

Research Opportunities in Needleless Anaesthesia in Dentistry– A Review

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Abstract

The objective of the paper is framed in three folds:(i) This paper is focused on emphasizing that needleless anaesthesia technique is a suitable alternative to the conventional painful injection method employed for the desensitisation of the teeth. (ii) The results and the limitations presented would assist the future to work further in the field so that the researchers don't have to commence the review of literature right from the start, (iii) The study indicate that iontophoretic method could be very well applied in dental field. In the present work, 45 tooth samples were used for analyzing using SEM and E-DAX methods and the observed results were presented in the results and discussion section of the paper.

Keywords: *Dental anesthesia, painless surgery, needle-free injection, iontophoresis, dental field.*

I. INTRODUCTION

Needle phobia, referred to as fear of needle is there in about 20% of the total people, out of

which 5 to 10% can faint. In rural areas, the consequence is even much more as some patients might run away from the hospitals due

to fear. Ever since the research works pertaining to medical field commenced, the usage of anesthesia has played a vital role. This anesthesia was never used before until it was founded by William Morton in 1846. Since then its growth has been a tremendous one that it is available in gels and patches [1,2]. Usually syringes are used to inject anesthesia ever since it was invented. However, this has led to complex tasks in case of senior citizens, children's, and patients who are allergenic to needles. Therefore, the need for an alternative technique has become a challenge for the research fraternity over a period of time, because of which subsequently the concept of "Iontophoresis" was invented. This current [3], [4] causes the ions of specific charges to get absorbed into the semipermeable membrane. Thus the [5] ions reach the dentin layer [6], [7] which is the second layer after the upper calcium coating. These ions make the nerves soft thus, numbness achieved and this could be used in dentist purpose. The aim of this paper is to study all the existing papers, to present a review of all the anesthesian procedures available in the past, and to prompt the use of needleless anesthesia in the dentistry operations.

II. MATERIALS AND METHODS

The review methodology of this paper has been done by (i) review of all the anesthesia procedures available in India and (ii) review of the entire anesthesia procedures available abroad (iii) validating the need and promotion of needleless anesthesia.

When the first anesthesia was utilized in the dental field, the patient lost his consciousness. The conventional procedure in making a patient losing his consciousness and then operating him was very tedious which led to loss of lives.

Then years later in the mid-19th Century epidural anesthesia was used with needle associated in it for delivering anesthesia. Now the technological advancements [8] have led to the discovery of microneedles [12-14]. These inventions however have led to many developments in the active process of drug delivery inside the body, but with no pain or less pain with a posed disadvantage associated with them. The main disadvantage is that the penetration of molecules i.e. the drug in the stratum corneum of the skin. Secondly, it is the continuous injection within the layers of the oral cavity may cause these layers to tear off. Hence, many researches are in progress in this field for these specific advancements. Thus, this paper is focused on presenting the merits and demerits based on the detailed review carried out. Accordingly, a young researcher who would like to work in this field of anesthesia can easily work in their research openings. Moreover, the authors of this paper have also justified the need of Needleless – oral anesthesia in dentist field and working on the same and proposed the concept of needle-free injection for anesthesia and desensitization of teeth using the method of iontophoresis for anesthesia in dentistry for making the teeth numb.

III. ANESTHESIA PRACTICES IN INDIA

In India, the research for iontophoretic techniques is blooming where renowned pharmacology students and scientists [12] have been attracted to this area of research. In a significant step towards eradicating, the use of needle the details shown in table-1 gives the statistics of researches from India pertaining to the field of Iontophoresis.

