Ifrah Sarfaraz

Anesthetic Efficacy of Gow-Gates versus Inferior Alveolar Nerve Block for Irreversible Pulpitis

Universidade Fernando Pessoa

Faculdade de Ciências da Saúde

Porto, 2020

Ifrah Sarfaraz

Anesthetic Efficacy of Gow-Gates versus Inferior Alveolar Nerve Block for Irreversible Pulpitis

Universidade Fernando Pessoa

Faculdade de Ciências da Saúde

Porto, 2020

I, Ifrah Sarfaraz, presenting a descriptive systematic review of quantitative researches on "Anesthetic Efficacy of Gow-Gates versus Inferior Alveolar Nerve Block for Irreversible Pulpitis" attest the originality of this work, which can be confirmed with the bibliographic references.

.

Dissertation submitted to
University of Fernando Pessoa
as a mandatory requirement for obtaining
Integrated Masters in Dental Medicine

ABSTRACT

Introduction:

Local anesthesia is a drug used to induce loss of sensation in a particular part of the body that results in nerve endings or obstruction of the peripheral nerve function. Local anesthetic injection may not only generate pain and fear, but also be a triggering factor related to medical emergencies in dental offices, with vasodepressor syncope and hyperventilation as major psychogenic reactions. Various techniques used for Inferior Alveolar Nerve Block (IANB) Mandibular teeth are:

- Conventional IANB
- Gow-Gates mandibular nerve block (GGMNB)
- Vazirani/Akinosi block (Closed mouth block)

Mainly Infiltration technique is used for anaesthetizing maxillary teeth (Maxillary nerve). Various approaches have their advantages and limitations. The failure rate for IANB is quite high as compared to Maxillary nerve infiltration. Clinicians have consistently sought an anesthetic alternative, which can increase success rates well below one hundred percent in the posterior mandible in particular. Therefore, during the treatment of the nerve block, dentists should therefore choose the highly appropriate technique with patient interest.

Foregoing in view, the purpose of this review was to assess the anesthetic efficacy of the IANB and GGMNB in patients with symptomatic irreversible pulpitis.

Objectives:

- To systematically review researches on the anesthetic efficacy of GGMNB versus IANB for irreversible pulpitis.
- To compare the outcomes of GGMNB and IANB for irreversible pulpitis.

Methodology:

It was a descriptive systematic review of quantitative researches wherein the “Preferred Reporting Items for Systematic Reviews (PRISMA)” was adopted, which ensured clarity in selection process of shortlisted paper and facilitated comprehensive approach to compose systematic review. PICO criteria, clearly identifying population (P), Intervention (I), Comparison (C),and Outcome (O), was used to structure the research question: “Is Gow-Gates technique (I) has better anesthetic efficacy (O) as compared to IANB (C) for patients with irreversible pulpitis (P)”?

The literature search was done on PubMed/Medline, Cochrane library, Google scholar and Ovid. Selection criteria was applied for population as patients of age more than 9 years of either gender with irreversible pulpitis while including articles published in English from all around the world regarding conventional IANB or IANB & Gow-Gates techniques, and articles published between the duration of 2009-2019 as approved vide final work proposal. The prospective randomized clinical trials or randomized controlled trials were included for the review in which anesthetic efficacy or success was measured. A total of six studies on Cochrane, sixteen studies on PubMed/Medline, two on Ovid and eighty seven studies on Google scholar were primarily identified. After removal of the duplicates (n=111), preliminary screening of titles and abstracts was done, and 103 studies were excluded because they were not meeting the eligibility criteria. A total of 8 articles were selected for full-text reading. Of these 8 studies, 3 studies were further excluded because focused question was not answered in it. At final stage, five articles were included.

Results:

The results of the five studies that are reviewed establish that anesthetic efficacy of Gow-Gates nerve block technique is better than IANB technique for irreversible pulpitis. However, the overall quality of the literature assessed is fair to poor. Three studies are randomized clinical trial and two randomized controlled trial. The validity and reliability of the studies included is appropriate. This is due to the appropriate study design and accuracy of the study in measuring the efficacy of the selected anesthetic techniques.

Conclusion:

Patients who receive either of these two mandibular nerve blocks i.e., there is a difference in the pain experienced i.e. Gow-Gates nerve block or IANB. There is evidence of a higher efficacy of the Gow-Gates technique than the IANB. Each of the two techniques is equally easy to execute with training. The value of knowing how to perform the Gow-Gates nerve block is that the Gow-Gates technique will most likely provide satisfactory anesthesia for a specific patient in situations where the IANB will not. Knowing how to perform only one method to block the inferior alveolar nerve limits the ability of the dentist to provide consistently successful anesthesia and makes it more difficult for all patients to achieve the goal of pain-free dentistry. Knowing how to perform Gow-Gates technique, on the other hand, increases the likelihood that patients may be pain-free when undergoing mandible dental procedures.

RESUMO

Introdução:

A anestesia local é um medicamento usado para induzir a perda de sensação em uma parte específica do corpo que resulta em terminações nervosas ou obstrução da função nervosa periférica. A injeção anestésica local pode não apenas gerar dor e medo, mas também ser um fator desencadeante relacionado a emergências médicas em consultórios, com síncope vasodepressora e hiperventilação como principais reações psicogênicas. Várias técnicas utilizadas para os dentes inferiores do Bloqueio do nervo alveolar inferior (BNAI) são:

• BNAI convencional

• bloqueio do nervo mandibular de Gow-Gates (BNMGG)

• Bloqueio de Vazirani / Akinosi (bloqueio de boca fechada)

Principalmente a técnica de infiltração é usada para anestesiar os dentes superiores (nervo maxilar). Várias abordagens têm suas vantagens e limitações. A taxa de falha do BNAI é bastante alta quando comparada à infiltração do nervo maxilar. Os médicos sempre procuraram uma alternativa anestésica, que pode aumentar as taxas de sucesso bem abaixo de cem por cento na mandíbula posterior, em particular. Portanto, durante o tratamento do bloqueio nervoso, os dentistas devem, portanto, escolher a técnica altamente apropriada do interesse do paciente.

Diante do exposto, o objetivo desta revisão foi avaliar a eficácia anestésica do BNAI e BNMGG em pacientes com pulpite irreversível sintomática.

Objetivos.

• Revisar sistematicamente pesquisas sobre a eficácia anestésica do BNMGG versus BNAI para pulpite irreversível.

• Comparar os resultados de BNMGG e BNAI para pulpite irreversível.

Metodologia:

Foi uma revisão sistemática descritiva de pesquisas quantitativas em que foram adotados os “Itens de Relatórios Preferidos para Revisões Sistemáticas (PRISMA)”, o que garantiu clareza no processo de seleção de artigos selecionados e facilitou a abordagem abrangente para compor a revisão sistemática. Os critérios do PICO, identificando claramente população (P), Intervenção (I), Comparação (C) e Resultado (O), foram utilizados para estruturar a questão de pesquisa: “A técnica de Gow-Gates (I) tem melhor eficácia anestésica (O) comparado ao IANB (C) para pacientes com pulpite irreversível (P) ”?

A pesquisa bibliográfica foi realizada na PubMed / Medline, biblioteca Cochrane, Google scholar e Ovid. Os critérios de seleção foram aplicados para a população com idade superior a 9 anos, de ambos os sexos, com pulpite irreversível, incluindo artigos publicados em inglês sobre as técnicas convencionais BNAI ou BNAI & Gow-Gates e artigos publicados entre 2009 -2019. Os ensaios clínicos randomizados prospectivos ou ensaios clínicos randomizados controlados foram incluídos na revisão em que a eficácia ou o sucesso anestésico foi medido. Um total de seis estudos na Cochrane, dezesseis estudos na PubMed / Medline, dois no Ovid e oitenta e sete estudos no Google scholar foram identificados principalmente. Após a remoção das duplicatas (n = 111), foi realizada triagem preliminar de títulos e resumos, e 103 estudos foram excluídos por não atenderem aos critérios de elegibilidade. Um total de 8 artigos foram selecionados para leitura em texto completo. Desses 8 estudos, 3 estudos foram mais excluídos a posterior porque a pergunta focalizada não foi respondida. Na fase final, cinco artigos foram incluídos.

Resultado:

Os resultados dos cinco estudos revisados estabelecem que a eficácia anestésica da técnica de bloqueio nervoso de Gow-Gates é melhor que a técnica BNAI para pulpite irreversível. No entanto, a qualidade geral da literatura avaliada é justa a ruim. Três estudos são ensaios clínicos randomizados e dois ensaios clínicos randomizados. A validade e a confiabilidade dos estudos incluídos são adequadas. Isso se deve ao desenho e à precisão adequados do estudo na medição da eficácia das técnicas anestésicas selecionadas.

Conclusão:

Pacientes que firam submetidos as duas técnicas de bloqueio do nervo mandibular, revelaiam uma diferença na dor experimentada, ou seja, bloqueio do nervo Gow-Gates ou BNMGG. Há evidências de uma maior eficácia da técnica de Gow-Gates do que a BNAI. Cada uma das duas técnicas é igualmente fácil de executar com treino. O valor de saber como executar o bloqueio nervoso de Gow-Gates é que esta técnica provavelmente fornecerá anestesia satisfatória para um paciente específico em situações em que a BNAI não o fará. Saber executar apenas um método para bloquear o nervo alveolar inferior limita a capacidade do medico dentista fornecer anestesia com sucesso consistente e torna mais difícil para todos os pacientes alcançar o objetivo da saude oral sem dor. Saber executar a técnica de Gow-Gates, por outro lado, aumenta a probabilidade de os pacientes sentirem-se livres de dor ao serem submetidos a procedimentos dentários mandibulares.

ACKNOWLEDGMENTS

First and foremost, all praises and thanks to Almighty Allah, for His countless and continued blessings throughout the research work; which enabled me to produce this humble piece of work. Accordingly, the unflinching support all along extended to me by wonderful professionals at University Fernando Pessoa (UFP) made this intricate task rather simple, interesting, and enlightening one besides being a great learning experience.

