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Iontophoresis in Dentistry: A Review

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Abstract

Systemic and local drug administrations are the two basic classifications for drug delivery in the oral cavity. Efficient drug delivery in the oral cavity is necessary for the treatment of oral illnesses in both soft and hard oral tissues (e.g., mucosal and enamel, respectively). Improved local and systemic medicine administration is made possible by the non-invasive technology known as iontophoresis (IP). Iontophoresis was primarily researched for transbuccal medication administration in the oral cavity. For various drugs, buccal iontophoresis significantly improved drug delivery when compared to passive transport. For the purpose of treating oral problems locally in the oral cavity, iontophoresis can improve drug penetration into the oral tissues. Iontophoresis has been tested for use in dentistry to cure hypersensitivity as well as to create local anaesthesia.

Introduction: Iontophoresis has become one of the most promising tools for transdermal medication delivery among recent discoveries. A direct electrical current is used to introduce ions into the bodily tissues during iontophoresis, a therapeutic procedure.1 It was first developed by LeDuc in 1903 as a method of transferring molecules over a membrane using an electrical current as the driving force. It was first known as ion transfer. Iontophoresis has undergone a variety of uses and popularity trends since that time.2 Iontophoresis has recently received more attention and is now a frequently employed clinical treatment. Iontophoresis is a painless, sterile, noninvasive method for introducing particular ions into a tissue that has been shown to have a beneficial impact on the healing process. This method has various advantages over other conventional methods.Iontophoresis is a simple and effective method that enhances local and systemic medicine delivery by using an electric field. In the oral cavity, transbuccal medicine administration was the main focus of iontophoresis research. When compared to passive transport, buccal iontophoresis greatly improved medication delivery for a number of different medicines. For local drug administration in the oral mucosa to treat oral problems, iontophoresis may enhance drug penetration into oral tissues. Iontophoresis has been testing to determine whether it may be used in dentistry to treat hypersensitivity and produce local anaesthetic.4 Aim of present review of literature is to discuss application of Iontophoresis in Dentistry.

Mechanism of Iontophoresis: Electric current passed via a membrane improves drug delivery in iontophoresis, both for medicines that are charged and uncharged. The underlying idea behind iontophoresis is that ions with like charges repel one another.[5,6] Iontophoresis functions via an electrophoresis, electro-osmosis, and electropermeabilization-based mechanism.[7,8] The cathode repels negatively charged ions in electrophoresis while the anode repels positively charged ions. The enhanced transfer of medicines with ionic charges is mostly due to this mechanism. The transport of ionic and neutral medicines is the foundation of electro-osmosis. Along with the bulk solvent flow, the electric field facilitates the passage of neutral and charged molecules over a charged membrane. The third method is electro-permeabilization, which alters the membrane barrier by increasing intrinsic permeability and changing the permeation pathway's characteristics, including the sizes and charges of the membrane pores.[9,10]

Factors Affecting Iontophoresis Transport: Iontophoresis outcomes have been demonstrated to be influenced by a variety of circumstances. The physicochemical characteristics of the substance, drug formulation, technology, biological variations, skin temperature, and duration of iontophoresis are some of these. The following elements must be taken into account:[2,11,12]

Influence of pH: For the iontophoretic administration of medicines, pH is significant. The ideal substance is one that predominately takes on an ionised state. It is crucial to maintain the pH as near to and, at least when working with vasodilators, at pH 5.5 and lower because when the pH decreases, the concentration of hydrogen ions increases and a vascular reaction (vasodilatation) is triggered because of C-fiber activation. It is preferred to have a sizable fraction of the drug in the ionised state for the best IP. To balance this, a medication must be administered at a pH that is safe and tolerable for the patient.[2,13]

Strength and Density: The amount of current supplied per square inch of surface area is known as current density. When choosing appropriate current levels, the following factors should be taken into account for IP. The current needs to be strong enough to give the desired rate of drug delivery. It shouldn't have any negative impacts on the skin.[2] The measured fluxes of a 1-cm2 have a linear relationship, but the current is restricted to 1 mA for patient comfort. In order to prevent localised skin burns and discomfort, this current should not be used for longer than three minutes. The risk of non-specific vascular reactions (vasodilatation) rises with increasing current. After a few seconds of iontophoresis with deionized or tap water, such a vascular response is triggered at a current of 0.4–0.5 mA/cm2. The release of substance P from C-fiber terminals and other reactions caused by the latter endings are likely caused by the current density being high enough in that tiny an area to stimulate the sensory nerve.[14,15]