Table 1. Statistics of Researches of anesthesia in India

Sl. No	Authors	Proposed theory	Limitations
1	Tejvir Kaur, 2018	Using iontophoresis in drug delivery	No dental application
2	Krishnaprasad Shetty, Satish SV, Krishna Rao Kilaru, March 2017	Comparing the efficacy of two different desensitizing agents and acidulated sodium fluoride(NaF) gel 0.33% with or without the iontophoretic procedure for relieving dentin hypersensitivity	Desensitisation of tooth - Comparative study.
3	Irudaya Nirmala J, Ramakrishnan T.,Sivaranjani P., November 2016	Treatment of patient with dentinal hypersensitivity using iontophoresis technique	Use of iontophoresis in dentinal hypersensitivity
4	LoheR.G.,Jadhkar S.S. , Modekar S.D. , Bhusare K.M., August 2016	Iontophoresis	No dental application.
5	Smirithi Sharma, Nayyar Parvez , Pramod Kumar Sharma, July 2015	Iontophoresis	No dental application.
6	SuchethaAghanasini,Rajeshwari H.R., March 2015	comparing desensitizing potential of novamin containing dentiforce and iontophoresis in the treatment of dentinal hypersensitivity	Comparative study using Novamin.
7	Rohan Sethi, Maya Sanjeev Indurkar, March 2015	Using APF gel iontophoresis and light cured dentin bonding agent for tooth hypersensitivity	Desensitisation of tooth - Comparative study
8	Dr.ShashikanthHegde,Dr.SushmitaMankude, March 2015	Compare the efficacy of operation modules for dentinal hypersensitivity and iontophoresis with acidulated phosphate gel and bifluoride varnish in its application.	Desensitisation of tooth - Comparative study
9	Balagani Pavan Kumar ,M.Sindhuri, January 2015	An update of needle free drug delivery system	Review article on the past 5 years
10	Radha Rani Earle,PaduchuriV.Subramanyam, April 2014	Transdermal drug delivery using microneedles	Needles are used.

11	Tejaswi R.Kale,Munira Momin, April 2014	Injection by using compressed gas with actuation in order to deliver the drug by generation of force at very high speed through a nozzle	No dental application.
12	Bhagyashri Chavan, Abha Doshi, Yashwant Malode, BaluMisal, August 2013	This article reviews jet injectors with respect to current applications and mechanical aspects.	No dental application.
13	Debjit Bhowmik, KP.Sampath Kumar, July 2013	Transdermal drug delivery	No dental application.
14	Sharma Nishu,Gnanarajan G, July 2013	Iontophoresis and laser techniques	No dental application.
15	Sharmraaj Subramaniam, Prasanna Neelakantan, 2013	Presents the technique for enhancing the efficacy of local anaesthetics.	Needles are used
16	Prabhakar Panzade,PrashantPuranik, August 2012	Iontophoresis	No dental application.
18	Vinod Dhote , Punit Bhatnagar, Pradyumna K. Mishra , Suresh C. Mahajan , Dinesh K. Mishra, December 2011	Iontophoresis	No dental application.
19	Shital H.Bariya, Mukesh C.Gohel, TejalA.Mehta, September 2011	Using microneedles for transdermal drug delivery	Needles are used
20	Azad Khan,MohdYasir,Mohd Asif, May 2011	Transdermal drug delivery of medications, both ionic and non-ionic using iontophoresis	No dental application.
21	Chanda Silpi, Bagga Manish Tiwari Raj Kumar, April 2011	Using microneedles for transdermal drug delivery	Needles are used
22	Jaydeep D Yadav[10], March 2011	Using microneedles for transdermal drug delivery	Needles are used
23	Memon Shakeel, Pathan Dilnawaz N, ZiyaurrehmanA.R, February 2011	Using microneedles for transdermal drug delivery	Needles are used
24	Dr.Prathima Srinivas , Chede.Laxmi Shanthi, Dr.M.Sadanandam, August 2010	Using microneedle for transdermal drug delivery	Needles are used

