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Illustrative Review on Needle Free Injection Technology

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ABSTRACT

Needle free injection technology was developed in order to initiate reduction in the number of needle stick accidents and associated issues. An extensive literature review was completed in thought with needle free injection technology and its applications, edges over needle injections, their components and types such as powder injection, liquid injection, or projectile injection. This review provides a description on needle free injection technology considering the involvement of generation of force by using compressed gas upon actuation in order to deliver a drug at very high speed through a nozzle. Also injection methods that use a spring load jet injector, battery powdered jet injector, and gas powdered jet injector are described. An overview of marketed merchandise, recent trends and other needle free drug delivery systems is given. Needle free injection technology is growing and has the potential to make the administration of drugs more economical, safe and convenient.

KEYWORDS: *Needle Free injection, Mhi-500, Recojet, Biojectorr 2000, Vitajet 3, Cool click.*

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History:

Needle-free systems were first represented by Marshall Lockhart in 1936 in his patent jet injection. Then in the early 1940's Higson and others developed high "guns" through the use of fine jet of liquid to pierce the skin and deposit the drug in underlying tissue.

INTRODUCTION

Injections are a popular method for delivering drugs in order to prevent and treat various ailments. But it is an invasive method of drug administration as it can cause tissue damage. Injections are often a common source of disease transmission, particularly when needles are often re-used and used in an incorrect way. To overcome obstacles related to needle based injections, needle free injection technologies (NFIT) have gained a significant popularity during the past few years and offer many benefits. These technologies square measure been meant for injecting liquid formulations, as well as injecting drugs and vaccines in a solid particle dosage form. Needle-free injection systems are innovative ways to introduce various medicines into patients without piercing the skin with a traditional needle.

Objectives:

1. It is less pain full and potentially safer.
2. The key benefits of avoiding a needle and ease of use of a liquid jet injector as compared to other delivery technologies.
3. The main advantages of this system are the elimination of broken needles, a more constant delivery of vaccines and drugs, and decrease worker safety risk.

Structure of Human skin:

The knowledge of the structure in the skin is essential to the successful administration of drugs through the needle free injection systems as these drugs are administered to the skin.

Human skin is generally made of two layers

- Epidermis
- Dermis.

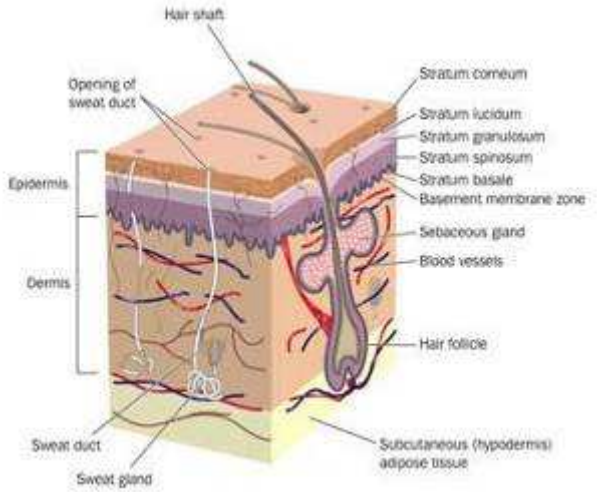

Fig.1: Layer of skin

The Epidermis

This is a stratified squamous epithelium layer i.e. are composed primarily of two types of cells: keratinocytes and dendritic cells. The Epidermis layer consist of number of other cells such as melanocytes, Langerhans cells and Merkel cells. The layers of epithelium are

Stratum spinosum

Its thickness varies from 5-10 cells. Intercellular spaces between acanthoid cells are bridged by rife desmosomes (adhering spot) that promote coupling between cells of the cuticle and provide resistance to physical stresses.

Stratum granulosum

It contains living cells, these are responsible for further synthesis and modification of proteins involved in keratinization. It is 1-3 cells layer in thickness.

Stratum corneum

The corneocyte are rich in protein and low in lipid content (hydrophilic nature) are surrounded by a continuous extracellular lipid matrix.

ADVANTAGES OF NFI TECHNOLOGY

The technology permits patients to self-administer, reduces tissue damage and distributes medicine more effectively and widely in the subcutaneous tissue without penetration in to deeper layers.