I would like to express my sincere appreciation and gratitude to my research supervisor; **Dr. Pedro Jorge Gongalaves Pereira, DDS, MSc, PhD,** for his focused attention, supervision, utmost support and guidance to help me accomplish this major milestone in compressed time frame. I sincerely thank him for his vehement efforts, patience, contribution and cooperation throughout.

I would like to specially thank the program coordinator **Dr. Patricia Manarte Monteiro** for being my guiding light at each step of the program. In addition, I am also grateful to all my teachers and library staff at UFP for all their dedication and time they have enthusiastically invested in helping me at various phases of this journey.

I feel highly indebted to the kindness and utter solace bestowed by my mentor in profession **Surg Cdr (Lt Col) Dr. Dil Rasheed, BDS (Hons), FCPS, MPH, DMA** throughout this period. Like always, he has been a great source of strength to extend the advisory support as and when needed.

I am thankful to my fellow colleague **Khadija Abid Khan** for her advisory support to grasp the essentials of research methodology prior venturing into research work.

I am also thankful to my classmates originating from various countries for all their encouragement and moral support including sharing a diversified treasury of knowledge including unique and novel dimensions to dentistry.

Last but not the least, I feel delighted to underline the fact that prayers and support particularly from my beloved parents and my entire family played key role in helping me stand where I am today.

LIST OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF ABBREVIATIONS

IANB	Inferior Alveolar Nerve Block
IAN	Inferior Alveolar Nerve
PABA	Para-aminobenzoic Acid
PICO	Patient Population (P), Intervention (I), Comparison (C), Outcomes (O),
PRISMA	Preferred Reporting Items for Systematic Reviews
VAS	Visual Analogue Scale
MeSH	Medical Subject Headings
epi	epinephrine
levo	levonordefrin
VA	Vazirani-Akinosi
HP VAS	Heft-Parker visual analog scale
BL	Buccal-plus-lingual infiltrations
RCT	Randomized controlled/clinical trial
GGNB	Gow-Gates nerve block
GGMNB	Gow-Gates mandibular nerve block

I. INTRODUCTION

1. Background

Local anesthesia is a drug used to induce loss of sensation in a particular part of the body that results in nerve endings or obstruction of the peripheral nerve function (Covino and Vassallo, 1976). Dental anesthesia has been used in dentistry since the 19th century to reduce or minimize discomfort related to intrusive dental procedures (Malamed, 2004). The dentistry and pain are typically associated in the mindset of the patients, particularly those with periodontal disorders, with weak dentures owing to several extractions or symptomatic teeth that need endodontic treatment. Thus, dentists identify a successful anesthetic before the procedure that focuses solely on treatment, without interfering with patients' gestures. (Singh, 2012)

Unlike many anesthetic drugs, which act as depressants in the central nervous system, local anesthesia avoids nociceptive pulses, preventing the development of possible action in the central nervous system. Local anesthetics have unique essential features in common structurally. These include a lipophilic group that is connected by an amide or ester link to a carbon chain that is linked to a hydrophilic group in addition. Such amide or ester relations identify local anesthetics. (Singh, 2012)

The main difference in the predicted length of medical anesthesia is that dentists are usually utilizing specific anesthesia methods. Clinicians have consistently sought an anesthetic alternative, which can increase success rates well below one hundred percent in the posterior mandible in particular.(Claffey et al., 2004, Robertson et al., 2007, Michaud et al., 2018, Mikesell et al., 2005). Relevant details are placed at **Appendix-I** for ready reference.

1.1. Efficacy of Anesthesia

The local anesthesia provides patient and clinician comfort and the planned procedures can be carried out in the best possible way. Clinical experience and research have shown that local dental anesthesia is not always as successful as needed. (Nakai et al., 2000, Milles, 1984, AlHindi et al., 2016, Sanchis et al., 2003, Davoudi et al., 2016, Malamed, 2019, Malamed, 2004, Bahl, 2004). Research shows that there are no 100 percent achievements in terms of mandibular block failure rates. The success rate is far better based on research and clinical experience of local anesthesia in maxilla. In the maxilla, the most effective method would be a buccal infiltration anesthesia close to the level of the apices of the teeth, while in the mandible, local anesthesia is done primarily by attempting to inject a volume of local anesthetic along the mandibular nerve before it reaches the mandible. Due to anatomical variations in the location of the third branch of the trigeminal nerve with respect to the mandible ramus, the effectiveness of local anesthesia is not 100%.

Various clinical trials also measured the effectiveness of local anesthesia in clinical dentistry. Research has shown that lidocaine may be less effective than articaine. A recent study by da Silva-Junior et al. compared 4% articaine and 1:100,000 epinephrine to 2% lidocaine with the 1:100,000 epinephrine in combination with 'inferior alveolar nerve block (IANB)', which concluded that articaine is more effective than lidocaine in anesthetizing impacted third mandibular molars. (da Silva-Junior et al., 2017). The superiority of articaine to lidocaine in the oral-infiltration technique has also been suggested in similar studies.(Robertson et al., 2007, Srinivasan et al., 2009, Powell, 2012, Kanaa et al., 2006)

Some studies also found that the effectiveness of lidocaine and articaine in IANB is not differentiated. (Ram and Amir, 2006, Tong et al., 2018, Zhang et al., 2019) Hence, the lack of agreement on the clinical success of articaine anesthetic solutions supports the need to thoroughly review the clinical data available and to make recommendations for the suitable use of local anesthetic in clinical dentistry.

1.2. Safety of Anesthesia

In a study of 52 cases of paresthesia in Denmark, Hillerup and Jensen reported that 54 percent of the nerve injuries were linked with articaine use. The authors concluded that "when applied for the mandibular block anesthesia, the higher incidence of injection injury occurred more than 20 times during the two-year period mentioned". (Hillerup and Jensen, 2006). The patient typically experiences the paresthesia on the day of the dental procedure, once the symptoms of any local anesthetic have been overcome. Patients also note the occurrence of paresthesia a few days to months after the procedure on rare occasions. Just 5 per cent of the 60 cases of paresthesia recorded in a sample of 1377 third molar surgeries reflected delayed paresthesia (Kipp et al., 1980). The biggest difference between delayed paresthesia and classical paresthesia is that the former starts immediately after the treatment and there is no assurance of regeneration, while the latter happens gradually, with return to the original condition (Borgonovo et al., 2012).

In a review of two forty eight cases of paresthesia, 89 percent cases of lingual nerve, 7.3% of inferior nerve alveolar and 3.7 percent cases of both lingual nerve and inferior alveolar nerve injury are recorded after a local anesthesia for non-surgical dental procedures. These cases were reported 3.6 and 7.4 times higher among 4% articaine and 4% prilocaine drugs respectively, which suggested that parathesia of mouth is more frequent following the use of local anesthetics.(Garisto et al., 2010) In retrospective analysis of paresthesias cases from 1999 to 2008, showed articaine solutions with higher concentration were significantly with higher complication rates. (Gaffen and Haas, 2009).

Allergicity is another question about local dental anesthesia. As a result of allergic reactions, the most common local ester anesthetics like procaine or novocaine has historically been withdrawn from the U.S. market. “Paraminobenzoic acid (PABA) compounds” are local anesthetic formulations called esters, which generate immune sensitivity. (Becker and Reed, 2006)

Hematoma is also a complication related to local anesthesia. Hematoma is triggered by a needle invasion of the artery or by an intravascular injection that induces damage to the affected vessel of blood. Trauma contributes to bleeding into the tissue, and hematoma development (14). Anesthetic penetration to the orbital region can also cause ocular paralysis and temporary blindness.(Meechan and Rood, 1997)

In the pterygomandibular area, trismus after anesthesia is usually caused by intramuscular injection of anesthetics. It can even occur 2–5 days after inferior anesthesia of the alveolar block. Needle fracture insertion into the styloid process can cause painful and severe trismus. It usually disappears within a few days, without further treatment being required.(Dhanrajani and Jonaidel, 2002, Meechan and Rood, 1997)

1.3. Conventional IANB

Scientists and physicians worldwide have been identifying the modern IANB as the most widely employed tool for decades. On the opposite, the syringe on the other side of the premolars hits the nerve. The insert point is 5 mm along a line that divides the nail of finger with a finger resting on the deepest point of ramus. The tissues will be extended and compressed for atraumatic needle use. The penetration length is between 20-25 mm until the bone is struck, removed and aspirate if negative-inject. (Malamed, 2014). Figure 1a and 1b placed at **Appendix-II**, show the points of reference for injection (Monheim and Bennett, 1984).

1.4. Failure of IANB

There are number of reasons associated with the failure of the IANB as enunciated hereunder:

1.4.1 Anxiety

Serious patient anxiety and fear are often the main causes for failure in anesthesia. With respect to the neurophysiological viewpoint, the person may experience intense or perceived discomfort (Haas, 2011a, Khoury et al., 2011, Kaufman et al., 1984) even if nerve conduction is interrupted.

1.4.2 Accessory innervations

A plexus of the nerves is given for the mandibular soft tissue and hard tissue. Even if the IAN is blocked, this plexus will permit sensation. In 10-20% of the instances, mylohyoid nerve provides mandibular molars with associated innervation.

1.4.3 Anesthetic solutions

There have been many new formulations introduced but the IANB failure remains unchanged. No significant difference was observed. (Hinkley et al., 1991)

1.4.4 Volume of anesthetic solutions

Franz and Perry related the differential level of blocking between myelinated axons to a disparity in essential lengths of axons, which must be exposed to the blocking concentration, as to a specific minimum concentration needed to block axons of various sizes (Franz and Perry, 1974). At the very least 6 mm of the nerve must be revealed in order to induce blockade. The extensive inter-nodal length of the inferior alveolar nerve is 1.8 mm. A total of 2.0 mL of solution must be deposited to produce a successful block. (Monheim and Bennett, 1984) Studies show, though, that 1.0 mL is the active quantity that cannot be assumed to succeed (Rood, 1977).