A. Inferences from the table 1

With the inferences from the above table 1, the author Mr.Tejevri Kaur et.al in his paper [13]

explains briefly about recent advances in using iontophoresis in drug delivery. Krishnaprasad Shettyet.al [14] compared the efficacy of two

desensitizing agents with and without iontophoresis in patients with dentinal hypersensitivity. A case study on treatment of patient with dentinal hypersensitivity using iontophoresis was proposed by the authors [15] Irudaya Nirmala J, et.al which outsources the positive outcomes of this method. Lohe R.G [16] et.al and authors Smirithi Sharma [17], Nayyar Parvez, Pramod Kumar sharma reviewed about the general iontophoretic methods and techniques. Comparative studies by the authors Rohan Sethi, Maya Sanjeev Indurkar was made between fluorides iontophoresis and dentin bonding agent for hypersensitivity [18]. Dr. Shashikanth Hegde et.al [19] evaluated and compared the efficacy two different modalities. The authors Balagani Pavan Kumar, M. Sindhuri, proposed the upcoming challenges in needle free [20] drug delivery system. The trends and progress in Microneedles was reviewed by authors Radha Rani et al. [2]. The concept of using force [21] for drug delivery was given by authors Tejaswi R. Kale, Munira Momin using compressed gas by which the drug can be delivered in high speed. The future prospects with respect to concept of jet injectors to their current clinical applications was discussed by Bhagyashri Chavan et al. [22] in their work. Authors [23] Sharma Nishu, Gnanarajan G and authors Debjit Bhowmik, KP. Sampath Kumar [24] published and presented a report about the transdermal drug delivery process, its current and future scope.

Several methods for enhancing the efficacy of local anaesthetics [25] were reported in the published literature. Sharmraaj Subramaniam, Prasanna Neelakantan, when administering local anesthesia to patients. The implications for the method of Iontophoresis by Mr. Vinod Dhote [26] et.al and its enhancements were in detail dealt by the authors. Prabhakar Panzade [27] et.al explored more about the [28] emerging trends in transdermal drug delivery system using microneedles. Mr. Azad Khan, Mohd Yasir, Mohd Asif went on to study about the Transdermal drug delivery of medications, both ionic and non-ionic [29] using iontophoresis following the previous studies which details us about the various applications of the methodology when applied. Chanda Silpi, Bagga Manish Tiwari Raj Kumar [30] talks about the method of using microneedles for transdermal drug delivery in medical field which were elaborately dealt with. A new method of using microneedle for transdermal drug delivery by patches [1] was proposed by Dr. Prathima Srinivas et al.

IV. ANESTHESIA PRACTICES OUTSIDE INDIA

Also in countries outside India, the research in iontophoresis is going on to eradicate the use of needles for drug delivery. The following Table-2 gives the statistics of researches done outside India on iontophoresis.

Table 2. Statistics of Researches of anesthesia outside India

Sl. No	Authors	Proposed theory	Inferences and Limitations
1	Chaterina Anjelia, Octarina Octarina [41], December 2021	The knowledge level of dental students on color stability composite resin restoration in the COVID-19 pandemic era	Study on the color stability of composite resin restoration
2	Dobrinka Mitkova Damyanova, Radosveta Andreeva-Borisova [42], June 2021	Relative share, frequency and correlation of restorations in both dental dentitions in childhood	Study on restorations in both dental dentitions in childhood