Delivery by this means could consequently induce mucosal as well as humoral immunity.

1. Avoid real as well as needle phobia based pain.
2. Prevent from needle stick hazard and sharps disposal.
3. Enhance stability by close storage and delivery as a dry powder.
4. Provide rapid delivery and reproducibility comparable with needle & syringe.
5. Improve bioavailability over other non- or less invasive drug delivery systems.
6. Improve immune response to DNA and conventional vaccines.
7. It is trouble free, simple and self-administered.
8. Low sensation and safety.
9. Solid dosage forms can be administered.
10. Minimal skin response and no bleeding or bruising.
11. Excellent dose response is observed with increased drug doses.

Disadvantages

1. The method is complex and expensive.
2. All systems don't seem to be fitted into one size.
3. Need for personnel training and maintenance.
4. It is not applicable for the Intravenous route.

Mechanisms and Diagramatic representation:

The mechanism generates force by using compressed gas (such as carbon dioxide or nitrogen) to propel the drug through a passage at a really high speed. While administration of drug occurs through the device, an ultra-fine stream of fluid penetrates through the skin layers which delivers the drug very quickly into the systemic circulation. The total time required to deliver an injection is less than 1/3 of a second and occurs in four stages:

1. Medication is driven at high speed through a small orifice
2. A fine stream of medication penetrates the tissue
3. Injection event requires less than 0.5 seconds.
4. Injections can be IM, SC or ID.

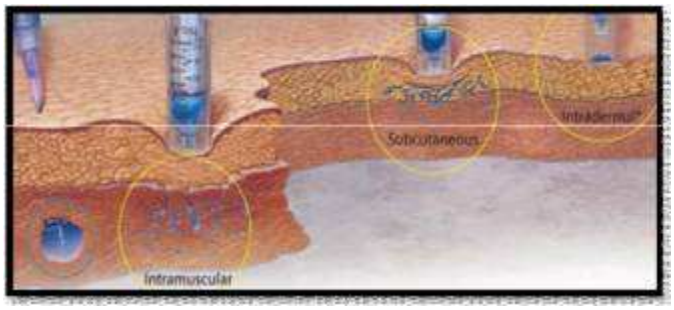

Fig2: Types of Parenteral Route

TYPES OF NEEDLE FREE INJECTION SYSTEMS

A. Powder injections
B. Liquid injections
C. Depot or projectile injection

In powder injection systems, a pre measured pulverized medication is put during a drug container which is opened by the compressed gas and thus the medication is delivered to tissue. The powders utilized in these systems require specific properties and specific size to ensure their stability and proper dispersion into the tissue. These types have bound advantages over the others like the therapeutic agent are more stable and may not require cold storage. In addition, for vaccines, a solid formulation presents the opportunity to combine fast acting and delayed-release forms of the vaccine so that the prime and boost shots can be given together in a single administration. Depot injections are given in the muscle where they create a store of a drug which is released continuously over a specified period of time.

Design

The air-forced needle-free injection systems unit usually manufactured from 3 components including an injection device, a disposable needle free syringe and an air cartridge. The injection device is composed of a sturdy plastic. It is designed to be easy to hold for self-administration of drugs. The needle-free syringe is also plastic. It is sterilized and is the only piece of the device that has got to bit the skin. The syringe is made to be disposed after every use.

Raw Material

Polymer easier to mould, fillers square measure added18 these fillers make plastics additional durable, lightweight, and rigid. Colorants are also incorporated into the plastic to modify the looks. Prior to manufacture, the plastics are typically supplied in pellet form with the colorants and fillers already incorporated. Air-forced systems typically use gas or component gas to propel the drugs into the body certain kinds of medicines work better with needle-free injection systems than totally different. Lidocaine hydrochloride, a local anaesthetic is suitable to be delivered needle free. Other medicines suitable for needle free systems include Fentanyl, Heparin and a variety of vaccines.

The Manufacturing Process

There square measure numerous methods of producing each needle-free injection system. The following process focuses

on the production of an air-forced system19 these systems are made through a step by step procedure which involves molding the pieces, assembling them, and decorating and labelling the final product. The individual pieces are typically produced off-site and assembled by the needle free injection system manufacturer. All of the manufacturing is done under sterile conditions to prevent the spread of disease.