1.4.5 Bifid mandibular canal

A bifid mandibular canal is an anatomical variant of the mandibular canal which means the division of the mandibular canal into two parts. A bundle of neurovascular canals can be found in different forms for every branched canals. Studies have shown that 0.35 percent of bifid mandibular canals occur. (Sanchis et al., 2003) The lack of one of the canals will contribute to ineffective or incomplete anesthesia. (Figure 2 placed at **Appendix-II** refers)

1.4.6 Inflammation and other related conditions in the trunk

During anesthesia, pulp and abscess inflammation are a major problem for endodontologists.(Modaresi et al., 2016) Researches have shown variation in the impulse production of nerve fibers attributable to inflammation in rabbits. Some studies suggest also variations in the presence of inflammation in peripheral sensory fibre.(Lundy and Linden, 2004, Traeger, 1979, Strichartz, 1976) Nevertheless question arises as to how the entire conduction of sensory fibers by an inflamed pulp can influence? Wallace responded that the whole neuron cell membrane will be impaired by activation of the tissue's resting membrane potential once the tissue becomes inflamed.(Wallace et al., 1985)

Conceptual details about Inferior Alveolar Nerve Block (IANB), Irreversible Pulpitis and Asymptomatic versus Symptomatic Irreversible Pulpitis are place at **Appendix-III** for reference**.**

1.5 Alternative Techniques for IANB

In 1884, the first neuroregional anesthesia in the jawbone was performed by infusion of a cocaine solution in the area of the mandibular foramen by William S. Halsted and Richard J. Hall. (Johnson et al., 2007) Different techniques for anesthetizing the mandibular or the IAN, linguistic and oral nerves were considered because of the problems and deficiencies found with IANB. (Todorović et al., 1986) Namely,

- Conventional IANB
- IANB described by Malamed SF
- Gow-Gates mandibular nerve block
- Vazirani/Akinosi block (Closed mouth block)
- Fischer 1.2.3 IANB

The conventional IANB is the most widely employed method for local anesthesia in mandibular surgery. In some instances, though, even the most experienced clinician lacks this nerve block. Sadly the rate of failure in this block is fairly high (15% to 20%). The failure rate of this conventional IANB was estimated by certain authors to be around 20% to 25%.(Dover, 1971).

In this procedure, the vertical line delineation is not very precise between two-thirds and three-quarters length between posterior boundary and coronoid notch and provides a substantial margin for error.(Quinn, 1998) It has been difficult to identify and implement clinically by beginners, which could lead to failure, to pick the location of initial needle entry as well as anatomical landmarks identified by Malamed. (Thangavelu et al., 2012)

A delayed induction of anesthesia is a recognized downside of the Gow-Gates method. The Gow-Gates technique was declared by Malamed (Malamed, 1981) to be latency 5 to 7 min. The latency of the central incisor was reached inside 10 to 12 minutes, according to Levy (Levy, 1981). The latency can be from 8 to 45 min according to Agren and Danielson (Agren and Danielsson, 1981). Malamed has further indicated that if new dental surgeons perform the Gow-Gates procedure, it can trigger more errors and injuries than standard techniques (Malamed, 1981).

1.5.1 Gow-Gates technique

This technique is mainly indicated in patients undergoing dental procedures in whom inferior alveolar nerve block does not provide adequate analgesia owing either to anatomical variation or due to accessory nerve supply. This approach provides true mandibular nerve block as it blocks the trunk of the nerve before it divides into its three main terminal branches. The incidence of intravascular injection is also lesser with this approach. A disadvantage of this approach is that there is undesired anesthesia of the lower lip and temporal region. The onset time of the block is also prolonged.

The patient is placed in a semisupine position or on a dental chair with the operator standing on the same side as the block to be performed. The mouth is opened as wide as possible. This is essential for the success of this block. Anatomic landmarks include the following:

- Corner of the mouth
- The intertragic notch
- Distolingual cusp of the second maxillary molar tooth

The aim is to reach the neck of the mandibular condyle. The second maxillary molar tooth is identified, and a needle is inserted at the level of the mesiolingual cusp along the medial side of the mandibular ramus. The point of insertion is much higher than that for an inferior alveolar nerve (IAN) block. The needle is inserted in such a way that it lies parallel to an imaginary line drawn from the intertragic notch to the angle of the mouth.

The needle is advanced by 2.5 cm so as to contact the bony neck of the mandibular condyle. It is then slightly withdrawn, and negative aspiration is confirmed in 2 planes. Finally, 1.8 mL of local anesthetic is injected slowly over 1 minute. This blocks the IAN and its branches and the lingual, mylohyoid, auriculotemporal, and buccal nerves. The points for placement of needle for the Gow-Gates technique are shown in Figures 3, 4 & 5 placed at **Appendix-II.**

The relevant details about Vazirani/Akinosi block (Closed mouth block) and Fischer 1.2.3 IANB and further amplifying details about **Gow-Gates** techniques are placed at **Appendix – IV** for ready reference

1.5.2 Irreversible Pulpitis with the Gow-Gates Injections & IANB

The ability to achieve and sustain adequate pulpal anesthesia is vital before any endodontic operation is performed. It helps to reduce patient discomfort and increases operator satisfaction and effectiveness.

The nociceptor is triggered by pH variations or mild temperature in inflamed pulp as their function varies through inflammatory mediators (kinins and prostaglandins). The consequence of the pain is the detection and distribution of A and C Delta fibers (Ikeda et al., 1997). Therefore, pain is substantially higher during irreversible pulpitis.

Mandible has a nonporous and dense cortical outer layer, and therefore usually requires a nerve block to be used at a site away from the teeth being treated. (Haas, 2011a) The anesthetic failure rate is 8 times higher in irreversible pulpitis as compared to normal. (Owatz et al., 2007) The occurrence of mechanical-allodynia is 57.2 percent for patients with irreversible pulpitis. The diagnosis of the root canal with irreversible pulpits teeth in comparison to teeth with healthy and necrotic pulp was significantly more severe when contrasted to mechanical allodynia decreased physical pain threshold. (Owatz et al., 2007)

In the study by Aggarwal et al. found the Gow-Gates procedure better than conventional IANB in patients presenting with irreversible pulpitis. The Gow-Gates success was reported as 52 percent and conventional IANB as 36 percent respectively. (Aggarwal et al., 2010)

Hence, multiple studies has been conducted which showed varying results in the anesthetic efficacy of Gow-Gates and IANB procedures in patients presenting with irreversible pulpits. Therefore the goal of the present systematic review is to extract the available data and provide valid evidence regarding the use of Gow-Gates and IANB procedures in patients presenting with irreversible pulpits. All trials regarding the utilization of these techniques in dentistry that meet the developed inclusion criteria will be analyzed. Hence, clinical recommendations will also be generated on the basis of results.

1.5.3 Complications

If a large volume of the local anesthetic is administered or an inadvertent intravascular injection has taken place, the patient may manifest a systemic toxic response to the local anesthetic used. This may involve minimal to moderate symptoms (eg, anxiety, numbness, dizziness, weakness, and tremors), but in some cases, it can result in central nervous system (CNS) and cardiovascular collapse.

An allergic reaction may develop to the preservatives added to the local anesthetic (eg, methylparaben or sodium metabisulfite) or to an ester-group local anesthetic. Persistent paresthesia and numbness may be due to trauma to the nerve or local hematoma formation.

Needle-track infection is possible. This can be avoided by employing single-use syringes and needles, using disinfectants, and avoiding areas with active infection.

Hematoma formation is possible. Edema and sloughing of tissues, although rare, can occur.(Haas DA. Alternative mandibular nerve block techniques: a review of the Gow-Gates and Akinosi-Vazirani closed-mouth mandibular nerve block techniques. J Am Dent Assoc. 2011 Sep. 142 Suppl 3:8S-12S)

Hence, various approaches have their advantages and limitations. Therefore, during the treatment of the nerve block, dentists should therefore choose the highly appropriate technique with patient interest.

1.6. Aims & Objectives

- To systematically review researches on the anesthetic efficacy of Gow-Gates versus inferior alveolar nerve block for irreversible pulpitis.
- To compare the outcomes of Gow-Gates and inferior alveolar nerve block for irreversible pulpitis.

II. DEVELOPMENT

2. Main Goal

Multiple studies have been conducted in the past which showed varying results in the anesthetic efficacy of Gow-Gates and IANB procedures in patients presenting with irreversible pulpits. Therefore the main goal of this present descriptive systematic review of quantitative researches is to extract the available data and provide valid evidence regarding the use of Gow-Gates and IANB procedures in patients presenting with irreversible pulpits. All trials regarding the utilization of these techniques in dentistry that meet the developed inclusion criteria were analyzed. Hence, clinical recommendations was generated on the basis of results.

2.1 Methodology of Review

The "Preferred Reporting Items for Systematic Reviews (PRISMA)" was adopted for the current review. (Moher et al., 2009, Shamseer et al., 2015)

2.2 Formulation of Research Question and Keywords Selection

A PICO [Patient Population (P), Intervention (I), Comparison (C), and Outcomes (O)] approach was used to structure and respond to a research question. It was found that higher precision can be achieved through the use of PICO templates and the relevance of search results can therefore also be improved. (Schardt et al. 2007).

PICO criteria for research question was: "Is Gow-Gates technique (I) has better anesthetic efficacy (O) as compared to IANB (C) for patients with irreversible pulpitis (P)"? According to this research question following keywords and Medical subject headings (MeSH) were used for the search**: "**Inferior alveolar nerve block, mandibular block, anesthetic success, anesthetic efficacy, Gow-Gates, pulpitis, irreversible pulpitis, acute pulpitis, and mandibular posterior teeth. Both spellings of "anaesthesia" and "anesthesia" and were searched separately**"**

2.3 Search Strategy

The literature search was done on PubMed, Cochrane library and Ovid Medline. The keywords and MeSH terms were searched individually and combined along with Boolean operators (AND, OR and NOT) to identify need of this review. Hence there was no systematic review was found specifically on this question, which further enhance and justify this review. The search for the selection of study was carried on Dec 1-7, 2019.