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| 3 | <i>DobrinkaMitkovaDamyanova, Valentina Velikova[43], June 2021</i> | Risk factors associated with the development of dental caries in Bulgarian children | Examined the risk factors associated with the development of dental caries in children in Bulgaria |
| 4 | <i>Muhiuddin Haider, Emily Vooris, Ananya Krishnan[44], March 2021</i> | Health facilities roles in measuring progress of universal health coverage | Study on the Health facilities roles |
| 5 | <i>DobrinkaMitkovaDamyanova, Valentina Velikova[45], September 2020</i> | The knowledge of dentists for preventive influence of the caries process | Methods for non-invasive treatment of the initial dental caries |
| 6 | George Z.Tan,PaulE.Orndorff, September 2018 | This article aims to study the antimicrobial efficacy of a silver-based iontophoresis with the interactive effects of electric current intensity and activation duration | No Dental application. |
| 7 | ApipaWanasathop,S.Kevin Li, August 2018 | Iontophoresis in oral cavity for both systematic and local treatments | Desensitisation of tooth - Comparative study |
| 8 | Zavattini Angelo, Charalambous Polyviosis, April 2018 | The author voices out the availability of methods and devices that may replace needle anesthesia. | Desensitisation of tooth - Comparative study |
| 9 | Ms Barbara Taylor, 2018 | Needle free injector with a computer-controlled motor and with an internal feedback system | No dental application. |
| 10 | Joon Lee, Kilsung Kwon, MinyoungKim[46], January 2017 | Reverse Electro dialysis | No dental application. |
| 11 | Xiangrui Yang, Shichao Wu, Anran Cheng, 2017 | Using Nano needles for drug delivery system for cancer diagnosis and treatment | Needles are used |
| 12 | Hironori Tsuchiya, October 2016 | Pharmacological mechanisms stating the failures of local anesthesia in dentistry | Needles are used |
| 13 | Kai Chen , Min Pan ,Zhi-Gang Feng[47], 2016 | Using microneedles to deliver drugs painlessly through stratum corneum | Needles are used |
| 14 | Carla M Lopes , Catia Soares, December 2015 | Iontophoresis and Sonophoresis | Desensitisation of tooth - Comparative study |
| 15 | Camila Cubayachi,Rene Oliveira do Couto, November 2015 | Iontophoresis involving mucosal penetration of PCL and LCL. | Desensitisation of tooth - Comparative study |
| 16 | Ahlam Zaid Alkilani, Maeliosaet.al[48], October 2015 | Transdermal drug delivery by velocity-based device | Needles are used |
| 17 | Gregory K.Tuttle, July 2015 | Using TuttleNumbNow a one-step localized method for anesthesia | Needles are used |

18	Kevin Ita[49], June 2015	Using hydrogel-forming microneedles for transdermal drug delivery.	Needles are used
19	ByeongHeeKim , Young Ho Seo, June 2015	Microneedles for the transdermal drug delivery applications.	Needles are used
20	Najat Bubteina , Sufyan Garoushi, 2015	Brief overview of dentinal hypersensitivity involving diagnosis, etiology and its clinical management.	Desensitisation of tooth research in progress.
21	Karmen Cheung ,Diganta B. Das, December 2014	Trends and progress in researches pertaining to industrial field and its scope.	No dental application.
22	Karmen Cheung ,Diganta B. Das, November 2014	Microneedles	Needles are used
23	Eduardo Borba Neves, Eduardo Mulinari[50], July 2014	Iontophoresis	No dental application.
24	Yen Lai Kee Second, Prasanna Neelakantan, November 2013	New methods in delivering painless local anesthesia in oral cavity	No dental application.
25	Dr Matthieu Roustit, Sophie Blaise, April 2013	Current applications of iontophoresis in therapeutics and its further potential investigations.	Desensitisation of tooth research in progress.
26	Dr Chris Thompson, 2012	Machines used in anesthesia	Needles are used
27	Nahid Tabassum, AasimSofi , Tahir Khuroo[11], March 2011	Using microneedles for transdermal drug delivery	Needles are used
28	Dirk Mohn, Matthias Zehnder, Wendelin J. Stark, Thomas Imfeld, January 2011	Treating decontaminate dental implants with electrochemical treatment	No dental application.
29	H.E.Kim, H.K.Kwon, B.I.Kim, October 2009	Comparing the conventional fluoride application method and theremineralisation effect of fluoride iontophoresis.	Desensitisation of tooth - Comparative study.

A. Inferences from the table 2

To consolidate the Table 2, it is clearly shown that most of the papers have the limitation of usage of needles and use of microneedles and it is clear that needleless anesthesia is not implemented in dentistry field. The authors George Z.Tan, Paul E.Orndorff [31] have briefly explained about the oligodynamic iontophoresis. ApipaWanasathop, S. Kevin Li [32] have explained about the use of iontophoresis for drug delivery in oral cavity for both systematic and local treatments. H.E.Kim, H.K.Kwon, B.I.Kim [33]

have compared the conventional fluoride and remineralization effect of fluoride iontophoresis and in vitro. The author Dr Matthieu Roustit [34], Sophie Blaise has briefly reviewed on the factors influencing iontophoresis and has explained in detail about the current applications of iontophoresis in therapeutics and its further potential investigations, including systemic and topical drugs and focusing on the treatment of scleroderma-related ulcerations. Najat Bubteina, Sufyan Garoushi[35] have done the review to inform the practitioners about dentin hypersensitivity to provide a brief overview of

