COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5 MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY

A Dissertation submitted
in partial fulfillment of the requirements
for the degree of

MASTER OF DENTAL SURGERY
BRANCH – IV
CONSERVATIVE DENTISTRY AND ENDODONTICS

THE TAMILNADU DR. MGR MEDICAL UNIVERSITY
CHENNAI – 600 032
2014 – 2017

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY** is a bonafide and genuine research work carried out by me under the guidance of **Dr.M. KAVITHA, MDS, Professor & HOD** Department of Conservative Dentistry and Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai-600003.

Dr. UMESH G

CERTIFICATE BY GUIDE

This is to certify that **Dr. UMESH G,** Post Graduate student (2014-2017) in the Department of Conservative Dentistry and Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai- 600003 has done this dissertation titled **COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5 MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY** under my direct guidance and supervision in partial fulfillment of the regulations laid down by the Tamil Nadu Dr. M.G.R Medical University Chennai- 600032, for M.D.S., Conservative Dentistry and Endodontics (Branch IV) Degree Examination.

Dr. M. KAVITHA, M.D.S.
PROFESSOR & HOD (GUIDE)

Department of Conservative Dentistry and Endodontics.
Tamil Nadu Government Dental College and Hospital
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ENDORSEMENT BY HEAD OF THE DEPARTMENT / HEAD OF THE INSTITUTION

This is to certify that the dissertation titled **COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5 MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY** is a bonafide research work done by **Dr. Umesh G**, Post Graduate student (2014-2017) in the Department of Conservative Dentistry & Endodontics under the guidance of **Dr. M. KAVITHA, M.D.S, PROFESSOR & HOD (GUIDE),** Department Of Conservative Dentistry & Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai-600003.

Dr. M. KAVITHA, M.D.S.,
Professor & HOD,
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Principal

Tamil Nadu Government Dental College and Hospital.
Chennai- 600003.

ACKNOWLEDGEMENT

I wish to place on record my deep sense of gratitude to my mentor and guide **Dr. M. Kavitha, MDS** for her keen interest, inspiration, immense help and expert guidance throughout the course of this study as Professor and Head of the Dept. of Conservative Dentistry and Endodontics, Tamil Nadu Govt. Dental college and Hospital, Chennai.

I extend my heartfelt gratitude and sincere thanks for giving me support and strength to **Dr. B. Ramaprabha, MDS** Professor of Department of conservative dentistry and Endodontics, Tamilnadu Govt Dental College and hospital for her timely guidance, motivation, suggestions and inspiration.

I take this opportunity to convey my sincere thanks and gratitude to **Dr. B. Saravanan, MDS Ph.D,** Principal, Tamil Nadu Govt. Dental College for permitting me to utilize the available facilities in this institution.

I honestly thank **Dr. K. Amudhalakshmi, MDS.,** Associate Professor for helping me with the materials when I needed the most for the study.

I sincierly thank to **Dr. D. Arunaraj MDS, Dr. A. Nandhini, MDS, Dr. P. Shakunthala, MDS.,** Associate Professors and **Dr. M. S. Sharmila, MDS, Dr. M. Sudharshana Rajini, MDS, Dr. N. Smitha, MDS, Dr. S. Venkatesh, MDS, Dr. S. Dhanalakshmi, MDS,** Assistant Professors for their guidance and encouragement throughout the past three years.

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I specially thank Biostatistician**, Valarmathi Srinivasan** of Tamil Nadu Dr. M.G.R. Medical University, for statistical guidance and help.

I thank to all of my patients who participated in the study and my dear co-pgs, seniors & juniors who helped me to make this possible.

All of this happened with the blessing of my mother **GOWRAMMA O**, father **GIRISH B**, my brothers Dr. **G P NAYAKA** & **SANTHOSH G** and best wishes of my lovely sister **BHAGYALAKSHMI G**. I cannot thank them but I will take this opportunity to tell them that ***"I love you all for everything you have given to me"***.

DECLARATION

TITLE OF DISSERTATION	**COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5 MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY**
PLACE OF THE STUDY	Tamil Nadu Government Dental College & Hospital, Chennai- 3.
DURATION OF THE COURSE	3 YEARS
NAME OF THE GUIDE	Dr. M. KAVITHA
HEAD OF THE DEPARTMENT	Dr. M. KAVITHA

I hereby declare that no part of dissertation will be utilized for gaining financial assistance or any promotion without obtaining prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai – 3. In addition I declare that no part of this work will be published either in print or in electronic media without the guide who has been actively involved in dissertation. The author has the right to preserve for publish of the work solely with the prior permission of Principal, Tamil Nadu Government Dental College & Hospital, Chennai – 3.

HOD **GUIDE** **SIGNATURE OF THE CANDIDATE**

TRIPARTITE AGREEMENT

This agreement herein after the "Agreement" is entered into on this day . Jan 2017 between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamil Nadu Government Dental College and Hospital, Chennai - 600 003, (hereafter referred to as, 'the college')

And

Dr. M. Kavitha aged 46 years working as **Professor & HOD** in Department of Conservative Dentistry & Endodontics at the college, having residence address at 69/4, Mettu street, Ayanavaram, Chennai- 600023(herein after referred to as the Principal Investigator)

And

Dr. Umesh G aged 27 years currently studying as **Post Graduate student** in Department of Conservative Dentistry & Endodontics, Tamil Nadu Government Dental College and Hospital, Chennai- 600003 (herein after referred to as the PG student and coinvestigator').

Whereas the PG student as part of his curriculum undertakes to research on **COMPARATIVE EVALUATION OF ANAESTHETIC EFFICACY OF 2 % LIDOCAINE + 1:80,000 EPINEPHRINE AND 4 % ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5 MOL/L MANNITOL OR 8.4 % SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN INVIVO STUDY** for which purpose the Principal Investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator.

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard.

Now this agreement witnesses as follows

1. The parties agree that all the Research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.

2. To the extent that the college has legal right to do so, shall grant to license or assign the copyright so vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.

3. The royalty so received by the college shall be shared equally by all the three parties.

4. The PG student and Principal Investigator shall under no circumstances deal with the copyright, Confidential information and know – how - generated during the

course of research/study in any manner whatsoever, while shall sole vest with the college.

5. The PG student and Principal Investigator undertake not to divulge (or) cause to be divulged any of the confidential information or, know-how to anyone in any manner whatsoever and for any purpose without the express written consent of the college.

6. All expenses pertaining to the research shall be decided upon by the Principal Investigator/ co-investigator or borne solely by the PG student. (co-investigator)

7. The college shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.

8. The Principal Investigator shall suitably guide the Student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic an area of research by the student researcher under guidance from the Principal Investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the College constituted for this purpose.

9. It is agreed that as regards other aspects not covered under this agreement, butwhich pertain to the research undertaken by the PG student, under guidance from thePrincipal Investigator, the decision of the college shall be binding and final.

10. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act 1996.

In witness where of the parties herein above mentioned have on this day, month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its **Principal** **PG Student**

Witnesses **Student Guide**

1.

2.

ABSTRACT

AIM: The purpose of this prospective, randomized, triple-blind study was to compare the anaesthetic efficacy of 2 % lidocaine + 1:80,000 epinephrine and 4 % articaine + 1:1,00,000 epinephrine buffered with 0.5 mol/l mannitol or 8.4 % sodium bicarbonate on the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis.

MATERIALS AND METHODS: 180 adult patients diagnosed with symptomatic irreversible pulpitis of a mandibular posterior tooth were randomly divided into 6 groups of 30 participants in each group. The patients received 1 cartridges of either 2 % lidocaine + 1:80,000 epinephrine or 4 % articaine + 1:1,00,000 epinephrine buffered buffered with 0.5 mol/l mannitol or 8.4 % sodium bicarbonate using conventional IAN block injections. Endodontic access preparation was initiated 15 minutes after injection. Pain on injection, pain on access preparation & pain on instrumentation was measured using Heft-Parker visual analog scale. Data were analyzed by the descriptive statistics, one way ANOVA & Tukeys post hoc tests.

RESULTS: There was no significant difference among any groups for pain on injection. Buffered local anaesthetics showed higher success rates compared to nonbuffered groups and articaine showed better efficacy than lignocaine in both buffered and non buffered groups for pain on acess opening & pain on instrumentation.

CONCLUSION : Buffered local anaesthetic solutions found to be promising in reducing pain. 0.5mol/L Mannitol and 8.4 % sodium bicarbonate proved that adding these buffering agents will improve the anaesthetic efficacy of 4 % articaine + 1:1,00,000 epinephrine than 2 % lignocaine + 1:80,000 epinephrine. 4 % articaine + 1:1,00,000 epinephrine performed better than 2 % lignocaine + 1:80,000 epinephrine in reducing pain.

KEY WORDS: Lignocaine, Articaine, Buffered Local Anaesthetic solution, 8.4 % Sodium Bicarbonate, 0.5 mol/L Mannitol.

ANNEXTURE I

TAMIL NADU GOVRNMENT DENTAL COLLEGE & HOSPITAL, CHENNAI – 3.
TELEPHONE : 044-253403343
FAX: 044- 25300681
date : 19/09/2015

Ref No: R.C No.0430/DE/2015 dated 27.01.2015, O/O Principal, TNGDC
Sub: IEC review of the research proposals,

Title of the work:	Comparative evaluation of anesthetic efficacy of 2% Lidocaine + 1:80,000 Epinephrine and 4% Articaine + 1:1,00,000 epinephrine buffered with 0.5mol/ L mannitol or 8.4% of sodium bicarbonate on the success of Inferior alveolar nerve block for teeth with symptomatic Irreversible Pulpitis – An in vivo study.
Principal Investigator:	Dr. Umesh G. II Yr. M.D.S., Student.
Department :	Department of Conservative Dentistry and Endodontics Tamil Nadu Govt. Dental College & Hospital , Chennai-3

Thank you for submitting your research proposal , which was considered at the Institutional Ethics Committee meeting held on 02-07-2015, at TN Govt. Dental College and the documents related to the study referred above were discussed and the modifications done as suggested and reported to us through your letter dated 18-09-2015 have been reviewed.

The decision of the members of the committee , the secretary and the Chairperson IEC of TN Govt. Dental College is here under:

Approved	Approved and advised to proceed with the study
Approved with suggestions	----------
Revision	----------
Rejected	----------

The principal investigators and their team are advised to adhere the guide lines given below:

1. You should get detailed informed consent from the patients / participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the institution or the Government.
3. You should inform the IEC, in case of any change of study procedure, site, and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s) .
6. You should complete the work within specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/ Professor.

MEMBER SECRETARY,
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

CHAIRPERSON
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

ANNEXTURE II

CASE SHEET

COMPARATIVE EVALUATION OF ANESTHETIC EFFICACY OF 2% LIDOCAINE + 1:80,000 EPINEPHRINE AND 4% ARTICAINE + 1:1,00,000 EPINEPHRINE BUFFERED WITH 0.5MOL/L MANNITOL OR 8.4% SODIUM BICARBONATE ON THE SUCCESS OF INFERIOR ALVEOLAR NERVE BLOCK FOR TEETH WITH SYMPTOMATIC IRREVERSIBLE PULPITIS - AN IN VIVO STUDY

PATIENTS NAME:_____ **AGE/SEX:**_____/____

PATIENT'S IDENTIFICATION NO:_____

CONTACT ADDRESS : _____

_____

_____

CONTACT NO : _____

INSTITUTION : TamilnaduGovernmentDentalCollege& Hospital,
Chennai - 600003

CENTRE : Departmentof Conservative Dentistry and Endodontics
TamilnaduGovernmentDentalCollege& Hospital,
Chennai- 600003

GROUP A / GROUP B / GROUP C / GROUP D / GROUP E / GROUP F : _____

CHIEF COMPLAINT:

HISTORY OF PRESENTING ILLNESS:

CLINICAL FINDINGS:

INVESTIGATIONS:

TREATMENT:

PROCEDURE FOLLOWED:

DURATION OF PROPCEDURE:

FOLLOW UP:

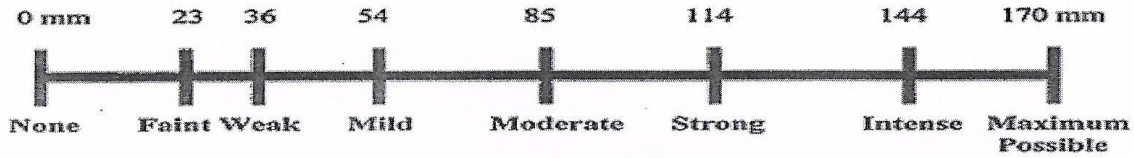
NAME OF THE INVESTIGATOR:

SIGNATURE OF THE INVESTIGATOR:

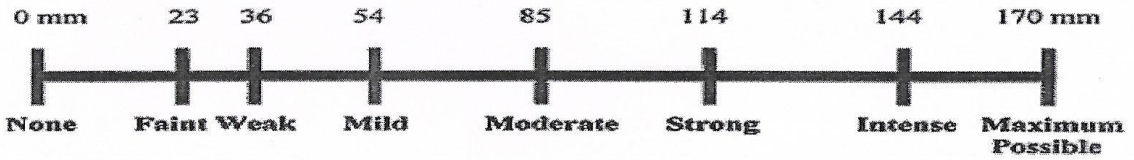
PATIENTS NAME:_____ AGE/SEX:_____/____

PATIENT'S IDENTIFICATION NO:_____

Pre operative pain

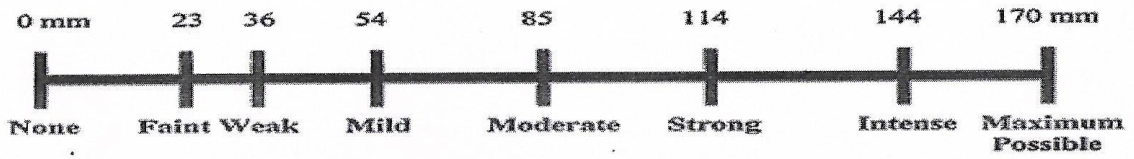


Pain on injection

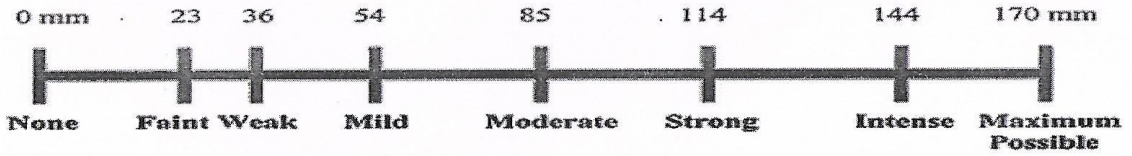


ONSET OF ANAESTHESIA/DURATION OF ACTION: .....