2.4 Inclusion Criteria

Following selection criteria was applied:

- **Population:** Patients of age more than 9 years of either gender with irreversible pulpitis.

- **Language:** Articles published in English from all around the world regarding conventional IANB or IANB and Gow-Gates techniques.
- **Timeline:** Articles published between the duration of 2009-2019 as approved vide final work proposal.
- **Study characteristics:** Prospective; randomized clinical trials or randomized controlled trials were included.
- **Outcome:** Articles were included in which anesthetic efficacy or success was measured.

2.5 Exclusion Criteria

Following was the exclusion criteria for the present review;

- Animal studies
- Gray literature
- Cross-sectional study
- Case control
- Cohort studies
- Unpublished data
- Commentaries and Conference papers
- Case report and case series
- Policy and guidelines.
- Review articles
- Meta-analysis

2.6 Study selection process

A total of six studies on Cochrane, sixteen studies on PubMed/Medline, two on Ovid and eighty seven studies on Google scholar were primarily identified. After removal of the duplicates (n=111), preliminary screening of titles and abstracts was done, and 103 studies were excluded because they were not meeting the eligibility criteria.

Those excluded studies were systematic reviews, meta-analysis, case-series, case reports, animal studies, cross-sectional studies, unpublished and gray literature and clinical guidelines and comparative studies on techniques other than Gow-gates and IANB, articles on premedication effects & anesthesia dosage. A total of 8 articles were selected for full-text reading. Of these 8 studies, 3 studies were further excluded because focused question was not answered in it as they were focusing on third molar impaction. At final stage, five articles were included. Flow chart of study selection process is placed at **Appendix-V** for ready reference

2.7 Quality assessment Tool

The "Cochrane Risk of Bias Tool for Randomized Controlled Trials" was used to assess the quality of included studies. If all criterions were matched (low for every domain) then study was labelled as "good". If one criteria was not matched (high risk for anyone domain) then study was labelled as fair and if two or more criteria were not matched (high risk or unclear in more than two domains) then study was graded as poor. (Page et al., 2018)

2.8 Results

After retaining articles following scanning of title, abstract and full text, five studies were successfully found and included in the systematic review. These studies are categorized as randomized clinical trial and these studies included patients with irreversible pulpitis. The list and detailed description of all the five studies including their detailed characteristics viz-a-viz quality analysis are placed at **Appendix-VI** for ready reference.

2.9 Characteristics of the included studies

The characteristics of the studies included in the current review has been displayed in table 1. Two studies (Study 2 & 5) have compared GGNB and IANB techniques, one study has compared GGNB, VA, BL and IANB techniques (Study 1), one study has compared GGNB, IANB and GGNB+IANB techniques (Study 3) and one study has compared GGNB, VA and IANB with buccal infiltration and conventional IANB techniques (Study 4). Total number subjects randomized were 558. Four studies have included both male and female patients and one study hasn't specified any gender. The age range of the 3 included studies (Study 1, 2 and 5) is 10-50 years, whereas in study 3 the upper limit of age isn't mentioned and in study 4 average age as 30 years has been reported. All the included studies in the current review has been published between 2010 and 2019. Out of 5 studies, 4 studies (study 1, 2, 4 and 5) showed GGNB has high anesthetic efficacy than IANB and only one study (study 3) showed insignificant difference between anesthetic efficacy of GGNB and IANB.

2.10 Quality assessment of included studies

The quality of included studies was assessed using "Cochrane Risk of Bias Tool for Randomized Controlled Trials (ROB)". The overall evaluation of the reviewed studies is good to poor, some have a high risk of bias and some have inappropriate methodology and a low reporting quality. The cardinal characteristics of these studies is presented in table 2. Among the 5 included studies, 2 studies (study 3 and 5) were of low ROB, 2 studies (study 2 and 4) showed high ROB and 1 study (study 1) showed some concerns.

TABLE 1: CHARACTERISTICS OF INCLUDED STUDIES

ITEM	STUDY				
	1	2	3	4	5
AUTHOR	Aggarwal et al	Ghoddusi J et al.	Saatchi M et al.	Sharma R et al.	Afridi R et al.
YEAR OF PUBLICATION	2010	2018	2018	2018	2019
METHODS / STUDY DESIGN	Double-blinded, prospective randomized controlled trial	A parallel-grouped, randomized, double-blind clinical trial	A randomized clinical trial, prospective study	A randomized clinical study	A randomized controlled trial
NO. OF GROUPS	4	2	3	4	2
SAMPLE SIZE	102 subjects, assigned into four groups: Gp#1=27, Gp#2=26, Gp#3=25 & Gp#4=24	80 subjects, assigned into two groups: Gp#1=40 & Gp#2=40	150 subjects, assigned into three groups: Gp#1=50, Gp#2=50 & Gp#3=50	120 subjects, assigned into two groups: Gp#1=30, Gp#2=30, Gp#3=30 & Gp#4=30	106 subjects, assigned into two groups: Gp#1=53 & Gp#2=53
AGE RANGE	21-32 years	18-50 years	More than 18 years	Average age 30 year	10-45 year
GENDER	Both male & female	Not mentioned	Both male & female	Both male & female	Both male & female
INTERVENTION	GGNB, VA, BL and IANB techniques	GGNB and IANB techniques	GGNB, IANB and GGNB+IANB techniques	GGNB, VA and IANB with buccal infiltration and conventional IANB techniques	GGNB and IANB techniques
OUTCOME ASSESSMENT SCALE	The pain was assessed by using “Heft-Parker visual analog scale”. The anesthetic success was noted as “none” or “weak/mild” pain	The pain was assessed by using “Visual analog scale”. VAS score 1-3 was labelled as mild pain, 4-6 as moderate, 7-9 as severe pain and 0 as no pain	The pain was assessed by using “HP-VAS”. The anesthesia success was described as the HP-VAS scores “0” without pain or with mild pain “1-54 mm”	The pain was assessed by using “Heft-Parker visual analog scale”. The pain scale was classified into four categories that “0” for no pain, “1-54 mm” as “faint, weak, or mild pain”, “55-114 mm” as “moderate pain” and “114 mm” as “strong, intense, and maximum possible pain”	The pain was assessed by using “VAS”. The score of “0” was labelled as “No pain”, 0-4 was labelled as “Mild pain”, 4-7 was labelled as “moderate pain” and >7 was defined as “Severe pain”
ANESTHETIC EFFICACY (GGNB VS IANB)	52% vs 36%	50% vs 42.5%	40% vs 44%	66.7% vs 46.7%	85% vs 72%

TABLE 2: QUALITY ASSESSMENT OF THE INCLUDED STUDIES

STUDY NO.	AUTHOR	YEAR	BIAS ARISING FROM THE RANDOM-IZATION PROCESS	BIAS CAUSED BY DEVIATIONS FROM INTENDED INTERVENE-TIONS	BIAS CAUSED BY MISSING OUTCOME DATA	BIAS IN MEASUREM-ENT OF THE OUTCOME	BIAS IN SELECTION OF THE REPORTED RESULT	OVERALL BIAS
1	Aggarwal et al	2010	+	?	+	+	+	?
2	Ghoddusi J et al.	2018	+	-	+	+	+	-
3	Saatchi M et al.	2018	+	+	+	+	+	+
4	Sharma R et al.	2018	+	-	+	-	+	-
5	Afridi R et al.	2019	+	+	+	+	+	+

Legend:

+ Low risk of bias; ? Some concerns; - High risk of bias

III. DISCUSSION

3.1 Summary of the Key findings

The results of the five studies that are reviewed establish that anesthetic efficacy of Gow-Gates nerve block technique is better than IANB technique for irreversible pulpitis. However, the overall quality of the literature assessed is fair to poor. Three studies are randomized clinical trial and two randomized controlled trial. The randomized controlled trial studies are; Aggarwal et al, 2010, Ghoddusi J et al. 2018 and Afridi et al. 2019 and randomized clinical trial are Saatchi M et al. 2018 and Sharma R et al. 2018. The validity and reliability of the studies included is appropriate. This is due to the appropriate study design and accuracy of the study in measuring the efficacy of the selected anesthetic techniques. There is lack of knowledge regarding allocation, concealment and blinding of the interventions. The details of allocation have not been mentioned by most researchers, leading to ambiguous results.

The existing literature provides enough evidence to set Gow-Gates nerve block as a benchmark. The policy guidelines for Gow-Gates nerve block for irreversible pulpitis, however, should be developed to enable dental surgeons or dentists to develop appropriate support strategies. It recommends dentist training to use suitable anesthetic technique. The exhaustive search for literature, the explicit selection criteria used and the validity evaluation of the included trials show a thoroughness and a systematic approach to the conclusion reached.

Three studies used "Visual Analog Scale Heft-Parker" for pain assessment and two studies used "Visual Analog Scale" for pain assessment. Studies by Aggarwal et al., 2010, Ghoddusi J et al. 2018, Saatchi M et al. 2018 and Sharma R et al. 2018 included patients over 18 years of age, while Afridi R et al. 2019 included patients between 10 and 45 years of age, making the outcome less generalizable to the pediatric population. Regarding infants, though, a standardized rating system should be established for the effectiveness of anesthetic techniques in dental procedures. Improving the quality of randomized controlled / clinical trials is also significant, particularly in the areas of blinding, allocation and concealment, failure and intention to treat analysis. Elaborated details pertaining to the key findings are placed at **Appendix VII** for ready reference.

3.2 Strengths of the Review

This review is unique and the first of its kind, no descriptive systematic reviews were found on anesthetic efficacy of Gow-Gates nerve block and inferior alveolar nerve block. The process of extracting literature is rigorous and assessed against criteria of inclusion to reduce bias. This review highlights facts and gives sufficient evidence that Gow-Gates nerve block is superior technique than IANB.

The Gow-Gates technique for mandibular anesthesia has been in use since 1947 and was first published in 1973.