the diagnosis, etiology and clinical management of dentin hypersensitivity. Hironori Tsuchiya[3] has reviewed about the pharmacological mechanisms stating the failures of dental local anesthesia by focusing on inflammatory acidosis, its products and mediators which may modify the properties of anesthetic agents and their targets. The researchers [39] has done the iontophoresis experiment on pigs with the help of the chemicals prilocaine hydrochloride (PCL) and lidocaine hydrochloride (LCL) to provide anesthesia. Yen Lai Kee Second, Prasanna Neelakantan [36] have discussed the newer methods of delivering painless local anesthesia in the oral cavity. The authors Zavattini Angelo, Charalambous Polyvios[12] highlighted the procedures and devices available which may replace the conventional needle-administered local anesthesia. Dirk Mohn, Matthias Zehnder, Wendelin J. Stark, Thomas Imfeld[37] has investigated the use of dental titanium implants as electrodes for the local generation of disinfectants.

Authors Karmen Cheung, Diganta B. Das[8] have reviewed about the various technologies developed in microneedle research and has shown its rapid growth in research papers and patent publications since its first inventions. Authors Camila Cubayachi, Rene Oliveira do Couto[38] have investigated the influence of iontophoresis in the mucosal penetration of lidocaine hydrochloride[LCL] and prilocaine hydrochloride[PCL] which are largely used in dentistry as local anesthetics. The review of the machines that are used in anesthesia are discussed by Dr Chris Thompson[39].

V. RESULTS AND DISCUSSIONS

From Table 1, it is inferred that, many authors [1], in their research [9], have proposed working with microneedle but not by Iontophoresis. The other researches Vinod Dhote [26], Prabhakar Panzade [27] and others have put forth their views in iontophoresis but for non dental applications. Recently

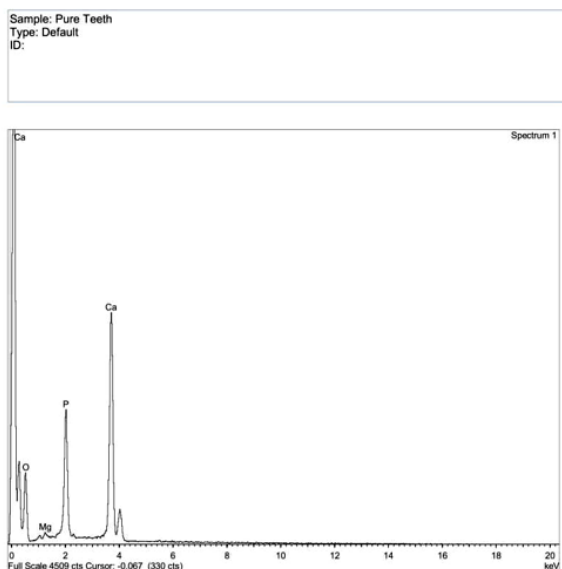
Krishnaprasad Shetty, Satish SV, Krishna Rao Kilaru researches [14] have studied about the availability of these desensitizing agents, paving ways for wide future researches in the dentist field.

In addition, Table 2, shows a wide range of researches in the in the past decade in medicine field and its advancements pertaining to needles used [8] intreating patients for surgeries using anesthesia. Newer methods of delivering anesthesia [31] was examined by many researchers by using various chemical compounds [40] having compared the effects of the experimental trials with different chemicals. Thus, many researches have experimented the cause using needles and its effective management [20] options encouraging the future researchers to take a lead in the upcoming years in the process of needless anaesthetic society.

Thus, this review article evidently presents the need of needleless anesthesia in dentistry field and its importance, implication and future scope.

From a comprehensive review of literature, it is inferred that iontophoric method has been applied in the field of dentistry [51-53].