Concentration of Drug: Depending on the drug being used, it has been demonstrated that the steady-state flux (ion movement) grows as the solute content rises in the donor compartment, or in the delivery electrode. According to report, increased drug concentration during and after IP is associated with increased epidermal uptake.[16,17]

Anatomical Factor: The depth of penetration varies from patient to patient and is influenced by anatomical factors such as the thickness of the skin at the application site, the existence of subcutaneous adipose tissue, and the size of other structures, such as skeletal muscle. Additionally, the existence and degree of inflammation can affect how well a drug penetrates the body due to the increased temperature (which may help the drug travel throughout the body).[2]

Physical Property of Drug: Due to the differences in the matrices, the substance will migrate differently when subjected to the influence of an electrical current. Differences in viscosities, substance electrical charge, and porosities may be responsible for this.[2]

Application of Iontophoresis in Dentistry

Iontophoresis for Non-Invasive Anesthesia: Iontophoresis has numerous dental uses, one of which is a minimally invasive anaesthetic procedure. Using this technique, deeper oral regions can receive local anaesthesia after topical application on the spot. Through an electrical influence, this technique helps positively charged lignocaine and adrenaline agents reach deeper tissues.[20] Due to the lack of needles, this technique can enhance the dentist–patient relationship. According to Thongkukiatkun et al., normal, exposed dentine needs to be anaesthetized with a topical treatment of 20% lignocaine and 0.1% epinephrine for 90 seconds at a time using an iontophoretic current of 120 mA.[21] According to Cubayachi et al., prilocaine hydrochloride and lidocaine hydrochloride combination leads in enhancement of the mucosal accumulation following iontophoresis by 86 and 12 times, respectively (pH 7.0). Therefore, using iontophoresis with a mix of medications at pH 7.0 can help in a needle-free method to hasten the start and lengthen the duration of buccal anaesthesia.[22]

Application of Iontophoresis for Management of Dentinal Hypersensitivity: In contrast to other dental diseases or defects, dentinal hypersensitivity is characterized by brief, acute pain that develops from exposed dentin in reaction to external stimuli.[22] It frequently affects the cervical portion of the canine and premolar facial surfaces.[23] The patient has discomfort and agony, which makes it harder for them to practise good dental hygiene. Thermal, chemical, and mechanical stressors can cause dentinal hypersensitivity.[24]

Dentinal hypersensitivity can be treated effectively with the iontophoresis approach. APF cream Due to the fluoride ions' deeper penetration, iontophoresis is efficient in lowering hypersensitivity right away and has relatively long-lasting effects. The fluoride content in teeth treated iontophoretically was double that of fluoride applied topically.[25] There are several theories as to how iontophoresis results in desensitisation of dentin. According to one process put out by Lefkowitz (1963), applying current to dentin causes the development of reparative dentin, which causes dead tracts in primary dentin.

Iontophoresis may also be explained by the idea that the electrical current modifies the sensory systems involved in pain conduction.[26]

Application of Iontophoresis in Endodontics: Iontophoresis-based cleaning can be used to remove biofilm from tooth root canals.[27] It has been seen that iontophoresis using potassium iodide was effective for removing gram-positive cocci's biofilm. A study on radioiodide was conducted using potentials between 1 and 3 volts to determine the rate of iodide penetration through the enamel surface and its progression towards the pulp, which was compared with natural diffusion. In this study, it was discovered that when comparing water extracts with acid extracts, acid extracts significantly contribute to the diffusion of medicines through the enamel. When iodide was examined with water extracts on or near the enamel surface, it was discovered to be weakly bound. Acid extracts revealed firmly bound iodide or iodide with higher penetration depth. Anions like fluoride and iodide have a lower entry rate than cations because the tooth has a negative charge. Consequently, the potential to boost penetration was determined to be positive.[28]