Pain on access opening



Pain on endodontic instrumentation



DURATION OF ANAESTHESIA: from..... to.....

LIST OF TABLES

LIST OF GRAPHS

ABBREVIATIONS USED

LA 1	LOCAL ANAESTHESIA 1
LA 2	LOCAL ANAESTHESIA 2
B 1	BUFFER 1
B 2	BUFFER 2
IAN	INFERIOR ALVEOLAR NERVE
IANB	INFERIOR ALVEOLAR NERVE BLOCK

CONTENTS

INTODUCTION

Local anaesthetic to reach pulp for profound pulpal anaesthesia is difficult in dentistry and also in Endodontics, In Endodontic practice adequate pulpal anaesthesia is a mandatory requirement for painless root canal treatment which involves the extirpation of pulp. Patient may experience intolerable pain if adequate pulpal anaesthesia is not achieved and doing a root canal treatment will be very difficult in such cases.

Currently Lignocaine is the most widely used local anaesthetic in endodontics throughout the world. First introduced by Löfgren and Lundquist in 1943, it has its potency fourfold greater than that of procaine, and toxicity double than that of procaine. Because of its good diffusibility, early onset of action, practitioners prefer lignocaine as their first choice of local anaesthetic solution in dentistry as well as in Endodontics[81].

Vasoconstrictors are added to local anaesthetic solutions to slow down the absorption rate and prolonging the duration of action, also reduces the toxicity of anaesthetics. Therefore, it is necessary to take into consideration that chances of reactive vasodilatation is more after surgery with usage of local anaesthetics with added vasoconstrictors. It also contributes in the acidic nature of the local anaesthetic solution directly.

To promote solubility and to increase shelf life, Local anaesthetic solutions are manufactured at a pH around 3.9. Pain on injection is one factor associated with the acidic nature of local anaesthetic solution. When we deposite such acidic solution, body neutralize that solution to physiologic pH to increase the availability of non ionized base form of local anaesthetic molecule for effective anaesthesia of the particular area.

Considering the available literature on use of local anaesthesia in endodontics, inferior alveolar nerve block for mandibular anaesthesia has highest failure rate ranging 44-81 %[13]. In general, most possible reason for failure is that difficulty for the local anaesthetic molecule to penetrate the perineural barrier around the nerve. Specifically for inferior alveolar nerve block failure, the causes include anatomical difficulty in depositing the solution exactly, accessory innervations, cross innervations, needle deflection and inflammatory mediators sensitizing sodium channels being resistant to lignocaine[98].

Many studies have been performed with the goal to increase success rates of the IANB. Researchers have studied adding hyaluronidase to the anaesthetic solution[117], adding carbonation to the anaesthetic solution[22], using dyphenhydramine as an anaesthetic solution[144,27,], using 0.5 % bupivacaine[41], using 3 % mepivacaine and 4 % prilocaine[92], using articaine[94], administering the block using a peripheral nerve stimulator for accurate placement[128], changing the epinephrine concentration[34,149], administering more anaesthetic[43], changing the amount and concentration of lidocaine[141], or combining meperidine and lidocaine[13]. Interestingly, none of these studies were able to show significant increase in the success rate of the IANB.

In order to improve the anaesthetic efficacy of inferior alveolar nerve block researchers have tried articaine as alternative because of its properties as achieving highest level of anaesthetic potency and lowest systemic toxicity. Thus, articaine said to be the local anaesthetic of superior value in tissues with suppurative inflammation, for adults, children, pregnant women, breastfeeding women, patients suffering from hepatic disorders and renal function impairment[25].

Further to increase the anaesthetic efficacy of local anaesthetic molecules, buffering or alkalanization of local anaesthetic molecules have been tried. Buffered local anaesthetics have a higher pH and may be more efficient in achieving pain control for the inferior alveolar nerve block. Amide local anaesthetics, such as lidocaine, have a weak base component. Lidocaine with epinephrine is a mixture of two chemical forms: a de-ionized, uncharged free base form and an ionized, charged cationic form[9]. The de-ionized form of the local anaesthetic is the active lipid-soluble form that readily enters the nerve membrane and blocks nerve conduction[62]. The presence of a sufficient amount of de-ionized free base anaesthetic is necessary to induce adequate anaesthesia.

Catchlove[20]. studied the influence of CO_2 and pH on local anaesthetic action, the addition of sodium bicarbonate to LAs will result in the production of carbon dioxide and water. They concluded that "carbon dioxide potentiates local anaesthesia by three mechanisms: a direct depressant effect of carbon dioxide on the axon, by concentrating local anaesthetic inside the nerve trunk, and by decreasing the pH inside the nerve which will allow a greater conversion of anaesthetic to its active cation form once inside the membrane".

Antonijevic et al found that a 0.5 mol/L solution of mannitol was most effective in opening the perineural membrane to allow for enhanced penetrability of macromolecules and/or ions. They demonstrated that the efficacy of both hydrophilic and lipophilic compounds could be improved dramatically by the concomitant alteration of perineural permeability[6].

No study has investigated the comparative evaluation of anaesthetic efficacy of 2 % lidocaine + 1:80,000 epinephrine and 4 % articaine + 1:1,00,000 epinephrine buffered with 0.5 mol/l mannitol or 8.4 % sodium bicarbonate on the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis. Therefore, the purpose of this prospective, randomized, triple-blind study is to determine and compare the effect of non buffered lignocaine and articaine with buffered lignocaine and articaine using mannitol or sodium bi carbonate as buffers on the anaesthetic success of the inferior alveolar nerve block in patients experiencing symptomatic irreversible pulpitis**.**

AIMS AND OBJECTIVES

Aim(s) of the study:

To Compare the Efficacy of two local anesthetic solutions buffered with two buffering agents to assess the pain on injection, access opening and endodontic instrumentation on the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis.

Objective(s) of the study:

To assess and compare,

1. anesthetic efficacy of 2 % lidocaine + 1:80,000 epinephrine.
2. anesthetic efficacy of 4 % articaine + 1:1,00,000 epinephrine.
3. anesthetic efficacy of 2 % lidocaine + 1:80,000 epinephrine buffered with 8.4 % sodium bicarbonate.
4. anesthetic efficacy of 2 % lidocaine + 1:80,000 epinephrine buffered with 0.5 mol/l mannitol.
5. anesthetic efficacy of 4 % articaine + 1:1,00,000 epinephrine buffered with 8.4 % sodium bicarbonate.
6. anesthetic efficacy of 4 % articaine + 1:1,00,000 epinephrine buffered with 0.5 mol/L mannitol.

On the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis by Heft-parker visual analogue scale on the pain on injection, access opening and endodontic instrumentation.

REVIEW OF LITERATURE

LIGNOCAINE

Peterson et al (1977)[106] compared anaesthetic efficacy of four solutions, mepivacaine with or without epinephrine, prilocaine and lignocaine via maxillary infiltration and IAN block. Anaesthesia achieved via infiltration was 56-100 % and via IAN block 56-90 %.

Kaufman et al (1984)[68] compared lignocaine with or without epinenephrine, bupivacaine and saline via PDL injection of maxillary lateral incisor. No anaesthesia was produced via the saline solution and lignocaine with epinephrine produced longest pulpal anesthesia.

Johnson et al (1985)[64] compared PDL injections (0.4 ml) of etidocaine and lignocaine of maxillary canine teeth. No significant difference in anaesthetic success were noted between the two solutions.

Handler et al (1987)[53] evaluated the effects of the vasoconstrictor epinephrine on the duration of pulpal anesthesia using the PDL injections (0.2 ml of all the test solutions). There was no statistical difference in the ability of lidocaine, lidocaine with epinephrine 1:50,000, lidocaine with epinephrine 1:100,000, and epinephrine 1:100,000, including epinephrine alone to produce anesthesia.

Edwards et al (1989)[38] evaluated the effectiveness of PDL injections (0.8 ml) using lignocaine epinephrine or saline. Lignocaine was significantly more effective in providing anesthesia (79 %) while PDL injections of saline or epinephrine provided 0 % anaesthetic success.

Chaney et al (1991)[23] compared three formulations of lignocaine (hydrochloride vs hydrocarbonate with or without epinephrine) for IAN block (1.8 ml).The aneasthetic success for the plain lignocaine hydrocarbonate solution was less than 10 % and the remaining two solutions were ranged in success from 37-63% and difference were not significant.

Mclean et al (1992)[93] compared bupivacaine to lignocaine using the PDL injection (0.8 ml). No significant difference in success rate between lignocaine & bupivacaine was evident (38 vs 33 % respectively)

Nist et al (1992)[97] evaluated the incisive nerve block (1.8 ml) and combination of IAN block (3.6 ml) and incisive nerve blocks with lignocaine . The incisive nerve block alone did not result in successful anesthesia in the central, lateral. The combination with IAN block was successful in the 1st and 2nd premolar and enhanced anaesthesia for laterals and 1st molar.

Mclean et al (1993)[92] compared prilocaine, mepivacaine and lignocaine for IAN block (1.8 ml). No significant difference in onset or success were found among the solutions.

Cohen et al (1993)[29] compared lignocaine and mepivacaine when given via IAN block (1.8 ml) for teeth with irreversible pulpities. Both lignocaine and mepivacaine IAN block resulted in 55 % success.

Coggins et al (1996)[28] Evaluated the anaesthetic efficacy of the intra osseous (IO) injection (1.8 ml lignocaine) as a primary technique in maxillary and mandibular 1st molars and lateral incisor. Anaesthetic success rate is 75 % and 78 % of mandular 1st molar and lateral incisor respectively. For maxillary first molar and lateral incisor, these values were 93 % and 90 % respectively.

Childer et al (1996)[24] evaluated the contribution of the PDL injection (0.4 ml) to the success of IAN block (1.8 ml) in mandibular 1st molar with lignocaine. Incidence of successful pulpal anaesthesia was greater for the combination of injection for the 1st 23 minutes of testing but difference were not significant after this point.

Replodge et al (1997)[115] compared primary IO injection of lignocaine or mepivacaine in mandibular 1st molar. Lignocaine resulted in a significantly higher rate of success than mepivacaine (75 % vs 45 %).

Vangheluwe et al (1997)[140] compared administering solutions of lignocaine or saline via intra pulpal delivery for supplemental anaesthesia for patients with irreversible pulpitis, overall 33 of 35 injections effective, suggesting that success is not solution dependent.

Reitz et al (1998)[114] evaluated the effect of repeated IO injection (0.9 ml) given 30 min following a combination of IAN block (1.8 ml) and IO injection (0.9 ml) in mandibular posterior teeth with lignocaine). The repeated IO injection did not result in an increase in duration of pulpal anaesthesia of 6-14 min, although this was not stastically significant.

Clark et al (1999)[26] compared the efficacy of IAN block of 3.6 ml lignocaine with or without the addition of a mylohyoid nerve block of 1.8 ml lignoocaine. There was no significant increase in success with the addition of the mylohyoid nerve block to an IAN block.

Ridenour et al (2001)[117] compared lignocine to lignocaine plus hyaluronidase solution in IAN block. There was no significant difference

between the two solution. But the addition of hyaluronidase resulted in an increase in post operative pain and trismus.

Yonchak et al(2001)[150] evaluated anaesthetic success obtained with unilateral or bilateral IAN block using 3.6 ml of lignocaine for each block. Success rate for bilateral IAN block were significantly higher for the central incisor (39 % vs 66 %) and canine (68 % vs 76 %) than for the unilateral block.

Kennedy et al (2003)[69] evaluated the significance of needle deflection on the success of IAN blocks using 2.8 ml lignocaine on patients with IP. No significant difference were observed on success rates using a conventional IAN block when compared with a bidirectional needle rotation technique.

Whitcomb M et al (2010)[143] randomly administered inferior alveolar nerve (IAN) blocks using a buffered 2 % lignocaine with 1: 100,000 epinephrine/sodium bicarbonate formulation and an unbuffered 2 % lignocaine with 1: 100,000 epinephrine formulation at 2 separate appointments spaced at least 1week apart using crossover design. They concluded that buffering a 2 % lignocaine with 1: 100,000 epinephrine with sodium bicarbonate did not statistically increase anaesthetic success, provide faster onset, or result in less pain of injection when compared with unbuffered 2 % lignocaine with 1: 100,000 epinephrine for an IAN block.

Wolf R et al (2011)[146] Conducted randomized, single-blind study to determine the anaesthetic efficacy of lignocaine with epinephrine & compared to lignocaine with epinephrine plus 0.5 M mannitol in inferior alveolar nerve blocks. Forty subjects randomly received an IAN block in 3 separate appointments with following formulations: A 1.8 mL solution of 36 mg

lignocaine with 18 mg epinephrine (control solution): A 2.84 mL solution of 36 mg lignocaine with 18 mg epinephrine (1.80 mL) plus 0.5 M mannitol (1.04 mL); and a 5 mL solution of 63.6 mg lignocaine with 32 mg epinephrine (3.18 mL) plus 0.5 M mannitol (1.82 mL). The results showed that 2.84 mL of lignocaine with epinephrine plus 0.5 M mannitol was significantly better than1.8 mL of lignocaine with epinephrine for the molars and premolars. The 5 mL of lignocaine with epinephrine plus 0.5 M mannitol was statistically better than1.8 mL of lignocaine with epinephrine and 2.84 mL of lignocaine with epinephrine plus 0.5 mol/L mannitol for all teeth except the central incisor. They concluded adding 0.5 M mannitol to lignocaine with epinephrine formulations significantly improved effectiveness in achieving a greater percentage of total pulpal anesthesia as compared with a lignocaine formulation without mannitol for IAN block.

Aggarwal V et al (2011)[5] evaluated the effect of ketorolac & dexamethasone infiltration along with standard IANB on the success rate. Ninety-four adult were selected. All patients received standard IANB of 2 % lignocaine with 1:200,000 epinephrine. Among this Twenty-four patients did not receive any supplemental infiltrations (control) whereas Twenty-four patients received supplemental buccal infiltration of 4 % articaine with 1:100,000 ephinephrine, and rest of the patients received supplemental buccal infiltration of 1 mL/4 mg of dexamethasone. Result showed Supplementary dexamethasone infiltration gave 45% success rate, which was insignificant with control IANB. They concluded Articaine and ketorolac infiltration can increase the success rate

of IANB in patients with irreversible pulpitis. None of the tested techniques gave 100 % success rate.