Assembling and labelling

In this production phase various events occur. Machines apply markings that show dose levels and force measurements. These machines square measure specially mark thus each printing is made precisely. Depending on the quality of the device, human workers or machines may assemble the devices. Making pieces the first step requires the production of the component plastic pieces from plastic pellets. This is done by a method known as injection molding. Pellets of plastic square measure put into a large holding been on an injection molding machine. They are heated to make them flow able. The material is then passed through a hydraulically controlled screw. As the screw rotates, the plastic is directed through a nozzle which then injects it into a mould. The mold is made up of two metal halves that form the shape of the part when brought together. When the plastic is in the mold, it is held under pressure for a specified amount of time and then allowed to cool. As it cools, the plastic inside hardens. The mould items square measure separated and the plastic part falls out onto a conveyor. The mold then closes again and the process is repeated.

Packaging

After the assembly step, the injection devices are placed into packaging. They are first wrapped in sterile films and then place into cardboard or plastic boxes. Each part is packaged so movement is minimal to forestall injury. For consumer product, an instruction manual is included along with safety information.

APPLICATIONS

1. Subcutaneous, intramuscular and intradermal administration of Vaccines e.g.., smallpox, polio, measles.
2. Intradermal administration of hormones e.g. growth hormone and anaesthetic e.g. lidocaine.
3. Subcutaneous administration of insulin.
4. Used in the treatment of migraine e.g. sumatriptin.

MANUFACTURERS OF NEEDLE FREE INJECTION

Mhi-500

Mhi-500 is the novel needle frees endocrine delivery system that offers advantages for all those involved in polygenic disease care. It is a true various to needle-based delivery systems. This technology achieved the Food and Drug Administration (FDA) approval in 1996 for the subcutaneous delivery of insulin and is CE marked for sale throughout the Europe. This system has been used to give thousands of successful injections without the use of a needle. The mhi-500 injects endocrine by using a fine, high pressure jet of insulin.

Recojet

Shreya Life Sciences has recently launched its recombinant human endocrine under the brand name Recosulin and a needle-free endocrine delivery device, Recojet. The new device is expected to give a lift to the therapy, as needle phobia was one of the reasons preventing insulin use on a wider scale. In general, needle-free injection technology works by forcing liquid medication at high speed through a small opening that is being held against the skin. This creates an ultra-fine stream of aggressive fluid that penetrates the skin without the utilization of a needle.

Bioject's needle free injection technology

Bioject's needle-free injection technology works by forcing liquid medication at high speed through a small gap that's control against the skin. The diameter of the orifice is smaller than the diameter of a human hair. This creates an ultra-fine stream of hard-hitting fluid that penetrates the skin without using a needle. Bioject's technology is unique as a result of it delivers injections to a number of injection depths and supports an outsized range of injection volumes. For instance, the Biojector 2000 can deliver intramuscular or subcutaneous injections up to one ml in volume. In addition, Bioject is developing a syringe for the Biojector 2000 that delivers intradermal injections that is currently in clinical trials.

Biojectorr 2000

The system can even deliver hypodermic injections, and is being used for intradermal injections in clinical trials the Biojector 2000 uses sterile, single-use syringes for individual injections, which prevent the cross- contamination that has been reportable with fixed-nozzle jet injection systems. More than ten million injections are administered with success victimization the Biojector 2000, with no reports of major complications. Because there's no needle, it provides healthcare workers with an unparalleled level of protection against accidental needle stick injuries. In risky situations, such as delivering injections to patients known to be infected with HIV or hepatitis, the Biojector is an ideal injection system.

Vitajet 3

The Vitajet 3 is an easy-to-use, economical needle-free injection system for delivering insulin. The system requires no maintenance or re-assembly. With disposable nozzles that are replaced once-a-week, the Vitajet 3 offers the quality of a reusable medical product, with the convenience and safety of a sterile disposable.

Cool click

Bioject developed the cool click needle-free injection system for delivering Saizen recombinant human endocrine. In some youngsters, naturally occurring growth hormone is absent or is produced in inadequate amounts. In these cases, Saizen or growth hormone replacement must be injected to maintain normal growth. The system includes bespoke quantity features to accurately deliver variable doses of Saizen and was designed with bright colours to create the appliance engaging and non-threatening to children.