Silver has antibacterial qualities. When delivered using iontophoresis, silver demonstrated a stronger antibacterial impact against Gram-negative bacteria and a weaker effect against Gram-positive bacteria.[29]

Application of Iontophoresis in Remineralization: In order to assess the impact of remineralization on the initial caries lesion in the enamel. In a study published in 2010, Lee YE et al. examined three topical fluoride regimens, including the application of Acidulated phosphate fluoride (1.23%) gel, NaF varnish 2% and 5% solution with iontophoresis. With the aid of a CLSM and digital microhardness tester, fluoride uptake and fluorescence lesion region were detected in this work. In comparison to the test group, the NaF with iontophoresis group showed diminished lesion depth and more fluoride uptake.[30]

Safety Concern: Iontophoresis induces tingling or itching depending on the strength of the delivered current. Skin irritation, which is harmless but irritating, is the most frequent local adverse effect of cutaneous iontophoresis. It affects both the anode and the cathode. The side effect that is most frequently reported, according to the iontophoresis protocols, is erythema. Burns have occasionally been observed, however they are usually caused by operator error and an incorrect choice of electrodes or formulation ingredients.[31]

Conclusion: Iontophoretic drug delivery is regarded as secure and non-intrusive. Since the current topical oral medication delivery methods are not very beneficial and successful, it is crucial to design an effective iontophoresis approach for local drug administration. Iontophoresis has been used in dentistry and oral care procedures, but its full potential has not yet been realised. For the treatment of conditions affecting the mouth, such as hypersensitivity and tooth decalcification, iontophoresis may be an effective medication delivery technique. This method may result in greater drug penetration into the teeth because it allows for accelerated ion movement while being influenced by an external electrical potential difference.

References

[1] Semalty A, Semalty M, Singh R, Saraf SK, Saraf S. Iontophoretic drug delivery system: a review. *Technol Health Care*. 2007;15(4):237-245.

[2] Rawat S, Vengurlekar S, Rakesh B, Jain S, Srikarti G. Transdermal delivery by iontophoresis. Indian J Pharm Sci. 2008 Jan;70(1):5-10. doi: 10.4103/0250-474X.40324. PMID: 20390073; PMCID: PMC2852061.

[3] Batheja P, Thakur R, Michniak B. Transdermal iontophoresis [published correction appears in Expert Opin Drug Deliv. 2006 Mar;3(2):303.

[4] Wanasathop A, Li SK. Iontophoretic Drug Delivery in the Oral Cavity. *Pharmaceutics*. 2018; 10(3):121. https://doi.org/10.3390/pharmaceutics10030121

[5] Ragit R, Fulzele P, Rathi N V, et al. (October 25, 2022) Iontophoresis as an Effective Drug Delivery System in Dentistry: A Review. Cureus 14(10): e30658. DOI 10.7759/cureus.30658

[6] Arowojolu MO: Fluoride iontophoresis versus topical fluoride application in the treatment of dentine hypersensitivity. Niger J Clin Pract. 2002, 5:87-90. 10.4314/njcp.v5i2.11117

[7] Kalia YN, Naik A, Garrison J, Guy RH: Iontophoretic drug delivery. Adv Drug Deliv Rev. 2004, 56:619-58. 10.1016/j.addr.2003.10.026

[8] Pikal MJ: The role of electroosmotic flow in transdermal iontophoresis . Adv Drug Deliv Rev. 2001, 46:281- 305. 10.1016/s0169-409x(00)00138-1

[9] Costello CT, Jeske AH: Iontophoresis: applications in transdermal medication delivery . Phys Ther. 1995, 75:554-63. 10.1093/ptj/75.6.554

[10] Becker SM, Kuznetsov AV: Transport In Biological Media. Elsevier, Oxford; 2013. 10.1016/C2011-0-05837-4

[11] Rai R, Srinivas CR: Iontophoresis in dermatology. Indian J Dermatol Venereol Leprol. 2005, 71:236-41. 10.4103/0378-6323.16613

[12] Karpiński TM: Selected medicines used in iontophoresis . Pharmaceutics. 2018, 10:204.