Kreimer T et al (2012)[23] Determined the anaesthetic efficacy of lignocaine with epinephrine compared with a combination of lignocaine with epinephrine plus 0.5 mol/L mannitol for inferior alveolar nerve blocks in patients experiencing symptomatic irreversible pulpitis. 55 emergency patients were randomly received IAN blocks by using a 3.18- mL formulation containing 63.6 mg of lignocaine with 31.8 mg epinephrine or a 5-mL formulation containing 63.6 mg of lignoocaine with 31.8 mg epinephrine plus 1.82 mL of 0.5 mol/L mannitol. The result showed 1.9 mL of lignocaine (76.4 mg) with epinephrine plus 0.5 mol/L mannitol had a significantly better success rate of 39 % when compared with the lignocaine formulation without mannitol. They Concluded for mandibular posterior teeth in patients with symptomatic irreversible pulpitis, the addition of 0.5 mol/L mannitol to 1.9 mL of lignocaine with epinephrine resulted in a statistically higher success rate whereas the combination of lignocaine/ mannitol formulation would not result in predictable pulpal anesthesia.

Sampaio RM et al (2012)[121] compared the anaesthetic efficacy of 0.5 % bupivacaine with 1:200,000 epinephrine with that of 2 % lignocaine with 1:100,000 epinephrine during pulpectomy in patients with irreversible pulpitis in mandibular posterior teeth. All patients reported the lip anesthesia after the application of both the solutions. By measuring pulpal anesthesia success with the pulp tester, lignocaine had a higher success rate than bupivacaine. They

concluded neither of the solutions resulted in an effective pain control during irreversible pulpitis treatments of mandibular molars.

Kanaa MD et al (2012)[25] Compared the efficacy of supplementary repeat inferior alveolar nerve block with 2 % lignocaine & epinephrine, buccal infiltration with 4 % articaine with epinephrine, intraligamentary injection or intraosseous injection after failed inferior alveolar nerve block for securing pain-free treatment in patients experiencing irreversible pulpitis in mandibular permanent teeth. Patients were received 2.0 mL of 2 % lignocaine with 1:80,000 epinephrine as an IANB injection. They concluded inferior alveolar nerve block injection alone does not always allow pain-free treatment for mandibular teeth with irreversible pulpitis. Supplementary buccal infiltration with 4 % articaine + epinephrine and intraosseous injection with 2 % lignocaine with intraligamentary and repeat inferior alveolar nerve block injections with 2 % lignocaine with epinephrine for patients experiencing irreversible pulpitis in mandibular permanent teeth.

Aggarwal V et al (2012)[3] Evaluated the anaesthetic efficacy of 1.8 mL and 3.6 mL of 2 % lignocaine with 1:200,000 epinephrine in patients with irreversible pulpitis. Fifty-five adults were selected and divided into two groups on a random basis & received an inferior alveolar nerve block with either 1.8 mL or 3.6 mL of 2 % lignocaine with 1:200,000 epinephrine. They found no significant differences in sex, age, or preoperative pain scores of the experimental groups. They concluded the increasing the volume of 2 % lignocaine to 3.6 mL improved the success rate as compared with 1.8 mL but did not give a clinical success rates of 100 %.

Kreimer T et al (2012)[70] Studied to determine the anaesthetic efficacy of lignocaine with epinephrine compared with a combination lignocaine with epinephrine plus 0.5 mol/L mannitol for inferior alveolar nerve blocks in patients experiencing symptomatic irreversible pulpitis. They concluded that the addition of 0.5 mol/L mannitol to 1.9 mL of lignocaine (76.4 mg) with epinephrine resulted in a statistically higher success rate. Whereas the combination, lignocaine and mannitol formulation would not result in predictable pulpal anesthesia.

Thimmaiah PB et al (2013)[134] Determined the anaesthetic efficacy of 2 % lignocaine with 1: 80,000 epinephrine & 0.5 mol/ L manitol in inferior alveolar nerve blocks in patients with symptomatic irreversible pulpitis. 60 subjects randomly received inferior alveolar nerve blocks using two solutions, 2.5 ml of 2 % lignocaine with 1:80,000 epinephrine whereas other composed of 1.6 ml of lignocaine with 1:80,000 epinephrine & 0.9ml of 0.5 mol/L manitol. They concluded that combination of local anaesthetic and mannitol should be used on regular basis to obtain successful anesthesia .

Hobeich P et al (2013)[63] compared the anaesthetic onset & pain on maxillary infiltration injection of 2 % lignocaine with 1:1,00,000 epinephrine and 2 % lignocaine with 1:1,00,000 epinephrine buffered with 5 % and 10 % sodium bicarbonate by volume. Thirty subjects with intact maxillary canines were selected. 1 of the 3 maxillary infiltration injections of 1.8 mL 2 % lignocaine with 1:1,00,000 epinephrine and 2 % lignocaine with 1:1,00,000 epinephrine buffered at 5 % and 10 % with sodium bicarbonate by volume at 3 separate appointments. They concluded that Two percent lignocaine with

1:1,00,000 epinephrine buffered with 5 % or 10 % sodium bicarbonate did not differ from non buffered solutions in anaesthetic onset or injection pain in maxillary infiltrations of canines with healthy pulps.

Aggarwal V et al (2013)[4] Evaluated the anaesthetic efficacy and injection pain of 1.8 mL of 2 % lignocaine with different concentrations of epinephrine (1 : 80,000 and 1 : 2,00,000) in patients with symptomatic irreversible pulpitis. Sixty-two adults were actively experiencing pain, & were randomly allocated into 2 groups & received 1.8 mL of 2 % lignocaine with either 1 : 80,000 or 1 : 2,00,000 epinephrine concentration. They concluded that two percent lignocaine solution used for inferior alveolar nerve block achieved similar success rates when used with 1 : 80,000 or 1 : 2,00,000 epinephrine concentration.

Balasco M et al (2013)[8] compared the pain of infiltration and pain of an incision and drainage procedure by using a buffered versus a non buffered solution of 2 % lignocaine with 1:100,000 epinephrine solution in symptomatic patients with a diagnosis of pulpal necrosis and acute swelling. Eighty-one adults were randomly divided into 2 treatment groups; who received 2 infiltrations by using either 2 % lignocaine with 1:100,000 epinephrine buffered with 0.18 mL 8.4 % sodium bicarbonate or 2 % lignocaine with 1:100,000 epinephrine. They stated that the addition of a sodium bicarbonate buffer to 2 % lignocaine with 1:100,000 epinephrine did not result in significantly decreased pain of infiltrations or significantly decreased pain of incision and drainage procedure when compared with 2 % lignocaine with 1:100,000 epinephrine.

Hashimoto S et al (2014)[32] investigated the effect of epinephrine on pharmacokinetics of lignocaine and the pulpal blood volume after maxillary infiltration anesthesia in rats. Measured the 14C-radioactivity and 14C-distribution in the maxilla and the dental pulp after the injection of 2 % 14C-lignocaine with or without 10 mg/ mL epinephrine into the palatine mucosa proximal to the first molar. They found that lignocaine had infiltrated into the molar pulp after infiltration anesthesia. Furthermore they suggested that epinephrine augmented the retention of lignocaine in the pulp.

Saatchi M et al (2015)[120] compared the anaesthetic efficacy of buffered with non buffered 2 % lignocaine with 1:80,000 epinephrine solution for a inferior alveolar nerve block in patients with mandibular posterior teeth experiencing symptomatic irreversible pulpitis. Eighty adult patients were selected and they received 2 cartridges of either 2 % lignocaine with 1:80,000 epinephrine buffered with 0.18 mL 8.4 % sodium bicarbonate or 2 % lignocaine with 1:80,000 epinephrine with 0.18 mL sterile distilled water using conventional inferior alveolar nerve block injections. They concluded buffering the 2 % lignocaine + 1:80,000 epinephrine with 8.4 % sodium bicarbonate did not improve success of the inferior alveolar nerve block in mandibular molars in patients with symptomatic irreversible pulpitis.

Schellenberg J et al (2015)[123] determined the effect of 4 % buffered lignocaine on anaesthetic success of the inferior alveolar nerve block in patients having symptomatic irreversible pulpitis. One hundred patients were selected, and given inferior alveolar nerve block using either 2.8 mL 4 % lignocaine with 1:100,000 epinephrine or 2.8 mL 4 % lignocaine with 1:100,000 epinephrine

buffered with sodium bicarbonate in a double-blind manner. They stated that for mandibular posterior teeth, a 4 % buffered lignocaine formulation did not result in a statistically significant increase in success rate or a decrease in injection pain of the inferior alveolar nerve block in patients with symptomatic irreversible pulpitis.

Shetty KP et al (2015)[126] compared the anaesthetic efficacy between the lignocaine with and without magnesium sulfate 50 % for inferior alveolar nerve blocks in patients with symptomatic irreversible Pulpitis. One hundred patients with symptomatic irreversible pulpitis of mandibular posterior teeth were selected randomly. They received 1 mL magnesium sulfate 50 % or distilled water 1 hour before administration of conventional inferior alveolar nerve block. They concluded that in mandibular posterior teeth diagnosed as symptomatic irreversible pulpitis, preoperative administration of 1 mL magnesium sulfate 50 % resulted in statistically significant increase in the success of inferior alveolar nerve block compared with placebo.

Fowler S et al (2015)[42] determined the incidence of missed inferior alveolar nerve blocks by using a 1- or 2-cartridge volume of 2 % lignocaine with 1:100,000 epinephrine in vital asymptomatic teeth and in emergency patients with the symptomatic irreversible pulpitis. Each subject received either a 1- or 2-cartridge volume of 2 % lignocaine with 1:100,000 epinephrine. They found that administration of a 2-cartridge volume was significantly better than a 1-cartridge volume in both asymptomatic subjects and in emergency patients with irreversible pulpitis.

Harreld TK (2015)[37] compared the pain of infiltration and the pain of an incision and drainage procedure of a buffered versus a non buffered 4 % lignocaine formulation in symptomatic emergency patients presenting with a diagnosis of pulpal necrosis, associated periapical area, and acute clinical swelling. Eighty-eight patients were randomly divided into 2 groups; either 4 % lignocaine with 1:100,000 epinephrine buffered with 0.18 mL 8.4 % sodium bicarbonate using the buffering system or 4 % lignocaine with 1:100,000 epinephrine. They concluded that buffering a 4 % lignocaine formulation did not significantly decrease the pain of infiltrations or significantly decrease the pain of incision and drainage procedure when compared with a non buffered 4 % lignocaine formulation in symptomatic patients with a diagnosis of pulpal necrosis and acute swelling.

ARTICAINE

Winter et al (1972)[145] compared maxillary infiltration 0f 1.0 ml articaine for lateral incisor to same volume of lignocaine and mepivacaine for anaesthetic efficacy in 39 patients and articaine in this study performed well compared to the other solutions.

Haas et al (1990)[50] compared articaine to prilocaine for both maxillary and mandibular buccal infiltration (1.5 ml) of canine tooth. The two solutions provided similar success rates for pulpal anaesthesia after infiltration (articaine 65 % vs prilocaine 50 %).

Haas et al (1991)[51] compared articaine to prilocaine for both maxillary and mandibular buccal infiltration (1.5 ml) of 2nd molars. Articaine resulted in higher success rate in both arches, although difference were not statistically significant.

Vahatalo et al (1993)[139] compared articaine to lignocaine for maxillary lateral incisor infiltration (0.6 ml). All infiltrations resulted in successful pulpal anaesthesia, with no significant difference of onset or duration of the two solutions.

Tofoli et al (2003)[135] compared the anaeasthetic efficacy of articaine in association with 2 different concentration of epinephrine for IAN block. No significant difference in success, onset or duration between the two solutions were observed.

Claffey et al (2004)[43] compared articaine and lignocaine when administered via IAN block in patients experiencing IP in mandibular posterior

teeth. Success rates were 23 % for lignocaine and 24 % for articaine, revealed no significant difference. Neither solution resulted in an acceptable rate of success for patients with IP.

Elizabeth C et at (2004)[39] compared anaesthetic efficacy of 4 % articaine with 1:100,000 epinephrine to 2 % lignocaine with 1:100,000 epinephrine for inferior alveolar nerve blocks in patients having irreversible pulpitis in mandibular posterior teeth. Seventy-two emergency patients diagnosed with irreversible pulpitis of a mandibular posterior tooth randomly received anaesthesia in a double-blind manner. They concluded there was no significant difference between the articaine and lignocaine solutions. Neither solution resulted in an acceptable rate of anaesthetic success in patients with irreversible pulpitis.

Berlin J et al (2005)[45] compared anaesthetic efficacy of intraligamentary injection of 4 % articaine with 1:100,000 epinephrine & 2 % lignocaine with 1:100,000 epinephrine in mandibular posterior teeth. Using crossover design, intraligamentary injections of above solutions were injected using computer-controlled local anaesthetics. They concluded efficacy of 4 % articaine with 1:100,000 epinephrine was similar to the efficacy of 2 % lignocaine with 1:100,000 epinephrine for intraligamentary injections.

Berlin et al (2005)[11] compared 1.4 ml of articaine and lignocaine when administered via computer controlled intraligamentary injections in mandibular posterior teeth . The success rates were 74 % for lignocaine and 86 % for articaine solutions. There was significant difference between the two solutions.

Mikesell et al (2005)[94] compared articaine and lignocaine when administered via IAN block, testing molars, premolars and incisors. Lignocaine resulted in anaesthetic success ranging from 2-48 % while articaine resulted in a range 4-54 %. There was not significant difference between articaine and lignocaine solutions.

Costa et al (2005)[32] compared 1.8 ml of articaine and lignocaine for infiltration of maxillary posterior teeth . There was no significant difference between the success rate of articaine and lignocaine. Articaine did produce significantly shorter onset and longer duration of anaesthesia than lignocaine.

Kanaa et al (2006)[67] compared articaine and lignocaine in mandibular buccal infiltration of 1st molar. Success rates were 65 % for articaine and 39 % for lignocaine, resulting in significantly more chance for anaesthetic with articaine.

Rosenberg et al (2007)[119] compared articaine and lignocaine buccal infiltration in mandibular posterior teeth with IP that requires supplemental anaesthesia. The mean percentage changes in VAS score was 70 % and 65 % for articaine and lignocaine respectively, demonstrating no significant difference.

Jung et al (2008)[65] compared buccal infiltration and IAN block for a standerd volume (1.7 ml) of articaine in mandibular 1st molar. Success rate of buccal infiltration (54 %) and IAN block (43 %) were not found to be statistically significant, onset of infiltration was significantly faster in both the solutions.

Evans et al (2008)[40] compared articaine with lignocaine in maxillary infiltration of 1st molar and lateral incisor. In maxillary lateral incisor articaine

exhibited a significantly higher success rates (88 %) when compared with lignocaine (62 %). Differences were not significant for first molar.

Corbett et al (2008)[31] compared articaine given by means of buccal or buccal and lingual infiltration to IAN block using lignocaine. Efficacy of articaine when given by infiltration was not statistically significant difference than using lignocaine via IAN block for mandibular 1st molar

Sherman et al (2008)[125] compared articaine and lignocaine in patients with IP in either maxilla or mandibular posterior teeth. Overall anaesthetic success was 87.5 % in both arches. Articaine was as effective but not statistically superior to lignocaine.