Fig 1.E-DAX Results for Tooth Sample



Inference from Pure Teeth – Fig. 1 shows the results obtained from E- DAX which shows the chemical elements present in tooth which contains Calcium (Ca) in higher levels. This is the teeth sample without any gel or iontophoresis.

Fig 2. E-DAX Results for Tooth Sample with Varnish – 0.3 mA current for 5 minutes

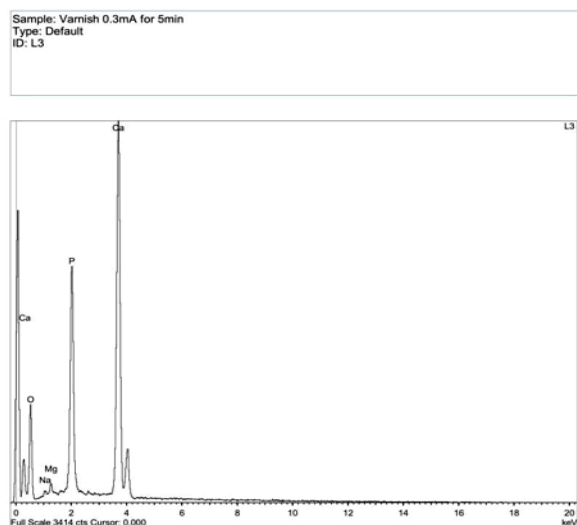
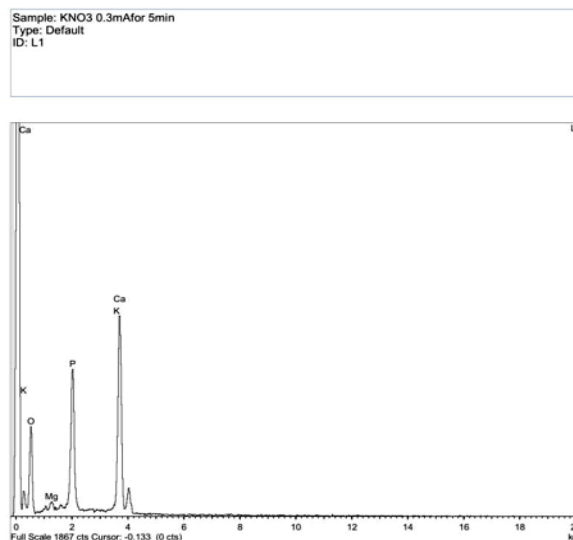


Fig 3. E-DAX Results for Tooth Sample with KNO3 – 0.3 mA current for 5 minutes



Inference from Teeth samples with Varnish - The E- DAX result for teeth sample with varnish gel, which is the control group (GP), which contains sodium element (Na) when compared to the pure teeth. This sodium (Na) helps in desensitizing the dentin layer. The process of iontophoresis is then carried on with 8 teeth samples. Fig. 2 shows the above process carried with 0.3 mA current for 5 minutes. The results were better when treated for 0.5 mA current for 3 minutes. The presence of sodium (Na) was found to be 0.61 in atomic weight.

Inference from Teeth samples with KNO3 – The teeth samples are now treated with KNO3. Fig. 3 shows the E-DAX results for teeth samples treated for 0.3 mA current for 5 minutes .The results for 0.5 mA current for a duration of 3 minutes gave promising results in which the traces of potassium ions (K) were nearly 60%.

VI. CONCLUSION

Thus, this entire paper voices out the need for researches and advancements in needle free anaesthetic methods, which has a wider scope in future. It also helps researches to understand the need for such methods and its significances. The concept of needle-free injection for

anesthesia and desensitisation of teeth with the method of iontophoresis or any alternative innovative procedures for anesthesia in dentistry for making the teeth numb is thoroughly studied and presented in various areas of research helping the future researchers to work with the above given data by understanding the concepts. Thus, by incorporating needle-free injection for anesthesia and desensitisation of teeth, in dentist field makes the operations in dentistry easily. By reading this paper researcher would sufficiently use this literature paper and start with the research rather than initiating a further study in this field. Thus, introducing a new era in the field of dentistry and reducing the time of surgery done.

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