Comparative studies by a variety of authors have given credibility to the technique by showing that it is predictable, accurate, simple, and safe to use. The technique has a very high success rate, has minimal toxic effects, shows very low positive blood aspiration, and is used without vasoconstrictors. Unlike the conventional inferior alveolar technique, and provided the mouth is fully opened, the Gow-Gates technique allows for the deposition of the anesthetic solution in the relatively avascular region at the neck of the condyle. The needle pathway is substantiated by geometrical and mathematical analysis which removes any doubt as to the validity of the technique. The clinician is now provided with a different conception of mandibular block anesthesia.

Possibilities of inadvertent intravascular delivery of local anesthetic is always there. Delivering of local anesthetic inside the blood vessel results in the systemic side effects and failure of anesthesia as not enough local anesthetic is available to act on the nerve. In Gow-Gate technique the vascular areas located near the site of injection include the internal maxillary artery and pterygoid plexus of vein. If the needle is placed at the recommended spot in contact of neck of the condyle and then only the solution is deposited, the possibilities of inadvertent intravascular injection can be completely eliminated.

According to the findings of Fanyuan Yu et al. 2017 they found lower rate of positive aspiration in Gow-Gate technique as compared to Inferior dental technique. Hence likelihood of vascular accidents is lesser. Animesh Barodiya et al. 2017 reported positive aspiration in the Gow-Gate technique owing to puncturing of the internal maxillary or middle meningeal artery.

The rate of positive aspiration for standard technique was found to be 10-15%. Abbas Haghighat et al. 2015 stated in his clinical study of comparison of success rate and onset time of two different anesthesia techniques found that the onset of anesthesia depends on closeness of approximation of the nerve blocking drugs to the related nerve trunk.

3.3 Limitation of the Review:

There is a limited literature on the research topic. Nevertheless, the word "irreversible pulpitis" is not widely used in existing literature, it has been difficult to search for literature and there is a risk of inconsistency or omission of some significant studies. Articles written in English were one of the criteria that could once again be a potential limitation. Resource shortages in terms of lack of full text available for some other studies.

IV. CONCLUSION

The results of the five studies that are reviewed establish that anesthetic efficacy of Gow-Gates nerve block technique is better than IANB technique for irreversible pulpitis. Nonetheless, buccal and lingual infiltration is also important to subside the pain along with regional block. In a nutshell, due vast blockage of nerve system in Gow gates technique, the anesthetic technique is quite superior but infiltration, type of anesthesia, age of the patient, and systemic diseases do play a role and somehow affect the ability of pain to subside. However, the overall quality of the literature assessed is fair to poor.

Ideally, students of dentistry should be taught all techniques for mandibular anesthesia. However, the use of all techniques in practice does not necessarily follow, possibly because the alternative techniques are not familiar to the faculty that supervises pre-doctoral clinical dentistry. While learning new techniques is difficult for dentists who are already in practice, the challenge is worth it because the benefits are substantial. Dentists who are not confident using these alternate mandibular nerve blocks such as Gow-Gates should be encouraged to take classes on local anesthetic strategies.

V BIBLIOGRAPHY

AFRIDI, R., SHAH, S. A., KHATTAK, I. U. J., SHAH, F. A., ZAIN, M. & ALI, F. 2019. COMPARISON OF ANESTHETIC EFFICACY OF CONVENTIONAL INFERIOR ALVEOLAR NERVE BLOCK AND GOW GATES TECHNIQUE IN PATIENTS WITH SYMPTOMATIC IRREVERSIBLE PULPITIS-RANDOMIZED CONTROL TRAIL. *Cell*, 333**,** 3277356.

AGGARWAL, V., JAIN, A. & KABI, D. 2009. Anesthetic efficacy of supplemental buccal and lingual infiltrations of articaine and lidocaine after an inferior alveolar nerve block in patients with irreversible pulpitis. *Journal of Endodontics*, 35**,** 925-9.

AGGARWAL, V., SINGLA, M. & KABI, D. 2010. Comparative evaluation of anesthetic efficacy of Gow-Gates mandibular conduction anesthesia, Vazirani-Akinosi technique, buccal-plus-lingual infiltrations, and conventional inferior alveolar nerve anesthesia in patients with irreversible pulpitis. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, 109**,** 303-308.

AGREN, E. & DANIELSSON, K. 1981. Conduction block analgesia in the mandible. A comparative investigation of the techniques of Fischer and Gow-Gates. *Swedish dental journal*, 5**,** 81-89.

ALHINDI, M., RASHED, B. & ALOTAIBI, N. 2016. Failure rate of inferior alveolar nerve block among dental students and interns. *Saudi Med J*, 37**,** 84-9.

BAHL, R. 2004. Local anesthesia in dentistry. *Anesthesia progress*, 51**,** 138.

BARODIYA A, THUKRAL R, AGRAWAL SM, RAI A, SINGH S. Temporary Blindness after Inferior Alveolar Nerve Block. Journal of Clinical and Diagnostic Research. 2017; 11: ZD24-ZD25

BECKER, D. E. & REED, K. L. 2006. Essentials of local anesthetic pharmacology. *Anesthesia progress*, 53**,** 98-110.

BORGONOVO, A., BIANCHI, A., MARCHETTI, A., CENSI, R. & MAIORANA, C. 2012. An uncommon clinical feature of IAN injury after third molar removal: a delayed paresthesia case series and literature review. *Quintessence Int*, 43**,** 353-9.

BORONAT LÓPEZ, A. & PEÑARROCHA DIAGO, M. 2006. Failure of locoregional anesthesia in dental practice. Review of the literature. *Medicina oral, patologia oral y cirugia bucal*, 11**,** E510-E513.

BRANDT, R. G. 2010. Efficacy of Local Anesthetics in Clinical Dentistry: A Systematic Review and Meta-analysis.

BREMER, G. 1952. Measurements of special significance in connection with anesthesia of the inferior alveolar nerve. *Oral surgery, oral medicine, and oral pathology*, 5**,** 966-988.

CHEVALIER, V., ARBAB-CHIRANI, R., TEA, S. H. & ROUX, M. 2010. Facial palsy after inferior alveolar nerve block: case report and review of the literature. *International journal of oral and maxillofacial surgery*, 39**,** 1139-1142.

CHOI, E.-H., SEO, J.-Y., JUNG, B.-Y. & PARK, W. 2009. Diplopia after inferior alveolar nerve block anesthesia: report of 2 cases and literature review. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, 107**,** e21-e24.

CHRISTENSEN, G. J. 2001. *Clinicians Report - English.* [Online]. Available: http://www.cliniciansreport.org/node/3392.

CLAFFEY, E., READER, A., NUSSTEIN, J., BECK, M. & WEAVER, J. 2004. Anesthetic efficacy of articaine for inferior alveolar nerve blocks in patients with irreversible pulpitis. *Journal of endodontics*, 30**,** 568-571.

COHEN, H. P., CHA, B. Y. & SPÅNGBERG, L. S. 1993. Endodontic anesthesia in mandibular molars: a clinical study. *Journal of endodontics*, 19**,** 370-373.

COVINO, B. G. & VASSALLO, H. G. 1976. *Local Anesthetics: Mechanics of Action and Clinical Use*, Grune & Stratton.

DA SILVA-JUNIOR, G. P., DE ALMEIDA SOUZA, L. M. & GROPPO, F. C. 2017. Comparison of Articaine and Lidocaine for Buccal Infiltration After Inferior Alveolar Nerve Block For Intraoperative Pain Control During Impacted Mandibular Third Molar Surgery. *Anesth Prog*, 64**,** 80-84.

DAVOUDI, A., RISMANCHIAN, M., AKHAVAN, A., NOSOUHIAN, S., BAJOGHLI, F., HAGHIGHAT, A., ARBABZADEH, F., SAMIMI, P., FIEZ, A., SHADMEHR, E., TABARI, K. & JAHADI, S. 2016. A brief review on the efficacy of different possible and nonpharmacological techniques in eliminating discomfort of local anesthesia injection during dental procedures. *Anesth Essays Res*, 10**,** 13-6.

DHANRAJANI, P. J. & JONAIDEL, O. 2002. Trismus: aetiology, differential diagnosis and treatment. *Dent Update*, 29**,** 88-92, 94.

DOVER, W. 1971. The mandibular block injection--why it sometimes fails. *Oral health*, 61**,** 12.

ETHUNANDAN, M., TRAN, A. L., ANAND, R., BOWDEN, J., SEAL, M. T. & BRENNAN, P. A. 2007. Needle breakage following inferior alveolar nerve block: implications and management. *British dental journal*, 202**,** 395-397.

FRANZ, D. N. & PERRY, R. S. 1974. Mechanisms for differential block among single myelinated and non-myelinated axons by procaine. *The Journal of physiology*, 236**,** 193-210.

FULLMER, S., DRUM, M., READER, A., NUSSTEIN, J. & BECK, M. 2014. Effect of preoperative acetaminophen/hydrocodone on the efficacy of the inferior alveolar nerve block in patients with symptomatic irreversible pulpitis: a prospective, randomized, double-blind, placebo-controlled study. *Journal of endodontics*, 40**,** 1-5.

GAFFEN, A. S. & HAAS, D. A. 2009. Retrospective review of voluntary reports of nonsurgical paresthesia in dentistry. *Journal (Canadian Dental Association)*, 75**,** 579-579.

GARISTO, G. A., GAFFEN, A. S., LAWRENCE, H. P., TENENBAUM, H. C. & HAAS, D. A. 2010. Occurrence of paresthesia after dental local anesthetic administration in the United States. *Journal of the American Dental Association (1939),* 141**,** 836-844.

GHODDUSI, J., ZARRABI, M. H., DANESHVAR, F. & NAGHAVI, N. 2018. Efficacy of IANB and Gow-Gates Techniques in Mandibular Molars with Symptomatic Irreversible Pulpitis: A Prospective Randomized Double Blind Clinical Study. *Iranian endodontic journal,* 13**,** 143-148.

GOW-GATES, G. & WATSON, J. E. 1989. Gow-Gates mandibular block--applied anatomy and histology. *Anesth Prog,* 36**,** 193-5.