[13] Fang JY, Hung CF, Wong WW. Skin Pharmacol Physiol 2006; 19:28-37.

[14] Abramowitz D, Neoussikine B. Treatment by Ion Transfer, New York: Grune and Stratton; 1946. p. 87.

[15] Schriber WJ, editor. A manual of electrotherapy, 4th ed., Philadelphia: Lea and Febiger; 1975. p. 125-31

[16] Siddiqui O, Roberts MS, Polock AZ. The effect of iontophoresis and vehicle pH on the in-vitro permeation of lignocaine through human stratum corneum. J Pharm Pharmacol 1985;37:732-5.

[17] Abramson HA, Alley A. Mechanisms of histamine iontophoresis from aqueous media. Arch Phys Ther 1937;18:327

[18] Pikal MJ, Shah S. Transport mechanisms in iontophoresis II. Electroosmotic flow and transference number measurement for hairless mouse skin. Pharm Res 1990;7:313-21.

[19] Meechan JG. Intra-oral topical anaesthetics: a review. J Dent 2000;28(1):3–14. DOI: 10.1016/s0300-5712(99)00041-x.

[20] Thongkukiatkun W, Vongsavan K, Kraivaphan P, et al. Effects of the

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
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iontophoresis of lignocaine with epinephrine into exposed dentine on the sensitivity of the dentine in man. Arch Oral Biol 2015;60(8):1098–1103. DOI: 10.1016/j.archoralbio.2015. 04.006.

[21] Cubayachi C, Couto ROD, de Gaitani CM, et al. Needle-free buccal anesthesia using iontophoresis and amino amide salts combined in a mucoadhesive formulation. Colloids Surf B Biointerfa 2015;136:1193– 1201. DOI: 10.1016/j.colsurfb.2015.11.005

[22] American Academy of Periodontology. Glossary of periodontal Terms (2001).

[23] Sandhu SP, Sharma RL, Bharti V. Comparative evaluation of different strengths of electrical current in the management of dentinal hypersensitivity. Indian Journal of Dental Research. 2010 ;21(2):207-12

[24] Sethi R, Indurkar MS. Comparison of Fluoride Iontophoresis and Dentin Bonding Agent Application in the Treatment of Dentin Hypersensitivity: A clinical study. Indian J Dent Adv. 2015; 7(1):13-7.

[25] Arowojolu MO. Fluoride Iontophoresis Versus Topical Fluoride Application in the treatment of Dentine Hypersensitivity. Nigerian Journal of clinical practice. 2002 Dec;5(2):87-90.

[26] Kaur M. Methyl Prednisolone with Iontophoresis in the Treatment of Dentine Hypersensitivity. An In-Vitro and In-Vivo Study. IOSR Journal of Dental and Medical Sciences (IOSRJDMS). 2016;15(2):52-60.

[27] Gergova RT, Gueorgieva T, Dencheva-Garova MS, Krasteva-Panova AZ, Kalchinov V, Mitov I, Kamenoff J: Antimicrobial activity of different disinfection methods against biofilms in root canals . J Investig Clin Dent. 2016, 7:254-62. 10.1111/jicd.12147

[28] ST EC, TA JB: Influence of electrical potential on ion migration in teeth. 2. Quantitative measurements of I-131 penetration by an acid-leaching technique. J Dent Res. 1964, 43:175-86. 10.1177/00220345640430020401

[29] Shirwaiker RA, Wysk RA, Kariyawasam S, Voigt RC, Carrion H, Nembhard HB: Interdigitated silver-polymerbased antibacterial surface system activated by oligodynamic iontophoresis - an empirical characterization study. Biomed Microdevices. 2014, 16:1-10. 10.1007/s10544-013-9800-x2122.

[30] Lee YE, Baek HJ, Choi YH, Jeong SH, Park YD, Song KB: Comparison of remineralization effect of three opical fluoride regimens on enamel initial carious lesions. J Dent. 2010, 38:166-71.

[31] Roustit M, Blaise S, Cracowski JL. Trials and tribulations of skin iontophoresis in therapeutics. *Br J Clin Pharmacol*. 2014;77(1):63-71. doi:10.1111/bcp.12128.