for penetrating the skin which lasts about less than 0.25 seconds.
2. Dispersion phase: This phase lasts for 0.2 seconds.
3. The drop off phase: Lasts about less than 0.05 seconds[19].



local anaesthesia with needle injection



local anaesthesia with needle-free injector

COMPONENTS OF NEEDLE FREE INJECTIONS

1. **Adapter:** helps to refill the ampoule. It can attach to normal LA solution vials.
2. **Ampoule:** Delivers 0.3cc of LA solution. To fill the ampoule, pull the pistol out and load the solution inside. At its end there is micro millimeter opening that's what make the delivery of solution pain free.
3. **Silitop:** it's a silicone cap which is present at the top of the ampoule. It is the only part which comes in contact with the patients skin and it has to be disposed after every use[19].

MANY QUESTIONS ARISES BEFORE USING INJEX30

Q: How is local anaesthetic agent deposited if it doesn't pierce mucosa?

Ans: INJEX 30 deposits solution at optimal pressure and speed so it penetrates through the mucosa with minimal tissue damage into the periosteum.

Q: 0.3cc is enough for a infiltration, what about nerve blocks?

Ans: It acts faster than conventional infiltration, good for short procedures. For blocks dentist can use it as a small shot prior to using the needle to reduce the pain for needle penetration.

Q: Any of these parts are autoclavable, does silitop comes in contact with patients gums, it is to be disposed after each use?

Ans: Only silitop touches the patient skin, ampoule and adapter need cold Sterilization and yes silitop is to be dispose after each use. Silitop is affordable as it costs only 10rs.

Q: How mandibular anesthesia can be achieved?

Ans: In mandible it depends upon patients age, if patient is less than 18yrs then it will work in molar to molar region but if the age of patient is more than 18yrs than it will work only in premolar to premolar region.

Q: Which anesthetic solution can be used?

Ans: Dentist can use normal LA solution which can be refill in ampoule with the help of adapter.

CONCLUSION

Local anesthetics have made a great advancement in dentistry and have changed patients' perspectives of dental procedures to a great extent. But still there are people who have fear of needles and some have fear of dental procedure. To eliminate this stigma many devices have been introduced in the market to enhance patient oral care. Newer technologies are available but still there is a room for the improvement of painless techniques in administrating local anesthetics and further research needs to be done in this regard. It is important for dentist to be familiar with all the newer local anesthetic devices and techniques to provide enhanced pain free treatment to the patient.

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