Fig.3: Cool Click needle-free injection system

SeroJet

The SeroJet is a needle-free injection system for delivering Serostim recombinant human endocrine for treatment of HIV-associated wasting in adults. HIV-associated wasting could be a metabolic condition in which people infected with HIV lose weight. If not treated, this could result in increased morbidity and mortality. SeroJet may be a customised version of Bioject's Vitajet needle-free injection system. The system includes customised indefinite quantity features to accurately deliver variable doses of Serostim.

Fig.4: SeroJet

Iject

Bioject has developed a second-generation gas-powered injector known as the Iject, which is based on the design and performance of the B2000 and is intended to serve as a single-use pre-filled device. The Iject is pre-filled single-use disposable injection device configured to administer 0.5 to 1.00 ml subcutaneous or intramuscular injections. The device is distributed "ready to use.

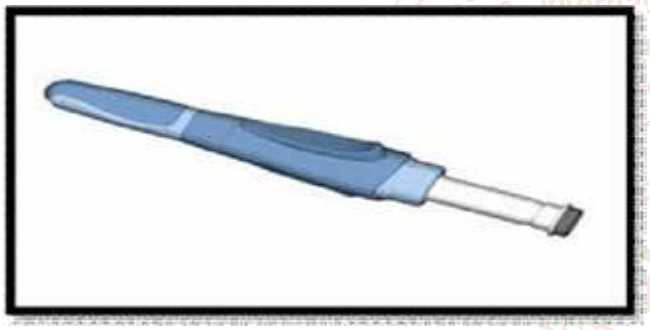

Fig.5: Iject

Quality control

It checks are done throughout the manufacturing process. Line inspectors check the plastic components to assure they adjust to predetermined specifications. Visual inspections square measure the first take a look at technique, but measuring equipment is also used to check the dimensions including size and thickness. Instruments that can be used include laser micrometers, calipers and microscopes. Inspectors also check to make sure the printing and labeling is correct and that all the parts are included in the final packages. Since these devices can have numerous safety issues, their production is strictly controlled by the Food and Drug Administration (FDA). Each manufacturer must conform to numerous production standards and specifications. Inspections are done to ensure that these companies are following good manufacturing practices.

RESCENT ADVANCES

Intraject Systems

Intraject system is the world's first disposable, needle free injection device for the delivery of liquid medicaments. Intraject is specially designed to meet the patient needs; being pre-filled and disposable the system is designed for contamination free self-injection. With minimal training a practioner, patient or a carer can deliver a reliable, virtually pain free injection.

Fig. 6: INTRAJECT

INJEX NEEDLE-FREE INJECTIONS FOR INFILTRATION ANAESTHESIA

INJEX Drug Company now offers a solution for previous local anaesthesia issues, a needle-free injection system. The INJEX System uses an injection ampoule with a small orifice of solely of zero.18 metric linear unit through which the anaesthetic is administered under treated pressure to the submucosa virtually painless and exactly where it is needed.

Areas of Application

The ampoule has to be placed on the attached gum at an angle of 90° directly above the tooth to be anaesthetized.

Pediatric Patients

Children area unit particularly tough dental patients because they are so very much afraid and cannot understand the purpose of the treatment. Experienced dentists are able to use INJEX to administer anaesthetic to all deciduous teeth. The shorter onset time also reduces the treatment induced stress for children. Since only zero.3 milliliter of local anaesthetic is administered.

Fig.7: INJEX for pediatrics

Adult patients

Many adults are afraid of the syringes with the needle as well as the pain induced by the dental treatment. This problem can be overcome with the 'needle- free syringe'

Fig.8: INJEX for Adult patient

CONCLUSION

Needle-free technology provides best alternative to deliver the concerned medicament in to the skin without inducing pain. Other benefits includes an embodiment of very fast injection in comparison with typical needles and no needle disposal associated problems. Not only it can profit the pharmaceutical industry in increasing the product sales, it has a further potential to increase compliance with dosage regimens and improved outcomes. For the emergency inoculation of drug this technique is used. Needle-free injection systems have additional potential to improve efficacy. In the developing world, there are major challenges of disease transmission through the re-use of needles. There appears to be tremendous opportunity for needle-free technology to have major impact in the trade. It is likely that dramatic change may occur only when a significant pharmaceutical or biotechnology company adopts needle-free technology.