Haase et al (2008)[52] compared articaine and lignocaine by mandibular 1st molar buccal infiltration after initial IAN block was given with articaine. Articaine resulted in a significantly higher success rate (88 %) than lignocaine (71 %) when given via buccal infiltration following an IAN block of articaine.

Srinivasan et al (2009)[131] compared articaine and lignocaine when delivered via buccal infiltration for maxillary posterior teeth diagnosed with IP. Success rate for articaine were 100 % for both 1st molar and 1st pre molar and for lignocaine were 30 % in first pre molar and 80 % in 1st molar. There was a highly significant difference.

Poorni S et al (2011)[108] studied the anaesthetic efficacy of 4 % articaine with 1:100,000 epinephrine in inferior alveolar nerve block (IANB) and infiltration anaesthetic techniques to anesthetize mandibular molars with irreversible pulpitis. They stated that although Buccal Infiltartion and IANB of 4 % articaine were equally effective, Buccal infiltration can be considered a viable

alternative in IANB for pulpal anesthesia in mandibular molars with irreversible pulpitis.

Martin M et al (2011)[85] conducted a prospective, randomized, single blind, crossover study comparing the degree of pulpal anesthesia with 1.8 mL and 3.6 mL of 4 % articaine with 1:100,000 epinephrine as a primary infiltration in the mandibular first molar. Eighty six asymptomatic adult subjects randomly received a primary mandibular buccal first molar infiltration of 1.8 mL or 3.6 mL 4 % articaine with 1:100,000 epinephrine in two separate appointments. They concluded that the anaesthetic efficacy of 3.6 mL 4 % articaine with 1:100,000 epinephrine is better than 1.8 mL of the same anaesthetic solution in a primary mandibular buccal infiltration of the first molar. However, the success rate of the 70 % is not high enough to support its use as a primary injection technique in the mandibular first molar.

McEntire M et al (2011)[90] Conducted a prospective, randomized, double-blind, crossover study comparing the degree of pulpal anesthesia obtained with 4 % articaine with 1:100,000 epinephrine and 4 % articaine with 1:200,000 epinephrine as a primary infiltration in the mandibular first molar. They concluded the anaesthetic efficacy of 4 % articaine with 1:200,000 epinephrine is comparable to 4 % articaine with 1:100,000 epinephrine in a primary mandibular buccal infiltration of the first molar.

Kanaa MD et al (2012)[66] compared the efficacy of supplementary repeat inferior alveolar nerve block with 2 % lignocaine & epinephrine, buccal infiltration with 4 % articaine with epinephrine, intraligamentary injection, or intraosseous injection after failed inferior alveolar nerve block for securing pain-

free treatment in patients experiencing irreversible pulpitis in mandibular permanent teeth. Patients were received 2.0 mL of 2 % lignocaine with 1:80,000 epinephrine as an IANB injection. They concluded inferior alveolar nerve block injection alone does not always allow pain-free treatment for mandibular teeth with irreversible pulpitis. Supplementary buccal infiltration with 4 % articaine with epinephrine and intraosseous injection with 2 % lidocaine with epinephrine are more likely to allow pain-free treatment than intraligamentary and repeat IANB injections with 2 % lidocaine with epinephrine for patients experiencing irreversible pulpitis in mandibular permanent teeth.

Monteiro MR et al (2013)[95] compared the anaesthetic efficacy of inferior alveolar nerve blocks with 1.8 mL of 2 % lignocaine to a buccal infiltration with 1.8 mL of 4 % articaine , both with 1 : 1,00,000 epinephrine, in patients with symptomatic irreversible pulpitis. They concluded that single anaesthesia techniques were not able to achieve pain-free emergency endodontic treatment, hence Supplemental anaesthetic techniques should be considered prior to the treatment procedures in order to increase the success rate.

Ahmad ZH et al (2014)[151] determined the anaesthetic efficacy of inferior alveolar nerve block using 4 % articaine and 2 % lignocaine supplemented with buccal infiltration. Fourty-five patients were selected and divided into three groups; group I with 2 % lignocaine + 1:2,00,000 epinephrine, group II with 2 % lignocaine + 1:80,000 epinephrine and group III with 4 % articaine + 1:1,00,000 epinephrine. They concluded that 4 % articaine can be used as effectively in obtaining profound anesthesia in patients with irreversible pulpitis.

Singla M et al (2014)[130] Compared anaesthetic efficacy of different volumes (1.8 mL vs. 3.6 mL) of 4 % articaine with 1 : 1,00,000 epinephrine injected as buccal infiltrations after a failed inferior alveolar nerve block in patients with symptomatic irreversible pulpitis. Two hundred and thirty-four adult Patients were selected. They concluded that increasing the volume of 4 % articaine with 1 : 1,00,000 epinephrine from 1.8 to 3.6 mL, given as supplementary buccal infiltrations after a failed primary inferior alveolar nerve block with 1.8 mL of 4 % articaine with 1 : 1,00,000, did not improves the anaesthetic success rates in patients with symptomatic irreversible pulpitis.

Rogers BS et al (2014)[118] investigated the efficacy of 4 % articaine with 2 % lignocaine for supplemental buccal infiltrations after an ineffective inferior alveolar nerve block in mandibular molars with irreversible pulpitis. In addition, the use of articaine for inferior alveolar nerve block and intraosseous injections was evaluated. They found Supplemental buccal infiltration with articaine was significantly more effective than lignocaine. The inferior alveolar success rate of 4 % articaine is more as compared with 2 % lignocaine.

Jason Kung et al (2015)[65] concluded in his systemic review that the use of articaine for patients with symptomatic irreversible pulpitis showed a significant advantage to using articaine over lidocaine for supplementary infiltration after mandibular block anesthesia but no advantage when used for mandibular block anesthesia alone or for maxillary infiltration.

MATERIALS AND METHODS

ARMAMENTARIUM (Fig 1-4 & Fig 9)

1. Mouth mirror, Explorer, Tweezer (GDC, Germany)
2. Electric pulp vitality tester (API, Ashoosons, India)
3. Electrolyte tooth paste (Thermoseal , ICPA Products)
4. ROEKO Endo-Frost (Coltène/Whaledent Private Ltd, INDIA
5. Aspirating syringe (Petite-Blue, Septodont, INDIA)
6. 1 ml micro liter syringe (DISPO VAN, Hindustan Syringes & Medical Devices Ltd, INDIA)
7. Septojet (27 G Long Needle, Septodont, INDIA)
8. Sterile cotton, sterile gauze
9. Rubber dam kit (GDC, Germany)
10. Disposable gloves, Face Mask, Head Cap
11. High speed Airotor hand piece (NSK,Tokyo, Japan)
12. Endo Access kit (Dentsply, US)
13. 10, 15, 20 H file (MANI, JAPAN)
14. 10, 15, 20 K file (MANI, JAPAN)
15. 3 % Sodium hypochlorite (Prime Dental product Private Ltd, INDIA)
16. Lubricating paste ((R C Help, Prime Dental product Private Ltd, INDIA)
17. Intra canal dressing paste (RCCal, Prime Dental product Private Ltd, INDIA)
18. Temporary filling (Prime Dental product Private Ltd, INDIA)

EXPERIMENTAL MATERIALS (Fig 5-8)

1. 2 % Lignocaine with 1: 80,000 Adrenaline (Lignospan Special, Septodont, INDIA)
2. 4 % Articaine with 1:1,00,000 Adrenaline (Septanet, Septodont, INDIA)
3. 8.4 % Sodium bicarbonate solution (Micro fine chemicals, INDIA)
4. 0.5 MOL/L Mannitol solution (Aculife healthcare Pvt. Ltd, INDIA)

METHODOLOGY

The study was carried out in the Department of Conservative Dentistry And Endodontics Tamilnadu Government Dental College And Hospital, Chennai, Tamilnadu, India.

Study design

Ethical clearance was obtained from the Institution's Ethical Committee (Annexure I). 180 subjects who fulfilled the inclusion and exclusion criteria were chosen for the study with no discrimination based on sex, caste, religion or socioeconomic status.

The complete treatment procedure was explained to the patients and a written informed consent was obtained from all the patients selected for the study. The 180 subjects were randomly divided into 6 groups of 30 subjects each.

Blinding has been done by labeling the two local anaesthetic solutions as LA1 & LA2 and buffering agents as B1 & B2. The labeled materials were allocated to groups randomly as follow (Fig 10-11) :

1. Group I : LA2
2. Group II : LA1
3. Group III : LA2 + B1
4. Group IV : LA1 + B1
5. Group V : LA2 + B2
6. Group VI : LA1 + B2

Study protocol:

1. Institutional ethical committee approval
2. Obtaining Thorough history,
3. Thorough Clinical Examination including diagnosis,

4. Radiographic evaluation of selected region using intra oral periapical radiograph (IOPA) considering patient safety guidelines during radiographic exposure with lead apron and thyroid collar for the patient and thermal tests(TT) to confirm diagnosis,
5. Informed consent from the patient,
6. Patients allotted randomly to the respective group as Sequence generated by computerized permutted block.
7. Preparing the buffered anaesthetic solution for nerve block(IANB),
8. Pain assessment by Heft-parker visual analogue scale on the pain on injection, access opening and endodontic instrumentation.
9. Post operative instructions

CRITERIA FOR SELECTION

Inclusion Criteria:

1. Between the age of 18-65 years
2. In good health (ASA classification class I)
3. able to provide informed consent
4. Dental Caries mandibular molars with diagnosis of symptomatic irreversible pulpitis

Exclusion criteria:

1. Allergies to local anaesthetics or sulfites
2. Allergies to mannitol
3. Bellow the age of 18 years
4. History of significant medical conditions(ASA Class II or higher)
5. Taking any medication, which may affect the pain assessment
6. Active pathosis at the site of injection

7. Inability to give informed concent

Methodology of examination:

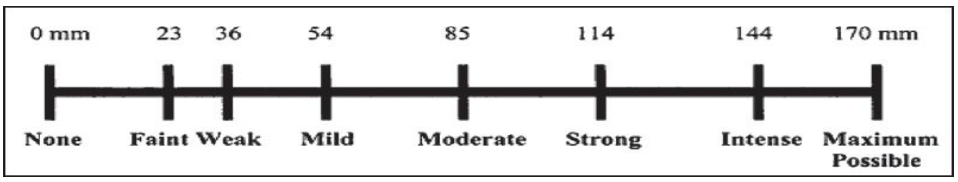
Thorough History and Clinical Examination for an accurate diagnosis of symptomatic irreversible pulpitis with electric pulp test (EPT) (Fig 16), thermal test (cold test) (Fig 17), then Radiological Examination (IOPA) to confirm diagnosis and to rule out any other pathology.

DATA COLLECTION & METHODS

Clinical parameters:

Pain assessment : Heft -Parker Visual Analogue Scale

Observed clinical parameters: Pain assessment on pain on injection, access opening and endodontic instrumentation.



Radiological parameters:

IOPA to confirm diagnosis and to rule out any other pathology.

Buffering agents used in the study (Fig 11):

1. 8.4 % of Sodium Bicarbonate is commercially available in 50mEq/vial (McGUFF Company, Inc).
2. 0.5 mol/L mannitol is prepared from commercially available 20% mannitol solution (Baxter India) in the department of biochemistry, Madras Medical College, Chennai.

RANDOMIZATION

Sequence generation:

Sequence generated by computerized permutted block randomization with block size 6 for each set.

Allocation concealment mechanism (Fig 12):

Allocation concealment done to protect the randomization process so that the treatment to be carried out is not known before the patient is entered into the study. Silver colour opaque envelops are used to keep the randomization details and the prepared local anaesthetic to be injected for the allotted patient.

Blinding (Fig 10-11):

This study done with triple blinding. The one preparing the anaesthetic solution was blinded as they are unaware of the fact that which group is going to receive the prepared solutions, participants and operator were blinded since both were not knowing the solution injecting or receiving respectively . Those assessing outcomes are blinded since they were not knowing to which group the patient belongs to or which solution they have received.

OPERATIVE PROCEDURE:

Before starting any operative procedure, *test dose* (fig 18,19) of local anaesthetic solution and buffered solutions will be given for all the participants to check for allergy to any material. In case of any complication, the materials for management of allergy were kept ready (fig 23).

Preparing the buffered solutions (Fig 13-15):

The buffered local anaesthetic solution should be freshly prepared before injecting, is prepared in the following manner:

1. Drawing the 3ml of local anaesthetic solution from 30ml vial of 2 % lignocaine and replacing the drawn solution by 3ml 0f 8.4 % sodium bicarbonate or 3 ml of 0.5 mol/L mannitol
2. Drawing the 6ml of local anaesthetic solution from 30ml vial of 4 % articaine and 6ml of 8.4 % sodium bicarbonate or 6ml of 0.5 mol/L mannitol (since we are using 4 % articaine which is double the concentration compared to 2 % lignocaine).
3. The prepared buffered solution is mixed well before injection.
4. The prepared local anaesthetic solution injected using conventional IANB to the patient allotted to respective group (Fig 20).
5. Access opening done under rubber dam isolation (Fig 21).
6. Instrumentation done upto 20 size K file till the measured working length (Fig 22).

Group I: LA2

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block
3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation
5. Post operative instructions

Group II: LA1

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block

3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation
5. Post operative instruction

Group III: LA2 + B1

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block
3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation
5. Post operative instruction

Group IV: LA1 + B1

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block
3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation

5. Post operative instruction

Group V: LA2 + B2

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block
3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation
5. Post operative instruction

Group VI : LA1 + B2

1. Draping the Patient
2. Preparing the solutions to inject for inferior alveolar nerve block
3. Marking of Landmarks for Needle penetration and injection of solution for inferior alveolar nerve block
4. Completion of nerve block and assessment of pain for the following
    a. Pain on injection
    b. Pain on access opening and cavity preparation
    c. Pain on endodontic instrumentation
5. Post operative instruction

Evaluation intervals:

Pre operative pain was measured before starting the endodontic procedure as base line data and Pain on injection, pain on endodontic access cavity preparation & pain on endodontic instrumentation were evaluated.