GOW-GATES, G. A. 1973. Mandibular conduction anesthesia: a new technique using extraoral landmarks. *Oral surgery, oral medicine, and oral pathology,* 36**,** 321-328.

HAAS, D. A. 2011a. Alternative mandibular nerve block techniques: a review of the Gow-Gates and Akinosi-Vazirani closed-mouth mandibular nerve block techniques. *J Am Dent Assoc,* 142 Suppl 3**,** 8s-12s.

HAAS, D. A. 2011b. Alternative mandibular nerve block techniques: a review of the Gow-Gates and Akinosi-Vazirani closed-mouth mandibular nerve block techniques. *Journal of the American Dental Association (1939),* 142 Suppl 3**,** 8S-12S.

HAGHIGHAT A1, JAFARI Z, HASHEMINIA D, SAMANDARI MH, SAFARIAN V, DAVOUDI A Comparison of success rate and onset time of two different anesthesia techniques.Med Oral Patol Oral Cir Bucal. 2015 Jul 20

HE, Y. & CHEN, J. 2012. Aphonia induced by block anesthesia of inferior alveolar nerve: a case report. *Hua xi kou qiang yi xue za zhi = Huaxi kouqiang yixue zazhi = West China journal of stomatology,* 30**,** 103-108.

HILLERUP, S. & JENSEN, R. 2006. Nerve injury caused by mandibular block analgesia. *International journal of oral and maxillofacial surgery,* 35**,** 437-443.

HINKLEY, S. A., READER, A., BECK, M. & MEYERS, W. J. 1991. An evaluation of 4% prilocaine with 1:200,000 epinephrine and 2% mepivacaine with 1:20,000 levonordefrin compared with 2% lidocaine with:100,000 epinephrine for inferior alveolar nerve block. *Anesthesia progress,* 38**,** 84-89.

IANIRO, S. R., JEANSONNE, B. G., MCNEAL, S. F. & ELEAZER, P. D. 2007. The effect of preoperative acetaminophen or a combination of acetaminophen and Ibuprofen on the success of inferior alveolar nerve block for teeth with irreversible pulpitis. *Journal of endodontics,* 33**,** 11-14.

IKEDA, H., TOKITA, Y. & SUDA, H. 1997. Capsaicin-sensitive A delta fibers in cat tooth pulp. *J Dent Res,* 76**,** 1341-9.

INGLE, J. I., BAKLAND, L. K. & BAUMGARTNER, J. C. 2008. *Ingle's endodontics 6,* Pmph usa.

JOFRÉ, J. & MÜNZENMAYER, C. 1998. Design and preliminary evaluation of an extraoral Gow-Gates guiding device. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics,* 85**,** 661-664.

JOHANSEN, O. 2004. Comparison of articaine and lidocaine used as dental local anesthetics. *Project Thesis,* 10.

JOHNSON, T. M., BADOVINAC, R. & SHAEFER, J. 2007. Teaching alternatives to the standard inferior alveolar nerve block in dental education: outcomes in clinical practice. *Journal of dental education,* 71**,** 1145-1152.

KAFALIAS, M. C., GOW-GATES, G. A. & SALIBA, G. J. 1987. The Gow-Gates technique for mandibular block anesthesia. A discussion and a mathematical analysis. *Anesth Prog,* 34**,** 142-9.

KANAA, M. D., MEECHAN, J. G., CORBETT, I. P. & WHITWORTH, J. M. 2006. Speed of injection influences efficacy of inferior alveolar nerve blocks: a double-blind randomized controlled trial in volunteers. *Journal of endodontics,* 32**,** 919-923.

KAUFMAN, E., WEINSTEIN, P. & MILGROM, P. 1984. Difficulties in achieving local anesthesia. *Journal of the American Dental Association (1939),* 108**,** 205-208.

KHOURY, J. N., MIHAILIDIS, S., GHABRIEL, M. & TOWNSEND, G. 2011. Applied anatomy of the pterygomandibular space: improving the success of inferior alveolar nerve blocks. *Australian dental journal,* 56**,** 112-121.

KIPP, D. P., GOLDSTEIN, B. H. & WEISS, W. W., JR. 1980. Dysesthesia after mandibular third molar surgery: a retrospective study and analysis of 1,377 surgical procedures. *J Am Dent Assoc,* 100**,** 185-92.

KOHLER, B. R., CASTELLÓN, L. & LAISSLE, G. 2008. Gow-Gates technique: a pilot study for extraction procedures with clinical evaluation and review. *Anesth Prog,* 55**,** 2-8.

LEVY, T. P. 1981. An assessment of the Gow-Gates mandibular block for third molar surgery. *Journal of the American Dental Association (1939),* 103**,** 37-41.

LINDEMANN, M., READER, A., NUSSTEIN, J., DRUM, M. & BECK, M. 2008. Effect of sublingual triazolam on the success of inferior alveolar nerve block in patients with irreversible pulpitis. *Journal of endodontics,* 34**,** 1167-1170.

LUNDY, F. T. & LINDEN, G. J. 2004. Neuropeptides and Neurogenic Mechanisms in Oral and Periodontal Inflammation. *Critical Reviews in Oral Biology & Medicine,* 15**,** 82-98.

MALAMED, S. 2014. Handbook of local anesthesia: Elsevier Health Sciences.

MALAMED, S. F. 1981. The Gow-Gates mandibular block. Evaluation after 4,275 cases. *Oral surgery, oral medicine, and oral pathology,* 51**,** 463-467.

MALAMED, S. F. 2004. *Handbook of local anesthesia,* Elsevier Health Sciences.

MALAMED, S. F. 2007. Articaine versus lidocaine: the author responds. *Journal of the California Dental Association,* 35**,** 383-385.

MALAMED, S. F. 2012. Handbook of Local Anesthesia, 6e.
MALAMED, S. F. 2019. *Handbook of local anesthesia-e-book*, Elsevier Health Sciences.
MEECHAN, J. G. & ROOD, J. P. 1997. Adverse effects of dental local anaesthesia. *Dent Update,* 24**,** 315-8.
MICHAUD, P.-L., FLOOD, B. & BRILLANT, M. S. 2018. Reversing the effects of 2% Lidocaine: A randomized controlled clinical trial. *Journal of dentistry,* 72**,** 76-79.
MIKESELL, P., NUSSTEIN, J., READER, A., BECK, M. & WEAVER, J. 2005. A comparison of articaine and lidocaine for inferior alveolar nerve blocks. *Journal of endodontics,* 31**,** 265-270.
MILLES, M. 1984. The missed inferior alveolar block: a new look at an old problem. *Anesth Prog,* 31**,** 87-90.
MODARESI, J., DAVOUDI, A., BADRIAN, H. & SABZIAN, R. 2016. Irreversible pulpitis and achieving profound anesthesia: Complexities and managements. *Anesth Essays Res,* 10**,** 3-6.
MODARESI, J., DIANAT, O. & SOLUTI, A. 2008. Effect of pulp inflammation on nerve impulse quality with or without anesthesia. *Journal of endodontics,* 34**,** 438-441.
MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G. & GROUP, P. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Journal of clinical epidemiology,* 62**,** 1006-1012.
MONHEIM, L. M. & BENNETT, C. R. 1984. *Monheim's local anesthesia and pain control in dental practice*, Mosby.
MULU, W., DEMILIE, T., YIMER, M., MESHESHA, K. & ABERA, B. 2014. Dental caries and associated factors among primary school children in Bahir Dar city: a cross-sectional study. *BMC research notes,* 7**,** 949.
NAKAI, Y., MILGROM, P., MANCL, L., COLDWELL, S. E., DOMOTO, P. K. & RAMSAY, D. S. 2000. Effectiveness of local anesthesia in pediatric dental practice. *J Am Dent Assoc,* 131**,** 1699-705.
OLESON, M., DRUM, M., READER, A., NUSSTEIN, J. & BECK, M. 2010. Effect of preoperative ibuprofen on the success of the inferior alveolar nerve block in patients with irreversible pulpitis. *Journal of endodontics,* 36**,** 379-382.
OWATZ, C. B., KHAN, A. A., SCHINDLER, W. G., SCHWARTZ, S. A., KEISER, K. & HARGREAVES, K. M. 2007. The incidence of mechanical allodynia in patients with irreversible pulpitis. *Journal of endodontics,* 33**,** 552-556.
PAGE, M. J., MCKENZIE, J. E. & HIGGINS, J. P. T. 2018. Tools for assessing risk of reporting biases in studies and syntheses of studies: a systematic review. *BMJ Open,* 8**,** e019703.
POTOCNIK, I., TOMSIC, M., SKETELJ, J. & BAJROVIC, F. F. 2006. Articaine is more effective than lidocaine or mepivacaine in rat sensory nerve conduction block in vitro. *Journal of dental research,* 85**,** 162-166.
POWELL, V. 2012. Articaine is superior to lidocaine in providing pulpal anesthesia. *Journal of the American Dental Association (1939),* 143**,** 897-898.
QUINN, J. H. 1998. Inferior alveolar nerve block using the internal oblique ridge. *Journal of the American Dental Association (1939),* 129**,** 1147-1148.
RAM, D. & AMIR, E. 2006. Comparison of articaine 4% and lidocaine 2% in paediatric dental patients. *International journal of paediatric dentistry,* 16**,** 252-256.
READER, A., NUSSTEIN, J. & DRUM, M. 2011. *Successful local anesthesia for restorative dentistry and endodontics*, Quintessence Publishing Company.
ROBERTSON, D., NUSSTEIN, J., READER, A., BECK, M. & MCCARTNEY, M. 2007. The anesthetic efficacy of articaine in buccal infiltration of mandibular posterior teeth. *Journal of the American Dental Association (1939),* 138**,** 1104-1112.
ROOD, J. P. 1977. Some anatomical and physiological causes of failure to achieve mandibular analgesia. *British Journal of Oral Surgery,* 15**,** 75-82.
ROY, M. L. & NARAHASHI, T. 1992. Differential properties of tetrodotoxin-sensitive and tetrodotoxin-resistant sodium channels in rat dorsal root ganglion neurons. *The Journal of neuroscience : the official journal of the Society for Neuroscience,* 12**,** 2104-2111.
SAATCHI, M., SHAFIEE, M., KHADEMI, A. & MEMARZADEH, B. 2018. Anesthetic Efficacy of Gow-Gates Nerve Block, Inferior Alveolar Nerve Block, and Their Combination in Mandibular Molars with Symptomatic Irreversible Pulpitis: A Prospective, Randomized Clinical Trial. *J Endod,* 44**,** 384-388.
SANCHIS, J. M., PENARROCHA, M. & SOLER, F. 2003. Bifid mandibular canal. *J Oral Maxillofac Surg,* 61**,** 422-4.
SHAMSEER, L., MOHER, D., CLARKE, M., GHERSI, D., LIBERATI, A., PETTICREW, M., SHEKELLE, P. & STEWART, L. A. 2015. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ : British Medical Journal,* 349**,** g7647.
SHARMA, R., JAYAKUMAR, T., LEKHA, S., SRIREKHA, A., PANCHAJANYA, S., SHWETHA, R. & ODEDRA, K. 2018. A comparative evaluation of the efficacy of different mandibular anesthetic techniques in patients with irreversible pulpitis. *Endodontology,* 30**,** 45-49.
SHERMAN, M. G., FLAX, M., NAMEROW, K. & MURRAY, P. E. 2008. Anesthetic efficacy of the Gow-Gates injection and maxillary infiltration with articaine and lidocaine for irreversible pulpitis. *Journal of endodontics,* 34**,** 656-659.
SILLANPÄÄ, M., VUORI, V. & LEHTINEN, R. 1988. The mylohyoid nerve and mandibular anesthesia. *International journal of oral and maxillofacial surgery,* 17**,** 206-207.
SIMPSON, M., DRUM, M., NUSSTEIN, J., READER, A. & BECK, M. 2011. Effect of combination of preoperative ibuprofen/acetaminophen on the success of the inferior alveolar nerve block in patients with symptomatic irreversible pulpitis. *Journal of endodontics,* 37**,** 593-597.