REFERENCES

[1] Wilson P. Needle-free immunization as effective as needle and syringe method. Council Research News. Available at: April 19, 2007.

[2] Reis EC, Jacobson RM, Tarbell S and Weniger BG. Taking the sting out of shots: control of vaccination-associated pain and adverse reactions. Pediatr Ann. 1998; 27:375-386.

[3] Hingson RA, Davis HS and Rosen M. The historical development of jet injection and envisioned uses in mass immunization and mass therapy based upon two decades experience. Mil Med. 1963; 128:516-524.

[4] Jones GF, Rapp-Gabrielson V, Wilke R, Thacker EL, Thacker BJ, Gergen L, Sweeney D and Wasmoen T. Intradermal vaccination for Mycoplasma hyopneumoniae. J Swine Health Prod. 2005; 13:19-27.

[5] Apley M and Thacker B. Determination of the pharmacokinetics of procaine penicillin in swine administered by intramuscular injection and with a needleless injection device. National Pork Board Research Abstract.

[6] Available at: http://www.pork.org/porkscience/research/documents/02-136-apley.abs.9-26-03.pdf. Accessed April 19, 2007.

[7] Senn MK, Bradford JR, Cook DL and Loskutov A. Comparison of pharmacokinetic parameters for Excenel RTU when injected by needle or Felton Pulse 250 needle-free injector. AASV Proc. 2004; 263-265.

[8] Almond GW and Roberts JD. Assessment of a needleless injection device for iron dextran administration to piglets. IPVS Proc. 2004; 618.

[9] Mitragotri S. Current status and future prospects of needle-free liquid jet injectors. Nat Rev Drug Disco. 2006; 5:543–548.

[10] Schlossberg CA, Daniels CS, Cook DL. Accuracy and precision of Pulse Micro-dose injection device using Draxxin, Excede, Excenel and sterile water. AASV Proc. 2008.

[11] United States Patent (needle free injection system) Patent No: US6, 676,630 B2.

[12] Weston Medical. Weston Medical.com FAQs. Available at: www.Weston medical.com/faqs.htm.

[13] www.penjet.com

[14] www.bioject.com

[15] www.cdc.gov/nip/dev/N3draft0007 doc

[16] www.cdc.gov/nip/dev/N2draft000603 Doc.

[17] http://www.pharmatutor.org/articles/needle-freeinjection-technology? Page=0, 1.

[18] Mitragotri S. Current status and future prospects of needle-free liquid jet injectors. Nat Rev Drug Discov. 2006; 5:543–548.

[19] Needle-FreeInjectionTechnology.www.cdc.gov/vaccine safety /vaxtech/nfit

[20] Epidermal delivery, Ideal platform to deliver vaccines and immunological compounds. http://www.pantec-biosolutions.com/en/products-and services/epidermal-deliverys

[21] Technology Overview, Needle-free injection what is it? http://www.bioject.com/about/technol ogy.

[22] http://www.ismp.org/Newsletters/acu tecare/articleis/20061130.asp.

[23] http://www.bioject.com/products/zetajet.

[24] Hunter Cora H. Suppository injector. US2589388. 1952.

[25] Ortho Pharma Corp. Single dose cavity dispenser. US2630804. 1953.

[26] Nat Tuberculosis Ass. Pellet injector. US3072121. 1963.

[27] Robinson Ralph R. Cervical implant method and device. US3572335. 1971.

[28] Hanson Raymond L. Pill gun. US4060083. 1977.

[29] James Davidov. Anal medication applicator. US4808166. 1989.

[30] Alcon Laboratories, inc. Means and method for dispensing substances. US4871094. 1989.

[31] Endocon, Inc... Automatic balling gun. US5399162. 1995.

[32] US5405324. Cselle; Edward. Implantation device. 1995.

[33] Sumitomo Pharmaceuticals Company, Limited. Device for administering solid preparations. EP0292936A2. 1988.

[34] Oratec Interventions, Inc. Method and apparatus for soft tissue fixation. US5823994. 1998.

[35] Oratec Interventions, Inc. Method and apparatus for applying thermal energy to tissue asymmetrically. US6176857. 2001.

[36] Lg Chemical Ltd. Syringe assembly. US6402716. 2002.