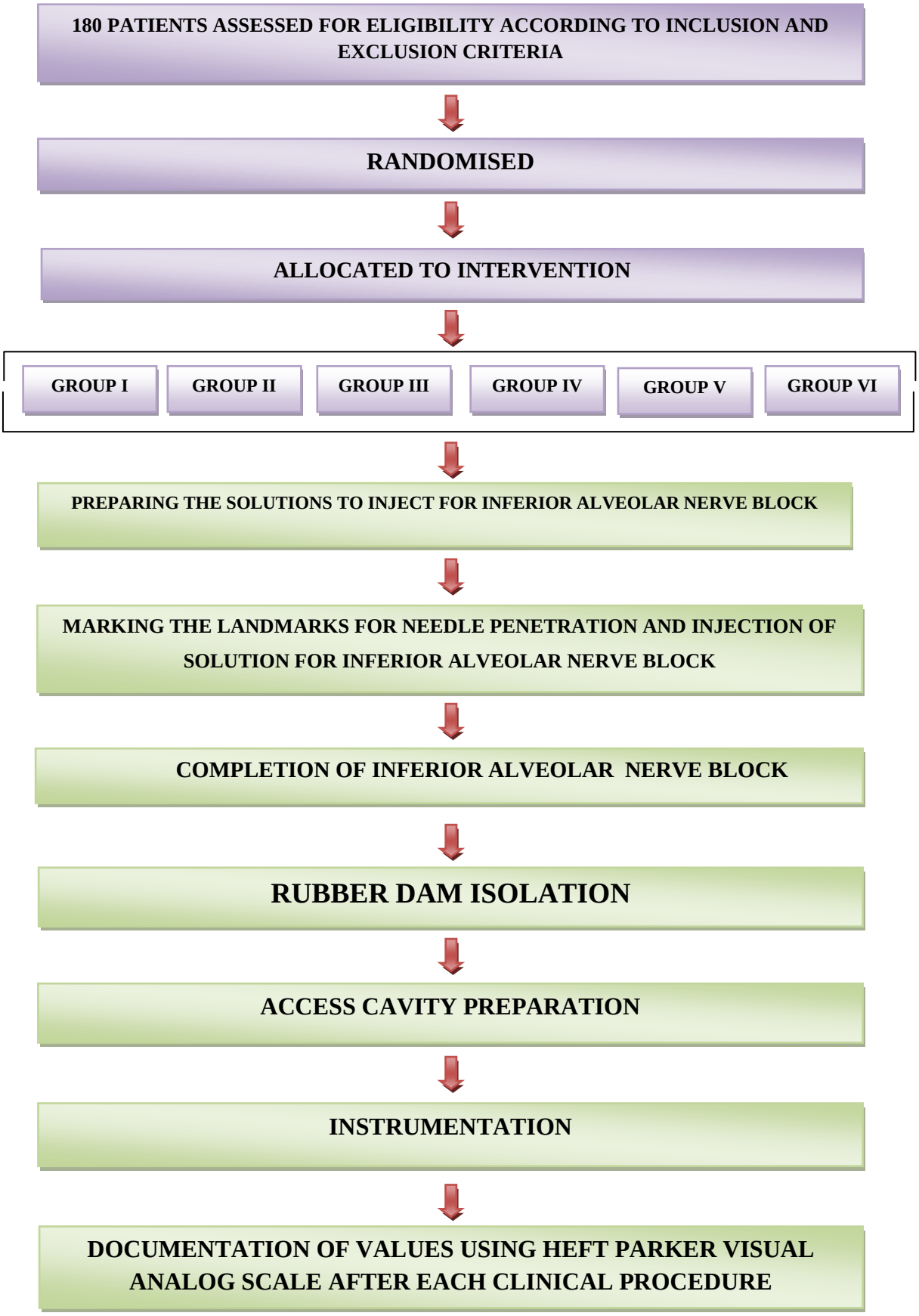
Post operative follow up:

The patients were reviewed immediatly after the operative procedure for the Pain on injection, pain on endodontic access cavity preparation and pain on endodontic instrumentation to record the values on Heft Parker Visual Analog Scale. The following data were obtained:

1. Pain on injection
2. Pain on endodontic access opening
3. Pain on instrumentation

All data obtained were tabulated and analysed statistically using statistical software SPSS version 22.

PROCEDURAL FLOW CHART



ARMAMENTARIUM

Fig 1. DIAGNOSTIC INSTRUMENT KIT

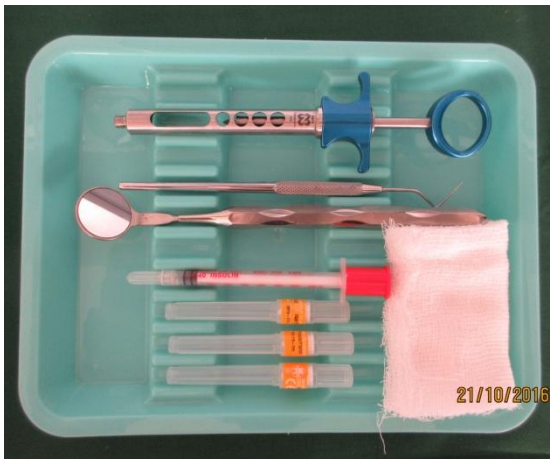


Fig 2. LOCAL ANAESTHESIA INJECTION KIT

Fig 3. ACCESS OPENING KIT

Fig 4. INTRUMENTATION KIT

MATERIALS

Fig 5. 8.4% SODIUM BICARBONATE

Fig 6. 0.5MOL/L MANNITOL

Fig 7. 2% LIGNOCAINE + 1:80,000 EPINEPHRINE

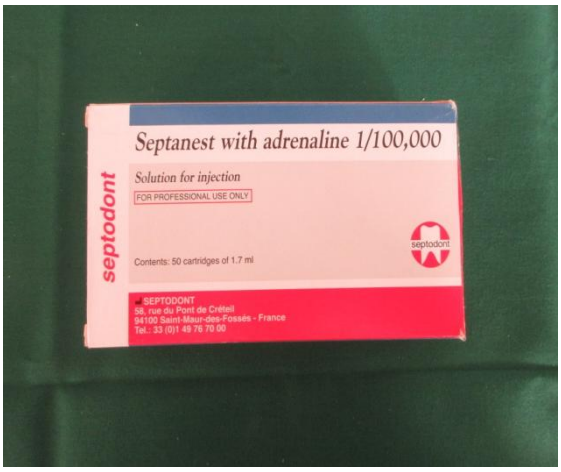


Fig 8. 4% ARTICAINE + 1:1,00,000 EPINEPHRINE

Fig 9. MATERIAS USED FOR ACESS AND BIOMECHANICAL PREPARATION

LABELLING MATERIAL FOR RANDOMIZATION AND CONCEALMENT

Fig 10. LABELLED LOCAL ANAESTHETIC SOLUTIONS

Fig 11. LABELLED BUFFERING AGENTS

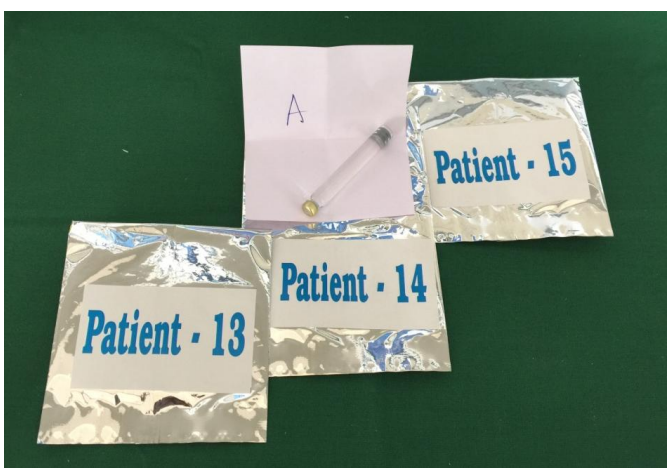


Fig 12. ALLOCATION CONCEALMENT

PREPARING THE BUFFERED LOCAL ANAESTHETIC SOLUTION

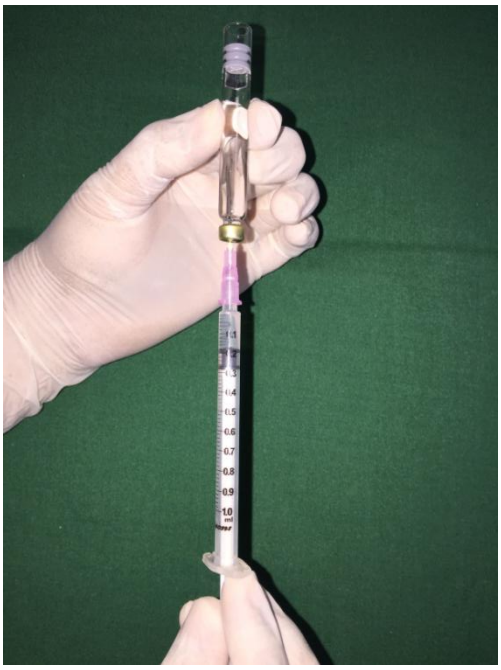


Fig 13. WITHDRAW 0.18 ML OF LOCAL ANAESTHESIA

Fig 14. WITHDRAW 0.18 ML OF BUFFERING AGENT

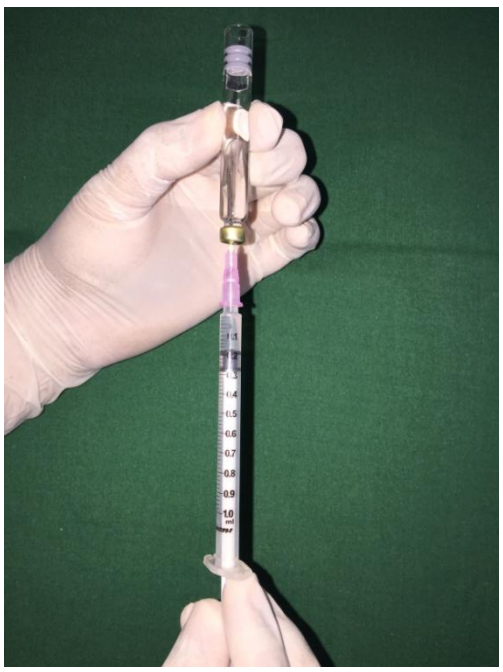


Fig 15. REPLACING THE DRAWN LOCAL ANAESTHESIA BY BUFFERING AGENT

OPERATIVE PROCEDURE

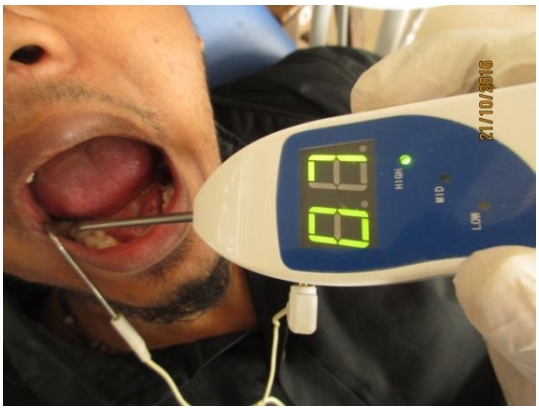


Fig 16. PULP VITALITY USING EPT

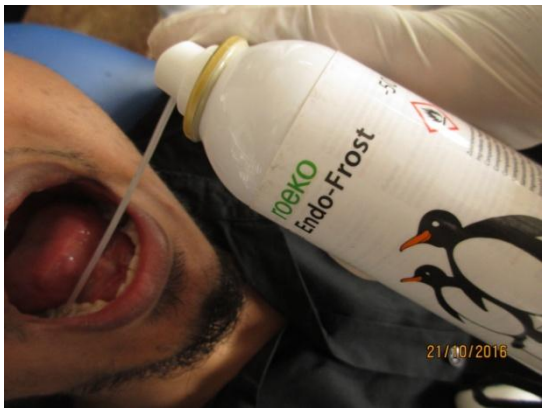
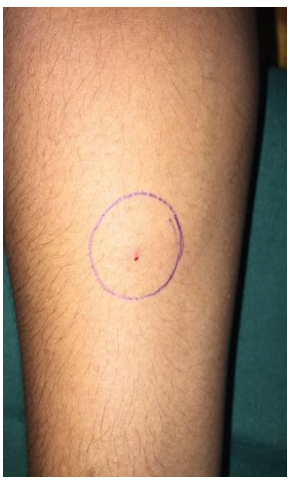


Fig 17. PULP VITALITY USING COLD SPRAY

Fig 18. TEST DOSE



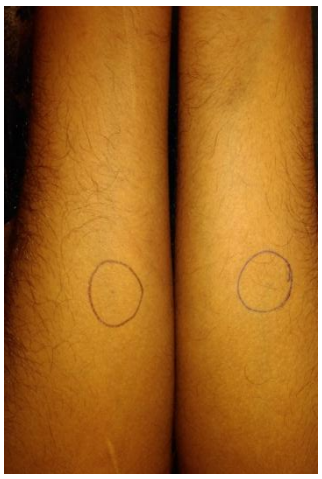


Fig 19. MARKING OF AREA AFTER TEST DOSE

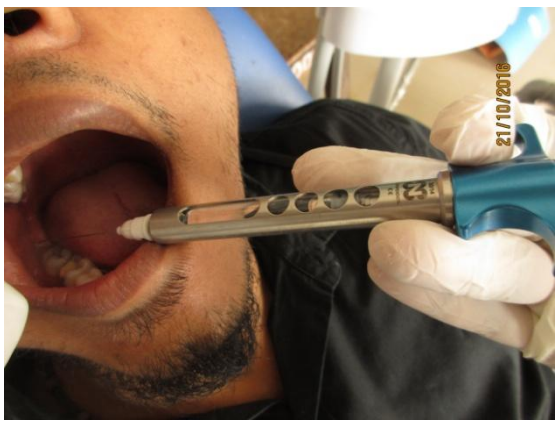


Fig 20. LOCAL ANAESTHETIC INJECTION

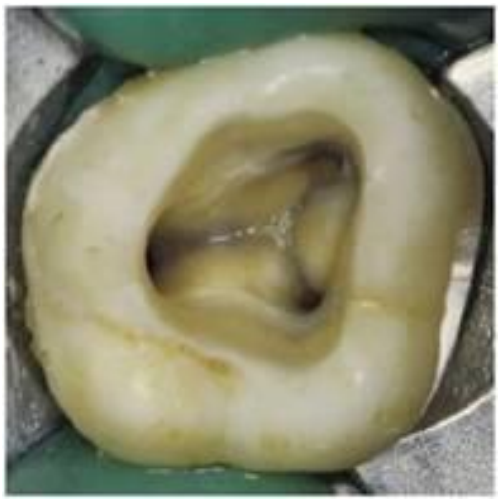


Fig 21. ACCESS OPENING

Fig 22. WORKING LENGTH MEASURED FOR INSTRUMENTATION

MATERIAL FOR COMPLICATION MANAGEMENT

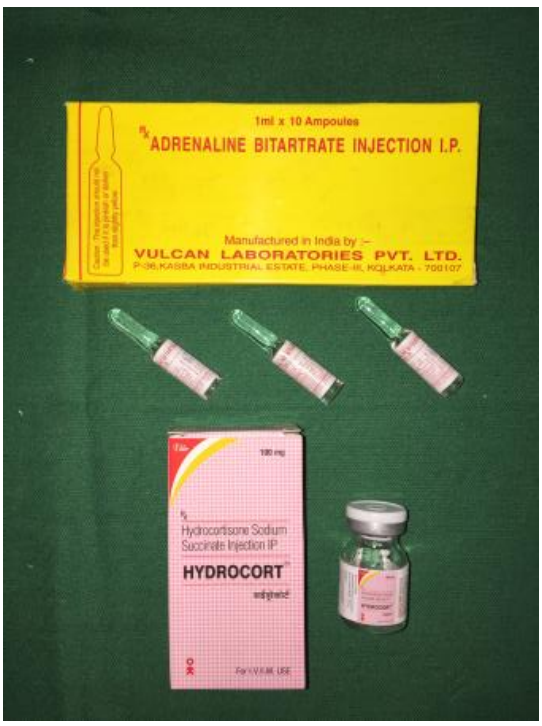


Fig 23. ADRENALINE AND HYDROCARTISONE

RESULTS

One hundred eighty adult patients participated in this study. All were emergency patients reported to Tamil Nadu Government Dental College And Hospital, Chennai-03. All the participants were selected following the established inclusion and exclusion criteria for this study.