SINGH, P. 2012. An emphasis on the wide usage and important role of local anesthesia in dentistry: A strategic review. *Dental research journal,* 9**,** 127-132.

SMYTH, J. & MARLEY, J. 2010. An unusual delayed complication of inferior alveolar nerve block. *The British journal of oral & maxillofacial surgery,* 48**,** 51-52.

SORENSEN, H., SKIDMORE, L., RZASA, D., KLEIER, S., LEVINSON, S. & HENDRY, M. 2004. Comparison of pulpal sodium channel density in normal teeth to diseased teeth with severe spontaneous pain. *J Endod,* 30**,** 287.

SRINIVASAN, N., KAVITHA, M., LOGANATHAN, C. S. & PADMINI, G. 2009. Comparison of anesthetic efficacy of 4% articaine and 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics,* 107**,** 133-136.

STRICHARTZ, G. 1976. Molecular mechanisms of nerve block by local anesthetics. *Anesthesiology,* 45**,** 421-441.

SUREJ KUMAR, L. K., MANUEL, S., SUDHESH, A. & THAHA, K. A. 2010. Abducent nerve palsy following an inferior alveolar nerve block. *Journal of maxillofacial and oral surgery,* 9**,** 106-106.

SWEE, J., SILVESTRI, A. R., JR., FINKELMAN, M. D., RICH, A. P., ALEXANDER, S. A. & LOO, C. Y. 2013. Inferior alveolar nerve block and third-molar agenesis: a retrospective clinical study. *Journal of the American Dental Association (1939),* 144**,** 389-395.

THANGAVELU, K., KANNAN, R. & KUMAR, N. S. 2012. Inferior alveolar nerve block: Alternative technique. *Anesth Essays Res,* 6**,** 53-7.

TIOL, A. 2001. Tecnica innovadora para el bloqueo mandibular, con el uso de una guia metalica. *Rev Pract Odontol,* 6**,** 7-14.

TODOROVIĆ, L., STAJCIĆ, Z. & PETROVIĆ, V. 1986. Mandibular versus inferior dental anaesthesia: clinical assessment of 3 different techniques. *International journal of oral and maxillofacial surgery,* 15**,** 733-738.

TONG, H. J., ALZAHRANI, F. S., SIM, Y. F., TAHMASSEBI, J. F. & DUGGAL, M. 2018. Anaesthetic efficacy of articaine versus lidocaine in children's dentistry: a systematic review and meta-analysis. *International journal of paediatric dentistry,* 28**,** 347-360.

TORRENTE-CASTELLS, E., GARGALLO-ALBIOL, J., RODRÍGUEZ-BAEZA, A., BERINI-AYTÉS, L. & GAY-ESCODA, C. 2008. Necrosis of the skin of the chin: a possible complication of inferior alveolar nerve block injection. *Journal of the American Dental Association (1939),* 139**,** 1625-1630.

TORTAMANO, I. P., SIVIERO, M., COSTA, C. G., BUSCARIOLO, I. A. & ARMONIA, P. L. 2009. A comparison of the anesthetic efficacy of articaine and lidocaine in patients with irreversible pulpitis. *J Endod,* 35**,** 165-8.

TRAEGER, K. A. 1979. Hematoma following inferior alveolar injection: a possible cause for anesthesia failure. *Anesth Prog,* 26**,** 122-3.

WALLACE, J. A., MICHANOWICZ, A. E., MUNDELL, R. D. & WILSON, E. G. 1985. A pilot study of the clinical problem of regionally anesthetizing the pulp of an acutely inflamed mandibular molar. *Oral surgery, oral medicine, and oral pathology,* 59**,** 517-521.

WRIGHT, E. F. 2011. Medial pterygoid trismus (myospasm) following inferior alveolar nerve block: case report and literature review. *General dentistry,* 59**,** 64-67.

YOON, R. K. & CHUSSID, S. 2012. Ocular complications following an inferior alveolar nerve block on a child patient: a review of the literature and report of a case. *Pediatric dentistry,* 34**,** 343-346.

YU F, XIAO Y, LIU H, WU F, LOU F, CHEN D, et al. Evaluation of three block anesthesia methods for pain management during mandibular third molar extraction: *A meta-analysis, 2017*

ZHANG, A., TANG, H., LIU, S., MA, C., MA, S. & ZHAO, H. 2019. Anesthetic Efficiency of Articaine Versus Lidocaine in the Extraction of Lower Third Molars: A Meta-Analysis and Systematic Review. *Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons,* 77**,** 18-28.

LIST OF APPENDICES

APPENDIX-I

LOCAL ANESTHESIA SOLUTIONS AVAILABLE FOR USE IN CLINICAL DENTISTRY

LOCAL ANESTHESIA SOLUTIONS AVAILABLE FOR USE IN CLINICAL DENTISTRY

Duration	Solution	Trade name	Infiltration (pulpal)	Nerve block (pulpal)	Soft tissue duration	Mgs per cartridge
Short Duration-Plain	Lidocaine HCL 2%	Xylocaine	5 m	Not indicated	2 h	26
	Mepivacaine HCl 3%	Carbocaine, Isocaine, Polocaine, Scandanest	20-30 m	45-65 m	2-3 h	54
	Prilocaine HCl 4%	Citanest Plain	10-15 m	45-65 m	3-4 h	72
Normal Duration with vasoconstrictor	Articaine HCl 4% w/ epi 1:100,000	Sepotocaine, Articadent, Zorcaine	60-75 m	Up to 120 m	3-5 h	68
	Articaine HCl 4% w/ epi 1:200,000	Sepotocaine, Articadent	60-75 m	Up to 120 m	3-5 h	68
	Llidocaine HCL 2%w/ epi 1:50,000	Lidocaine, Xylocaine, Lignospan Standard, Octocaine 50	55-65 m	80-90 m	3-5 h	36
	Llidocaine HCL 2%w/ epi 1:100,000	Lidocaine, Xylocaine, Lignospan Standard, Octocaine 100	55-65 m	80-90 m	3-5 h	36
	Mepivicaine HCl 2% w/ levo 1:20,000	Carbocaine, Isocaine 2%, Polocaine, Scandanest 2%	40-60 m	60-90 m	3-5 h	36
	Prilocaine HCl 4% w/ epi 1:200,000	Citanest Forte	35-45 m	50-70 m	3-6 h	72
Long duration	Bupivacaine HCl 0.5% w/ epi 1:200,000	Marcaine, Vivacaine, Bupivacaine	Up to 7 h	Up to 7 h	Up to 12 h	9

(Claffey et al., 2004, Robertson et al., 2007, Michaud et al., 2018, Mikesell et al., 2005)

epi = epinephrine, levo = levonordefrin

APPENDIX-II

LIST OF FIGURES

Figure 1a: ANATOMICAL LANDMARK (Monheim and Bennett, 1984)

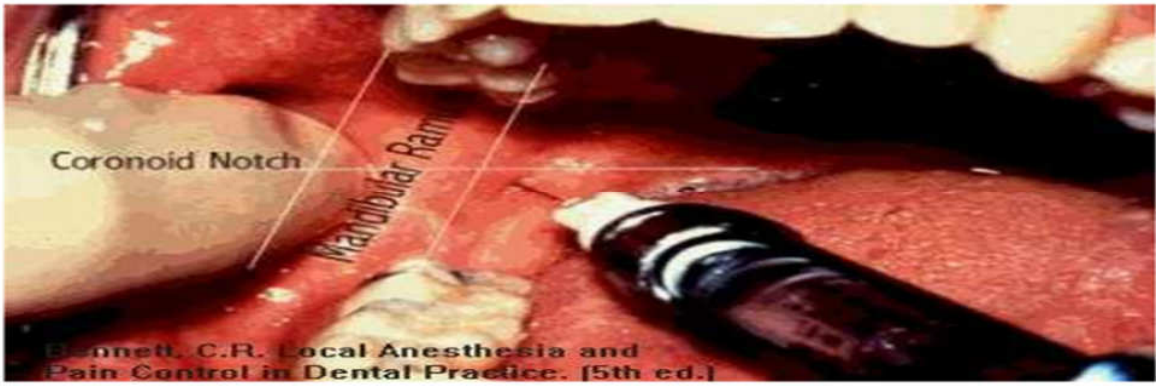


Figure 1b: ANATOMICAL LANDMARK (Monheim and Bennett, 1984)