Values of Pre operative pain was measured before starting the endodontic procedure as base line data and Pain on injection, pain on endodontic access cavity preparation & pain on endodontic instrumentation was evaluated after completion of endodontic procedure were tabulated. None of the patients presented with allergy to any material in the study.

TABLE 01: Base line values of preoperative pain using Heft Parker Visual Analog Scale

PARTICIPANT SERIAL NUMBER	PRE OPERATIVE PAIN(MM)					
	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V	GROUP VI
01	170	123	93	160	124	143
02	170	95	153	137	89	133
03	138	113	97	142	120	137
04	126	157	53	90	105	145
05	140	123	123	103	145	50
06	157	143	143	105	50	126
07	123	156	156	145	126	140
08	143	142	142	50	140	133
09	156	90	90	126	133	166
10	142	103	103	140	166	88
11	90	105	105	133	88	143
12	103	145	145	166	143	156
13	105	50	50	88	156	105
14	145	126	126	143	105	145
15	50	140	140	156	145	143
16	126	133	133	105	50	133
17	140	166	166	145	126	137
18	133	88	88	50	140	145
19	166	143	143	126	133	50
20	88	156	156	140	145	126
21	143	142	142	133	50	140
22	156	123	123	166	126	133
23	142	95	95	88	140	166
24	90	113	113	143	133	88
25	103	157	157	156	166	143
26	105	123	123	142	88	156
27	144	143	143	123	143	105
28	170	156	156	140	156	156
29	126	142	142	133	105	105
30	140	90	90	166	145	145

TABLE 02: Group I Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	43	140	55
02	50	103	170
03	66	126	126
04	78	140	140
05	30	157	157
06	58	123	123
07	95	143	143
08	140	84	22
09	44	45	30
10	75	120	58
11	28	134	95
12	16	163	140
13	30	58	103
14	22	95	105
15	30	140	145
16	58	44	50
17	95	75	126
18	140	126	140
19	44	140	157
20	75	157	123
21	88	123	143
22	143	143	22
23	156	84	30
24	142	45	58
25	90	120	95
26	140	140	140
27	44	44	103
28	75	75	105
29	88	126	145
30	143	140	50

TABLE 03: Group II Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	71	118	160
02	0	0	0
03	13	135	55
04	58	84	157
05	95	45	123
06	140	120	143
07	44	134	22
08	75	163	30
09	28	58	58
10	16	95	95
11	30	140	140
12	22	44	103
13	30	75	105
14	95	135	145
15	140	84	160
16	44	45	0
17	75	120	125
18	28	134	157
19	16	163	123
20	30	58	143
21	22	95	22
22	16	90	30
23	30	103	58
24	22	105	95
25	30	145	140
26	95	50	103
27	140	126	105
28	44	22	145
29	66	30	160
30	78	95	170

TABLE 04: Group III Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	54	40	07
02	90	63	61
03	65	0	12
04	50	05	07
05	102	35	39
06	66	63	122
07	83	0	63
08	95	27	13
09	62	93	84
10	39	123	74
11	122	47	65
12	63	05	50
13	13	35	102
14	84	63	66
15	74	0	83
16	65	27	95
17	50	93	90
18	102	62	103
19	66	39	105
20	83	122	145
21	95	63	50
22	62	13	126
23	39	84	65
24	122	66	50
25	74	83	102
26	65	95	66
27	50	62	83
28	102	39	95
29	66	122	133
30	83	74	111

TABLE 05: Group IV Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	0	0	27
02	15	17	41
03	44	73	28
04	38	12	36
05	22	28	73
06	73	36	10
07	12	73	26
08	28	10	84
09	36	26	93
10	73	122	133
11	10	63	10
12	26	13	26
13	84	84	84
14	93	66	22
15	133	28	73
16	73	36	12
17	83	73	28
18	165	10	36
19	28	26	73
20	28	122	10
21	36	63	26
22	73	13	84
23	10	84	26
24	26	84	84
25	84	74	22
26	93	65	73
27	133	50	12
28	10	102	28
29	26	66	36
30	84	83	73

TABLE 06: Group V Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	20	25	30
02	123	70	95
03	67	0	17
04	122	84	66
05	63	93	83
06	13	133	95
07	84	73	62
08	74	83	39
09	65	165	122
10	50	28	63
11	102	28	13
12	66	36	30
13	83	73	95
14	95	10	17
15	62	28	66
16	39	28	83
17	122	36	95
18	74	95	62
19	65	62	39
20	50	39	122
21	102	122	73
22	66	74	10
23	83	65	28
24	95	66	28
25	62	83	36
26	39	95	95
27	122	62	165
28	74	39	28
29	135	122	28
30	153	133	36

TABLE 07: Group VI Values measured using Heft Parker Visual Analog Scale for observed clinical parameters

PARTICIPANT SERIAL NUMBER	PAIN ON INJECTION(MM)	PAIN ON ENDODONTIC ACCESS OPENING(MM)	PAIN ON ENDODONTIC INSTRUMENTATION(MM)
01	03	71	07
02	15	17	21
03	93	85	70
04	73	36	05
05	10	73	35
06	26	10	63
07	84	26	0
08	93	84	27
09	133	93	93
10	73	133	62
11	83	10	39
12	165	26	122
13	28	84	63
14	28	22	13
15	36	73	84
16	73	12	66
17	10	28	83
18	28	36	95
19	28	73	62
20	36	122	39
21	95	63	122
22	62	13	36
23	39	84	73
24	122	84	10
25	74	74	28
26	65	65	28
27	03	50	36
28	15	102	95
29	93	66	33
30	73	83	110

BASE LINE DATA

The mean and standard deviation values and results of ANOVA & Tukeys Post Hoc tests were obtained for pre operative pain are presented in Table 8 to 10

Table 8: Mean And Standard Deviation of preoperative pain for Group I, II, III, IV, V & VI.

OBSERVED CLINICAL PARAMETER	GROUPS											
	I		II		III		IV		V		VI	
	MEAN	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD
PRE OPERATIVE PAIN	131.00	28.6	126.03	27.2	122.97	30.5	128.00	30.7	122.07	32.3	129.37	29.2

Table 9: ONE WAY ANOVA analysis for preoperative pain values for Group I, II, III, IV, V & VI

OBSERVED CLINICAL PARAMETER	Significance between groups
PRE OPERATIVE PAIN	0.856

Table 10: Tukey Post Hoc Test results of preoperative pain values for Group I, II, III, IV, V & VI.

(I)GROUP	(J)GROUP	PRE OPERATIVE PAIN
1	2	.987
	3	.903
	4	.999
	5	.890
	6	1.000
2	1	.987
	3	.999
	4	1.000
	5	.998
	6	.998
3	1	.903
	2	.999
	4	.987
	5	1.000
	6	.962
4	1	.999
	2	1.000
	3	.987
	5	.983
	6	1.000
5	1	.890
	2	.998
	3	1.000
	4	.983
	6	.954
6	1	1.000
	2	.998
	3	.962
	4	1.000
	5	.954

The dependant variables in our study were:

1. Pain on injection
2. Pain on endodontic access opening
3. Pain on instrumentation

The independent variables analyzed were 6 different materials and at various intervals of time corresponding to the procedures

The quantitative data obtained were subject to the following statistical analysis:

- **Descriptive Statistics for mean and standard deviation.**
- **One Way Analysis of Variance for Intergroup analysis.**
- **Tukey Post Hoc Test for Pairwise comparison.**

The p value of less than 0.05 ($p<0.05$) was considered significant in our study.

The mean and standard deviation values and results of ANOVA & Tukeys Post Hoc tests were obtained for observed clinical parameters are presented in Table 11 to 13

Table 11: DISCRIPTIVE RESULTS for Observed Clinical Parameters Of Group I, II, III, IV, V & VI in their Mean And Standard Deviation Values.

OBSERVED CLINICAL PARAMETERS	GROUPS											
	I		II		III		IV		V		VI	
	MEAN	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD	*MEAN*	SD
PAIN ON INJECTION	77.53	43.1	53.1	39.6	72.8	24.5	54.6	42.0	79.0	33.3	58.6	41.1
PAIN ON ACCESS OPENING	111.77	37.8	93.7	43.3	54.7	36.9	53.4	34.2	68.3	40.0	59.9	34.1
PAIN ON INSTRUMENTATION	103.3	45.5	105.9	50.5	95.5	36.9	46.3	32.0	60.7	38.2	54.0	35.3

Table 12: ONE WAY ANOVA for Observed Clinical Parameters Of Group I, II, III, IV, V & VI in their P Values.

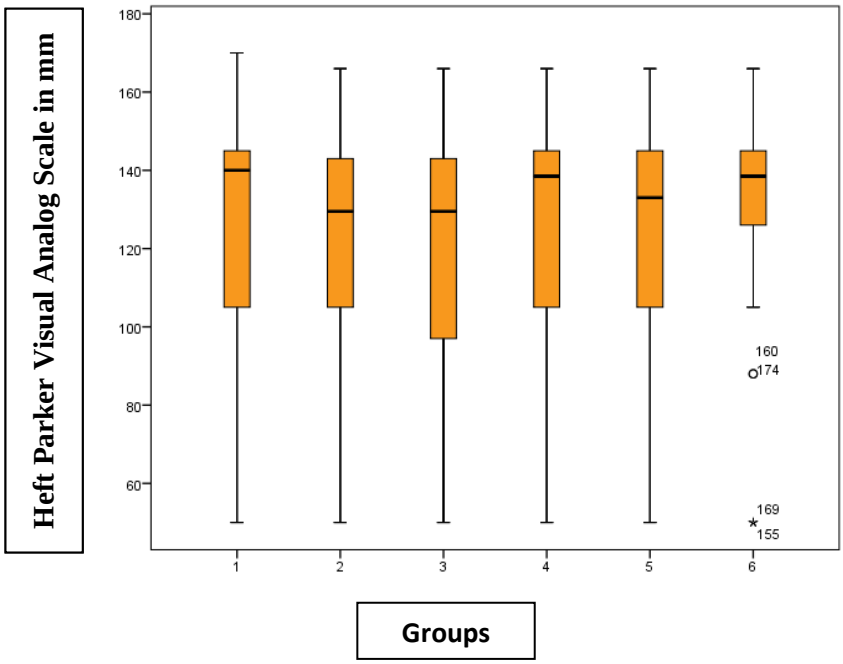
OBSERVED CLINICAL PARAMETERS	Significance between groups
PAIN ON INJECTION	0.015
PAIN ON ACCESS OPENING	0.000
PAIN ON INSTRUMENTATION	0.000

Table 13: Tukey Post Hoc Test results for Observed Clinical Parameters Of Group I, II, III, IV, V & VI in their P Values.

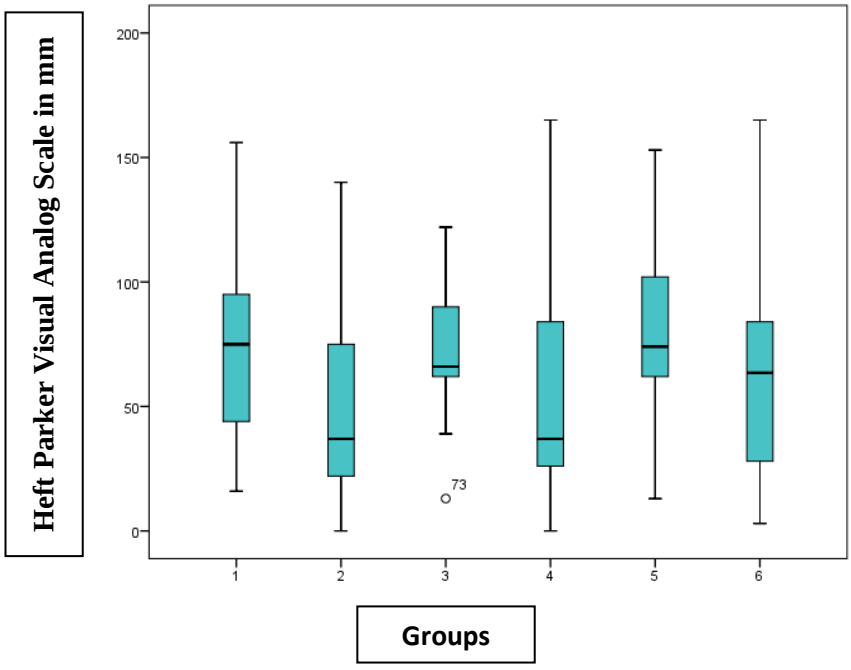
(I)GROUP	(J)GROUP	PAIN ON INJECTION	PAIN ON ACCESS OPENING	PAIN ON INSTRUMENTATION
1	2	.130	.437	1.000
	3	.997	.000	.096
	4	.183	.000	.000
	5	1.000	.000	.001
	6	.386	.000	.000
2	1	.130	.437	1.000
	3	.335	.001	.118
	4	1.000	.001	.000
	5	.091	.103	.002
	6	.993	.009	.000
3	1	.997	.000	.096
	2	.335	.001	.118
	4	.428	1.000	.067
	5	.989	.734	.722
	6	.693	.995	.322
4	1	.183	.000	.000
	2	1.000	.001	.000
	3	.428	1.000	.067
	5	.132	.646	.748
	6	.999	.985	.978
5	1	1.000	.000	.001
	2	.091	.103	.002
	3	.989	.734	.722
	4	.132	.646	.748
	6	.301	.955	.988
6	1	.386	.000	.000
	2	.993	.009	.000
	3	.693	.995	.322
	4	.999	.985	.978
	5	.301	.955	.988

Graphical representation of results

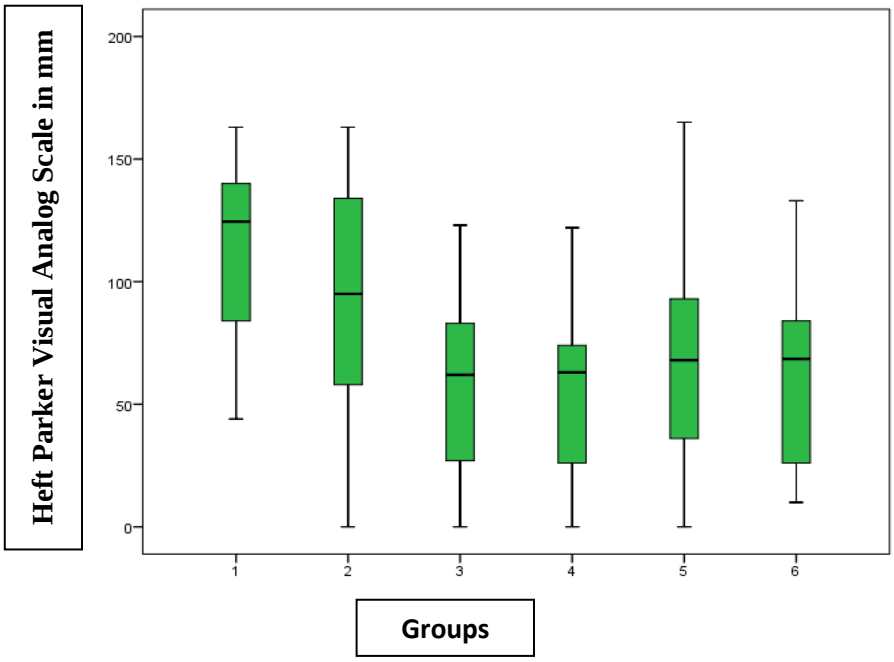
GRAPH 01: COMPARISON OF PREOPERATIVE VALUES



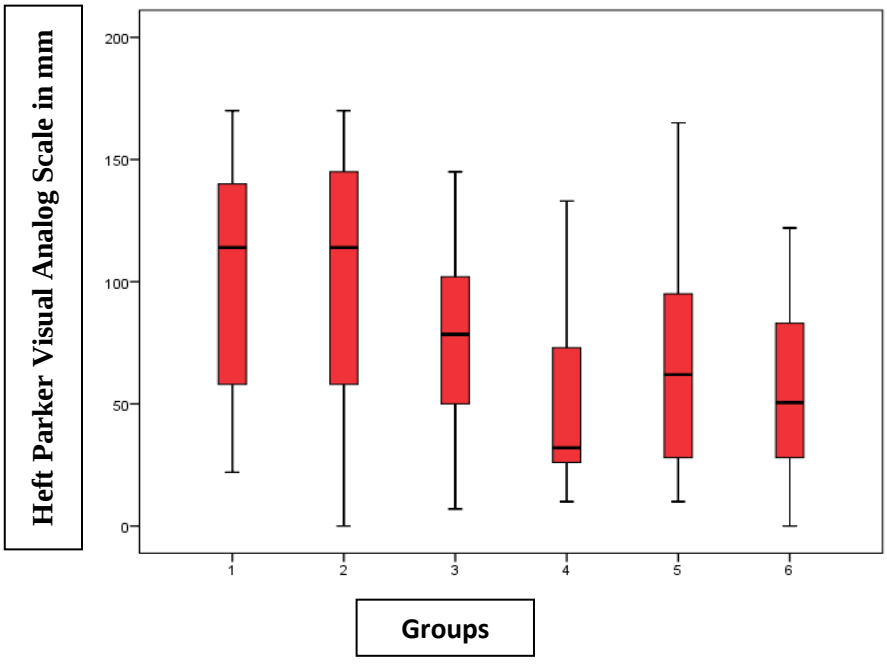
GRAPH 02: COMPARISON OF PAIN ON INJECTION VALUES



GRAPH 03: COMPARISON OF PAIN ON ACCESS OPENING VALUES



GRAPH 04: COMPARISON OF PAIN ON INSTUMENTATION VALUES



INFERENCE

Initial preoperative pain

Base line values of preoperative pain measured on Heft Parker visual analog scale for group I, II, III, IV, V, VI are tabulated in table 01. The mean and standard deviation for base line values of group I, II, III, IV, V, VI were 131.00±28.6, 126.03±27.2, 122.97±30.5, 128.00±30.7, 122.07±32.3, 129.37±29.2 respectively. Analyzing the data on ANOVA showed no significant difference between the groups with the P value 0.856. Tukeys post hoc results confirmed that there is significant difference among the groups.

Pain on injection

Pain on injection values measured on Heft Parker visual analog scale for group I, II, III, IV, V, VI are tabulated in table 02-07. The mean and standard deviation values of group I, II, III, IV, V, VI were 77.53±43.1, 53.1±39.6, 72.8±24.5, 54.6±42.0, 79.0±33.3, 58.6±41.1 respectively. Analyzing the data on ANOVA showed significant difference between the groups with the P value 0.015. Tukeys post hoc test failed to show the significant difference among the groups.

Pain on access opening

Pain on access opening values measured on Heft Parker visual analog scale for group I, II, III, IV, V, VI are tabulated in table 02-07. The mean and standard deviation values of group I, II, III, IV, V, VI were 111.77±37.8, 93.7±43.3, 54.7±36.9, 53.4±34.2, 68.3±40.0, 59.9±34.1 respectively. Analyzing the data on ANOVA showed highly significant difference between the groups with the P value

0.000. Tukeys post hoc results showed that there is significant difference among various groups as follow:

- Group I showed significant difference between group III, IV, V & VI with P value 0.000, 0.000, 0.000 & 0.000 respectively and no significant difference with group II (0.437).
- Group II showed significant difference between group III, IV & VI with P value 0.001, 0.001 & 0.009 respectively and no significant difference with group I & V (0.437 & 0.103).
- Group III showed significant difference between group I & II with P value 0.000 & 0.001 respectively and no significant difference between group IV, V & VI (1.000, 0.734 & 0.995).
- Group IV showed significant difference between group I & II with P value 0.000 & 0.001 respectively and no significant difference with group III, V & VI (1.000, 0.646 & 0.985).
- Group V showed significant difference between group I with P value 0.000 and no significant difference between group II, III, IV & VI (0.103, 0.734, 0.646 & 0.955).
- Group VI showed significant difference between group I & II with P value 0.000 & 0.000 respectively and no significant difference between group III, IV & V (0.995, 0.985 & 0.955).

IV<III<VI<V<II<I

Pain on Instrumentation

Pain on instrumentation values measured on Heft Parker visual analog scale for group I, II, III, IV, V, VI are tabulated in table 02-07. The mean and standard deviation values of group I, II, III, IV, V, VI were 103.3±45.5, 105.9±50.5, 95.5±36.9, 46.3±32.0, 60.7±38.2, 54.0±35.3 respectively showed variable difference in their numbers. Analyzing the data on ANOVA showed highly significant difference between the groups with the P value 0.000. tukeys post hoc results showed that there is significant difference among various groups as follow:

- Group I showed significant difference between group IV, V, VI with P value 0.000, 0.001, 0.000 respectively and no significant difference with group II & III with (1.000 & 0.096).
- Group II showed significant difference between group IV, V, VI with P value 0.000, 0.002, 0.000 respectively and no significant difference with group I & III (1.000 & 0.118).
- Group III showed no significant difference with group I, II, IV, V, VI (0.096, 0.118, 0.067, 0.722 & 0.322).
- Group IV showed significant difference between group I, II with P value 0.000, 0.000 respectively and no significant difference with group III, V & VI (0.067, 0.748 & 0.978).
- Group V showed significant difference between group I & II with P value 0.001 & 0.002 respectivly and no significant difference with group III, IV & VI (0.722, 0.748 & 0.988).

- Group VI showed significant difference between group I, II with P value 0.000, 0.000 respectively and no significant difference with group III, IV & V (0.322, 0.978 & 0.988).

IV<VI<V<III<I<II

Decoding of labeled materials for blinding

1. **LA1:** 4 % ARTICAINE WITH 1:1,00,000 EPINEPHRINE
2. **LA2:** 2 % LIGNOCAINE WITH 1:80,000 EPINEPHRINE
3. **B1:** 0.5 MOL/L MANNITOL
4. **B2:** 8.4 % SODIUM BICARBONATE

Distribution of materials to respective groups

1. **GROUP I :** 2% LIGNOCAINE WITH 1:80,000 EPINEPHRINE
2. **GROUP II :** 4% ARTICAINE WITH 1:1,00,000 EPINEPHRINE
3. **GROUP III :** 2% LIGNOCAINE WITH 1:80,000 EPINEPHRINE + 0.5 MOL/L MANNITOL
4. **GROUP IV :** 4 % ARTICAINE WITH 1:1,00,000 EPINEPHRINE + 0.5 MOL/L MANNITOL
5. **GROUP V :** 2 % LIGNOCAINE WITH 1:80,000 EPINEPHRINE + 8.4 % SODIUM BICARBONATE
6. **GROUP VI :** 4 % ARTICAINE WITH 1:1,00,000 EPINEPHRINE + 8.4 % SODIUM BICARBONATE

DISCUSSION

Local anesthetics exert their pharmacologic actions on the nerve membrane. Many theories have tried to explain the mechanism of action of local anesthetics. The specific receptor theory is the most accepted theory today. This theory holds that local anesthetics bind to specific receptors within the sodium channel which results in decreased or eliminated sodium permeability[82]. Local anesthetics bind the helical segments of sodium channels. Once bound, the sodium channels restrict movement of sodium across the membrane and keep sodium channels in an inactive configuration. The result is an ultimate failure of action potential and propagation down the neuron.

Local anesthetics are said to produce a use-dependent block. This concept suggests that local anesthetics are particularly effective in blocking high frequency nerve impulses because local anesthetics are better able to reach their site of action within the sodium channel during a channel's inactive state following depolarization. If a nerve is rapidly firing, the channels will be active more frequently increasing the opportunity for local anesthetic to reach the site of action, resulting in a use-dependent blockade of nerve impulse[2].

Pulpitis in human dentition can be described as a diseased state of teeth caused by any insult that disrupts the healthy pulp. This pathology can cause intermittent or spontaneous pain. Teeth in this state can respond differently to stimuli that would be considered normal. This is referred to as hypersensitivity or allodynia[56]. An extremely cold stimulus can be very helpful in the diagnosis of pulpitis. Pressure, heat, and especially cold sensations can be exaggerated and/or

prolonged. When pulpal disease has progressed to a state in that the body's normal immune response is unable to repair the damage from this disease, a diagnosis of irreversible pulpitis is made. The presence of pulpitis can be of significance when administering an IAN block. Lack of success of the IAN block can be due to possible heightened or hypersensitivity of the tooth[61].

Clinical studies in patients with symptomatic irreversible pulpitis have found success with the IANB occurred between 15-57 % of the time[111]. These studies would indicate that anesthesia is often difficult to achieve in symptomatic irreversible pulpitis. Claffey et al[25]. compared the anesthetic efficacy of 4 % articaine with 1:100,000 epinephrine to 2 % lidocaine with 1:100,000 epinephrine for inferior alveolar nerve blocks in patients experiencing irreversible pulpitis in mandibular posterior teeth. The success rate for the IANB using articaine was 24 % and for lidocaine 23 %. They found no significant difference between the articaine and lidocaine solutions. Tortamano et al[136]. also found that articaine and lidocaine had no significant difference in anesthetic success of the inferior alveolar nerve block and that neither solution resulted in a successful rate of anesthesia in posterior mandibular teeth. Sherman et al[125]. compared 4 % articaine with 1:100,000 epinephrine with 2 % lidocaine with 1:100,000 epinephrine for Gow-Gates blocks in patients experiencing symptomatic irrerversible pulpitis. No difference between the 2 anesthetics was found Aggarwal et al[2]. studied pretreatment medication with nonsteroidal anti-inflammatory drugs. Placebo gave 29 % success rate. Premedication with ketorolac gave 39 % success and ibuprofen gave 27 % success. There was no significant difference between the 3 groups in patients with

symptomatic irreversible pulpitis in mandibular posterior teeth. Oleson et al[102]. also studied the effect of preoperative ibuprofen on the success of the inferior alveolar nerve block in patients with irreversible pulpitis. The success rate for the IANB was 41 % with preoperative ibuprofen and 35 % with placebo with no significant difference between the 2 groups.

Hannan et al[55] noted that accurate placement of the needle via ultrasound technology also does not result in more successful pulpal anesthesia, showing that the accuracy of needle placement is not a primary reason for pulpal anesthetic failure in the mandible. Berns and sadow[12] researched radiographic methods to locate the mandibular foramen, to help give an accurate injection, but discovered it did not increase the rate of anesthetic success. Simon et al[128] studied accurate placement of solution deposition to the inferior alveolar nerve via a peripheral nerve stimulator and showed no increase in success rate of pulpal anesthesia when compared with a conventional inferior alveolar nerve block.

Accessory innervation via the mylohyoid nerve is hypothesized to contribute to inferior alveolar nerve block failure, specifically regarding pulpal anesthesia of the first mandibular molar[127] However, Clark et al[26] showed that a combination of inferior alveolar nerve block and mylohyoid nerve block did not improve pulpal anesthesia, nor does a mylohyoid nerve block predictably ensure pulpal anesthesia in mandibular teeth.

McCartney et al[89] studied the pain associated with needle insertion, placement, and solution deposition for the conventional inferior alveolar nerve block in patients with irreversible pulpitis. She found that moderate-to-severe pain may

occur 57 % to 89 % of the time with the inferior alveolar nerve block. There was no statistical difference between the pain for men or women with respect to needle insertion, placement, or deposition. The use of topical anaesthesia did not eliminate needle insertion pain.

Lidocaine is the most frequently used local anesthetic (LA), which contains a vasoconstrictor and antioxidant[30]. Commercially available lidocaine solutions with epinephrine have a low pH range between 2.9 and 4.4[78]. Decreasing the pH extends the shelf life of the solution and prevents its early oxidation[122,80]. However, a low pH may produce a burning sensation on the injection site, a slower onset of anesthesia, and a decrease in its clinical efficacy[20].

Articaine, the second most commonly used dental anesthetic, was first introduced to the European market in 1976 and entered the U.S. market in 2000[76] . By 2007, articaine was described as accounting for approximately 25 % of total sales, second only to lidocaine at 54 %[107]. The chemical composition of articaine contains a unique thiophene ring instead of the benzene ring found in lidocaine and other amide local anesthetics. This difference increases lipid solubility, thereby increasing diffusion through the lipid membrane of the epineurium, which purportedly explains its faster onset and higher success rate when compared with lidocaine[21,101].

Buffering of LAs (alkalinization) has been suggested to achieve pain control[35]. Alkalinization will increase the dissociation rate of the LA molecule and then increase the uncharged base form that crosses the nerve membrane to the intraneuronal site where it exerts its action[91,49] . The most common method for

buffering of LAs is with the addition of sodium bicarbonate. It is an alkalinizing agent, which is most commonly used for the treatment of metabolic acidosis. The addition of sodium bicarbonate to LAs not only will increase the pH of the solution but will also result in the production of carbon dioxide and water[1]. Carbon dioxide potentiates local anesthesia by 3 mechanisms[19,29].

1. A direct depressant effect of carbon dioxide on the axon
2. Concentrating LA inside the nerve trunk (diffusion trapping)
3. Converting LA to the active cation through its effect on pH at the site of action inside the nerve.

A possible reason for failure is the perineurial barrier around the nervemay not allow complete diffusion of the anesthetic solution into the nerve trunk. According to de Jong[36], ‘‘the perineurium’s innermost layer, the perilemma, is lined with a smooth mesothelial membrane. Tight junctions in the perilemma turn the perineurium into a nerve’s main diffusional barrier. Developmentally, the perilemma is a continuation of the pia-arachnoid membrane that covers brain and spinal cord, hence it is the blood/nerve equivalent of the central blood/brain barrier. These tough diffusion barriers lay waste to a substantial proportion of injected local anesthetic solution.’’ Under normal conditions, tight junctions along the inner layer of the perineurium maintain homeostasis in the endoneurial tissue containing peripheral neurons. These tight junctions act as a diffusion barrier not only for high molecular weight or hydrophilic substances[112,58,104], but also for lipophilic compounds[48]. This diffusion barrier is continuous along afferent somatic and autonomic

nerve fibers to their peripheral endings[33,75]. Inflammation causes a deficiency of the perineurial barrier and/or an enhanced permeability of endoneurial capillaries[31,71]. A similar disruption of the perineurial barrier can be produced by the extraneural application of hyperosmolar solutions[57,142]. Similar to what occurs at the blood brain barrier[110], the effects of hyperosmolar solutions have been linked to a transient shrinkage of perineurial cells with subsequent widening of zonulae occludens[31,72]. Antonijevic et al[6]. found that a 0.5 M solution of mannitol was most effective in opening the perineurial membrane to allow for enhanced penetrability for macromolecules and/or ions. They demonstrated that the efficacy of both hydrophilic and lipophilic compounds could be improved dramatically by the concomitant alteration of perineurial permeability. This effect is short lived, reaching a maximum effect at certain concentrations of mannitol and declining at higher concentrations[37,39,96,18]. Additionally,there is some evidence that hyperosmolar solutions like mannitol delay or block action potential propagation in selective A-type neurons in rats[87]. However, the effects on neural conduction of a diluted mannitol-lidocaine formulation are unknown.

The efficacy of buffered local anesthetics has been examined thoroughly in medicine. Many of the studies involving buffered anesthetics use the pain of injection as their assessment. McKay et al[91]. found that a non-buffered lidocaine with epinephrine solution had the higher mean pain score compared to a buffered solution. Both lidocaine with commercial epinephrine and plain lidocaine were significantly more painful than the corresponding buffered solutions. Steinbrook et al.[132] also studied pain of injection of buffered local anesthetics. They also found

that lidocaine buffered with sodium bicarbonate caused significantly less pain on skin infiltration.

Masters et al[86]. also found that the buffered solutions were significantly less painful than the control solutions. These authors as well as several other[84,37] concluded that pain of injection was reduced by a statistically significant amount when using buffered local anesthetics versus non-buffered solutions. These results are supported by the results of the systematic review of the literature & meta analysis[21,49,54] that also concluded that buffered local anesthetics result in less pain on injection than non-buffered solutions. Some authors were unable to establish any significant difference in the pain of injection between buffered and non-buffered local anesthetics.

In this study we used 2 buffers. 8.4% Sodium Bicarbonate most commonly used buffer and 0.5 mol/L Mannitol buffer having potential to cross blood brain barrier and nerve tissue made them to select them in our study. 2 % lidocaine + 1:80,000 epinephrine is most commonly used and 4 % articaine + 1:1,00,000 epinephrine is the second most used local anaesthetic system selected in this study.

Different methods have been used to determine pulpal anesthetic success. Bjorn[14] was the first to correlate a negative response to maximum output of electrical pulp stimulation to painless dental treatment. Dreven et al[37] evaluated the electric pulp tester as a measure of pulpal anesthesia before endodontic treatment in teeth with pulpal diagnosis of normal, reversible pulpitis and irreversible pulpitis. However, in irreversible pulpitis, the lack of response to vital pulp testing might not guarantee pulpal anesthesia. Hence, recording pain response during access

preparation and pulp extirpation is a viable alternative[37,99]. All the volunteers in this study reported lip numbness after each injection. It should be noted that although all the patients had subjective symptoms of lip numbness, the anesthesia was not successful in all cases. Literature search revealed that this phenomenon is also seen in uninflamed pulps in which, despite successful lip numbness, the clinician failed to get no response to the maximum stimulus on electric pulp testing[57,109].

Pain measurement is difficult to establish, because its perception and intensity are multifactorial, encompassing sensorial and effective factors. Quantifying and standardizing pain objectively across a group of individuals can be challenging. Numeric and verbal self-rating scales or behavioral observation scales have traditionally been used in clinical studies. On the basis of their established criteria, the VAS was found to be methodologically sound, conceptually simple, easy to administer, and unobtrusive to the respondent. It has a continuous frequency distribution allowing for rigorous statistical tests on average pain levels. Heft Parkar Visual Analog Scale is a combined metric scale for pain measurement that provides the subject with multiple cues that might improve communication and concordance between scales for individual pain determination. It integrates irregular spacing of 6 categorical scale descriptive words onto a 170-mm horizontal line. The inventors stressed that patients make categorical judgments on the basis of their understanding of the words, and that the categorical ratings are not an ordinal index[7]. Although the HP VAS might show deficiencies regarding understanding and perception, it provides a validated and meaningful measure of anesthetic efficiency; it is used for this purpose by many authors[103].

All the samples were selected randomly and allocated to sequence generated to specific group. Materials used in this study were labeled to blind the individual including operator. Randomizing the samples and blinding helped in reducing bias in this study.

Present study results for base line data of 180 patients show no statistical difference among all the groups. Patients had to present with symptomatic irreversible pulpities and the inflammation taking place within the nervous tissue of their teeth may significantly affect their perception of pain. Studies have reported that preoperative pain resulting from symptomatic irreversible pulpitis affects the success rate of the conventional IAN block[63,129,74,133,113,89,73,111]. If one group presented with higher initial pain scores than the other, the results of this study could be misleading. The mean initial pain reported by the all the groups in this study group showed no significant difference. Since, there was no statistically significant difference between the any groups with regard to initial pain, this helped to eliminate initial pain as a confounding variable.

Results of this study showed articaine performed better than lidocaine. Lidocaine has maintained its status as the most widely used local anesthetic in dentistry since its introduction. Proven efficacy, low allergenicity, and minimal toxicity through clinical use and research have confirmed the value and safety of this drug. Thus, it became labeled the gold standard to which all new local anesthetics are compared. Despite the gold standard status of lidoocaine, numerous reports have advocated the use of articaine hydrochloride as a superior anesthetic agent, primarily on the basis of its enhanced anesthetic potency, which is 1.5 times greater than that of lidocaine, with faster onset and increased success rate[79].

Articaine, which is 4-methyl-3(2-[propylamino]propionamido)-2-thiophene carboxylic acid, methyl ester hydrochloride is the only amide local anesthetic that contains a thiophene ring and an additional ester ring[77]. Lipid solubility is an intrinsic quality of local anesthetic potency. This quality permits the easier penetration of the anesthetic through the lipid nerve membrane and surrounding tissues[79]. The degree of anesthetic molecules binding to the nerve membrane was suggested to dictate the duration of the anesthetic effect. The more secure a bond is, the slower the anesthetic is released from the receptor sites in the sodium channels, and the greater the duration of the anesthetic effect. As determined by Courtney et al[33], mere lipid solubility of a local anesthetic did not determine the action on the ionic channels. Instead, Uihlein[138] determined that binding properties of the local anesthetic agent to plasma proteins have a greater correlation to action on ionic channels than does lipid solubility. Available literature indicates that articaine is equally effective in nerve block and infiltration anesthetic techniques when compared with other local anesthetics including lidocaine with epinephrine, mepivacaine with epinephrine or with levonordefrin, mepivacaine with norepinephrine, and prilocaine with epinephrine[147,116,10,136,105].

Although IANB is the local anesthesia technique of choice when treating mandibular molars, not all IANB injections result in successful pulpal anesthesia. The literature provides various explanations to the increased incidence of failure of IANB in patients with irreversible pulpitis as we discussed previously in this discussion. Articaine contains a thiophene ring instead of a benzene ring found in lidocaine, which might allow the molecule to diffuse more readily. This speculation

is corroborated by the claims that articaine is able to diffuse through soft and hard tissues more reliably than other local anesthetics[92].

In this study the anaesthetic effect of buffered solutions proved to be better than non buffered groups. Another explanation why anesthetics fail, relates to the theory that the lowered pH of inflamed tissue reduces the amount of the free base form of anesthetic to penetrate the nerve membrane. Therefore, there is less of the ionized form within the nerve to achieve anesthesia. Most local anesthetics are weak bases with pKa ranging from 7.5 to 9.0. According to Yagiela et al[148], "local anesthetics, which are acidic, are quickly neutralized by tissue fluid buffers, and a portion of the cationic form is converted to the nonionized base". The amount of the drug that is converted to nonionized base form is determined by the Henderson-Hasselbalch equation, which is:

$$\mathbf{pH = pK_a + \log ([A^-]/[HA])}$$

This equation is dependent on the surrounding body pH and the local anesthetic pKa. Buffered local anesthetics have a higher pH and may be more efficient in achieving pain control for the inferior alveolar nerve block. Local anesthetics, such as lidocaine & articaine have a weak base component, these local anesthetics with epinephrine is a mixture of two chemical forms: a non-ionized, uncharged free base form and an ionized, and charged cationic form[94,16]. The non-ionized form of the local anesthetic is the active lipid soluble form that readily enters the nerve membrane and blocks nerve conduction[96]. The presence of a sufficient amount of non-ionized free base anesthetic is necessary to induce anesthesia. Local anesthetics with epinephrine enters the body at a lower pH than that of the physiologic pH of 7.4. At this lower pH, local anaesthtic solutions must be buffered by the body to convert enough anesthetic to the de-ionized form to produce anesthesia[46,137]. Creating a solution that is buffered before injection

could result in a more effective anesthetic. Galindo[45]. used buffered local anesthetic solutions (pH of 7.4) in peripheral nerve blocks and regional anesthesia. They found that higher pH solutions established better quality anesthesia.

There are several proposed mechanisms for the improved nature of buffered anesthetics. One concept involves the idea that a higher pH of injected solution is less irritating to the tissues than the more acidic non-buffered conventional solutions[83,17]. Another mechanism states that the de-ionized anesthetic will enter the nerve sheath more quickly and result in the afore mentioned faster onset of anesthesia[101]. Anesthetic solutions are buffered with 8.4% sodium bicarbonate and0.05mol/L mannitol, resulting in the release of more of de-ionized form of LA.

The most common technique for the buffering of local anesthetics is by the addition of sodium bicarbonate. Each 84 mg of sodium bicarbonate contains 1 mg of sodium ions and 1 mg of bicarbonate ions. An 8.4 % solution of sodium bicarbonate would contain 1 mEq each of sodium and bicarbonate ions per mL. In this study 8.4 % of sodium bicarbonate buffered with both lidicaine & articaine in two of the experimental groups. Another technique for the addition for the buffering of local anaesthetics is by the addition of 0.5 mol/L mannitol. In our study lidocaine & articaine were also buffered with 0.5 mol/L mannitol in two other experimental groups. Both the buffered solutions along with two LA performed well with significant results when compared with the non buffered groups but there is no significant difference within the buffered groups.

SUMMARY

The aim of this study is to compare the efficacy of two local anesthetic solutions buffered with two buffering agents to assess the pain on injection, access opening and endodontic instrumentation on the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis.

180 subjects who fulfilled the inclusion and exclusion criteria were chosen for the study with no discrimination based on sex, caste, religion or socioeconomic status. The complete treatment procedure was explained to the patients and a written informed consent was obtained from all the patients selected for the study. The 180 subjects were randomly divided into 6 groups with 30 participants in each group. Blinding has been done by labeling the two local anaesthetic solutions as LA1 & LA2 and buffering agents as B1 & B2. The labeled materials were allocated to groups randomly as follow:

1. **GROUP I :** 2 % Lignocaine with 1:80,000 Epinephrine
2. **GROUP II :** 4 % Articaine with 1:1,00,000 Epinephrine
3. **GROUP III :** 2 % Lignocaine with 1:80,000 Epinephrine + 0.5 mol/l Mannitol
4. **GROUP IV :** 4 % Articaine with 1:1,00,000 Epinephrine + 0.5 mol/l Mannitol
5. **GROUP V :** 2 % Lignocaine with 1:80,000 Epinephrine + 8.4 % Sodium bicarbonate
6. **GROUP VI :** 4 % Articaine with 1:1,00,000 Epinephrine + 8.4 % Sodium bicarbonate

Before starting any operative procedure, *test dose* of local anaesthetic solution and buffered solutions will be given for all the participants of respective group to check for allergy to any material. The buffered local anaesthetic solution should be freshly prepared before injecting The prepared local anaesthetic solution injected using conventional IANB to the patient allotted to respective group. Access opening done under rubber dam isolation and instrumentation done upto 20 size K file till the measured working length. The patients were reviewed immediately for Pain on injection, pain on endodontic access cavity preparation and pain on endodontic instrumentation after each endodontic procedure to record the values on Heft Parker Visual Analog Scale.

The following data were obtained:

1. Pain on injection
2. Pain on endodontic access opening
3. Pain on instrumentation

All data obtained were tabulated and analysed statistically using statistical software SPSS version 22.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

1. 0.5mol/L Mannitol and 8.4 % sodium bicarbonate proved that adding these buffering agents will improve the anaesthetic efficacy of 4 % articaine + 1:1,00,000 epinephrine than 2 % lignocaine + 1:80,000 epinephrine
2. 4 % articaine + 1:1,00,000 epinephrine performed better than 2 % lignocaine + 1:80,000 epinephrine in reducing pain during endodontic access opening and instrumentation in patients with symptomatic irreversible in mandibular posterior teeth using conventional IANB technique
3. Buffered local anaesthetic solutions found to be promising in reducing pain than non buffered solution during endodontic access opening and instrumentation in patients with symptomatic irreversible in mandibular posterior teeth using conventional IANB technique

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