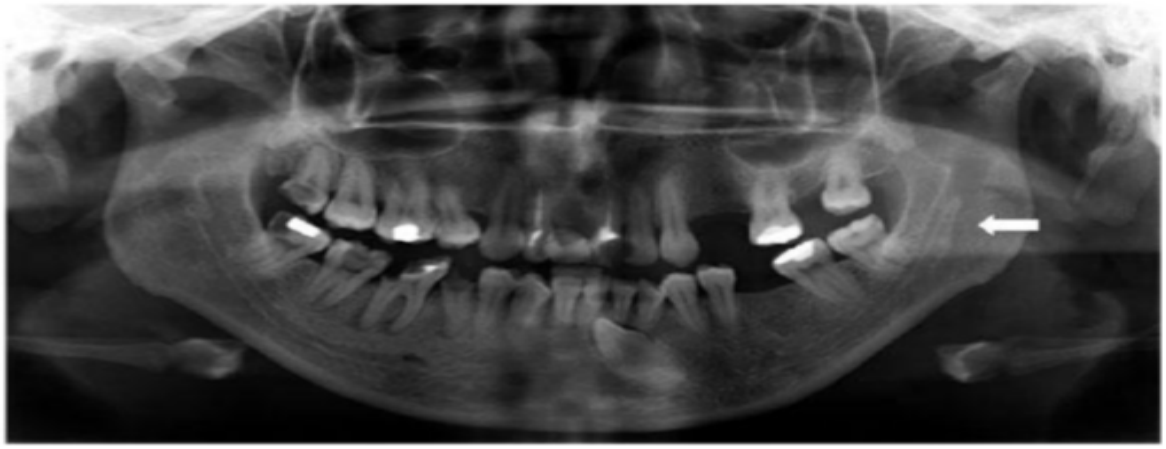


Figure 2: Bifid canal at white arrow (Sanchis et al., 2003)

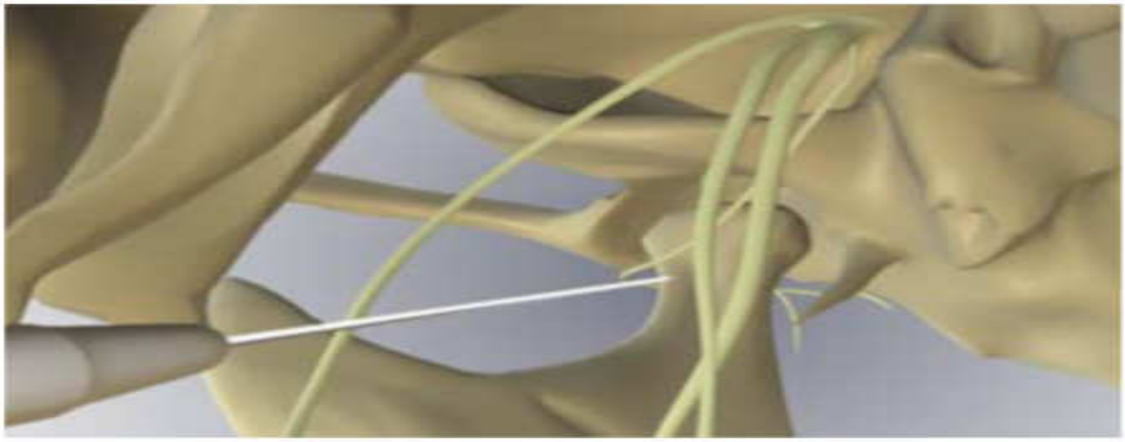


Figure 3: The final placement of needle for the Gow-Gates technique **(Haas, 2011b)**

Figure 4: A line from an intertragic notch to a corner of the mouth. Make the needle align with the plane when inserted **(Haas, 2011b)**

Figure 5: Point of needle insertion in Gow-Gates technique (Khoury et al., 2011)

APPENDIX –III

CONCEPTUAL DETAILS OF:
INFERIOR ALVEOLAR NERVE BLOCK (IANB)
IRREVERSIBLE PULPITIS
&
ASYMPTOMATIC VERSUS SYMPTOMATIC IRREVERSIBLE PULPITIS

INFERIOR ALVEOLAR NERVE BLOCK (IANB), IRREVERSIBLE PULPITIS & ASYMPTOMATIC VERSUS SYMPTOMATIC IRREVERSIBLE PULPITIS

The Inferior Alveolar Nerve Block (IANB)

IANB is a common technique used in dentistry in which dentist inserts a needle next to the mandibular foramen to deposit local anesthetic solution close to the nerve before going into the foramen, it is an area where inferior alveolar artery and vein are also situated. (Malamed, 2012) This is the superior and posterior area of the pterygoid plexus. The IANB failure rate has been noted as twenty to twenty five percent. (Thangavelu et al., 2012) The low success rate of this technique is due to technical errors like inadequately localizing anatomical landmarks or angling the needle. (Haas, 2011b)

The complications due to IANB varies from rare to common, consisting of trismus and pain caused by tearing of mucosa during insertion, needle removal, (Smyth and Marley, 2010) breakage of needle at the point of injection (Wright, 2011, Ethunandan et al., 2007) and facial paralysis induced by anesthetic solution accumulation in the parotid region. (Chevalier et al., 2010) The blood vessel disruption in this region and the intravascular injection of anesthetic fluid may also contribute to hematoma. Certain symptoms have been described as extraocular paralysis of the muscles and ptoses (Yoon and Chussid, 2012) aphony, (He and Chen, 2012) facial nerve paralysis and diplopia, (Surej Kumar et al., 2010, Choi et al., 2009) and necrosis of the skin of the chin (Torrente-Castells et al., 2008). Recently there were also claims that IANB could be a component of a third molar agenesis (Swee et al., 2013).

Hence there are rare to major complications even after the highest care given by dentists and clinicians before needle insertion and taking into account the landmarks.

Irreversible Pulpitis

Specific anesthetic problems arise in individuals with irreversible pulpitis. Next, conventional methods of anesthesia are not reliably adequate in pulp anesthesia.(Reader et al., 2011) Second, tissue-borne nerves can have higher resting potentials and hence decreased thresholds of excitability, preventing local anesthetics from blocking the transmitted impulse in those areas sufficiently (Modaresi et al., 2008, Wallace et al., 1985).

Third and fourthly, increased sodium expression and increased expression in irreversible pulpitis nerve tissue of tetrodotoxin resistant sodium channels will increase resistance to anesthetics (Roy

and Narahashi, 1992, Sorensen et al., 2004). In addition to the above, people often struggle from discomfort and reduce their pain thresholds (Reader et al., 2011).

Asymptomatic versus Symptomatic Irreversible Pulpitis

Comparisons between asymptomatic and symptomatic irreversible pulpitis should be carefully examined while examining the anesthetic impact on the teeth identified as irreversible pulpitis. A diagnosis of asymptomatic irreversible pulpitis is not equal between an asymptomatic irreversible pulpitis of pain or acute symptoms and symptomatic irreversible pulpitis in which the person has a persistent, quantifiable pain arising from acute odontogenic symptoms. The activation or sensitization *of* nociceptors *by* inflammation-released cytokines (such as prostaglandins) (Ingle et al., 2008) is a hypothesis which indicates poor anesthetic success levels of symptomatic irreversible pulpitis. Furthermore, inflammation induces improvements to the pain management mechanism of the central nervous system (Simpson et al., 2011).

Different approaches for enhancing anesthetic outcomes, from supplemental anesthetic methods and multiple anesthetic solutions, to premedication and alternate inferior alveolar block approaches, have been studied, because success rates of the IANB declined in patients with both symptomatic and asymptomatic irreversible pulpitis. Research which analyze different pre-medication methods also shown no major difference in the efficacy of the IANB following the application of ibuprofen, acetaminopher/ibuprofen, vicodin or sublingual triazolam in patients with irreversible pulpitis. (Fullmer et al., 2014, Ianiro et al., 2007, Lindemann et al., 2008, Oleson et al., 2010, Simpson et al., 2011)

Anesthesia of auriculotemporal and mylohyoid nerves may overcome pain as well as a beneficial local anesthetic control role in the accessory innervation. That level could be smaller because of the inferior alveolar vein and artery further distant from the target site than the IANB, which may be also the explanation why researchers suggested that exogenous epinephrine absorption was lower with Gow-Gates methodology resulted in around 2% of positive aspiration, opposed to 10 to 15% of IANB. (Haas, 2011b, Kohler et al., 2008)When administered, instruct the patients to hold their mouth open for at least 20 seconds, to maintain the IAN near to the location of injection to boost the anesthesia. Anesthesia usually takes 5-10 minutes, which is longer than that for the IANB (typically between 3 to 5 minutes).(Gow-Gates, 1973, Haas, 2011b)

ANNEX –IV

DETAILS ABOUT

VAZIRANI/AKINOSI BLOCK (CLOSED MOUTH BLOCK), FISCHER 1.2.3 IANB & GOW-GATES TECHNIQUES

VAZIRANI/AKINOSI BLOCK (CLOSED MOUTH BLOCK), FISCHER 1.2.3 IANB & GOW-GATES TECHNIQUES

Vazirani/Akinosi Block (Closed Mouth Block) Technique

In case the person is unable to open the mouth entirely, it is better to use the closed mouth block technique (Vazirani / Akinosi block). There is therefore a small risk that the pterygoic plexus could inject the needle and damage the vessels (Dover, 1971). Failures in the conventional IANB and the Akinosi block procedure have been observed (Boronat López and Peñarrocha Diago, 2006) . The Malamed Closed-mouth approach shows a higher frequency of failures than conventional IANBs. (Bremer, 1952) Due to the higher level of failures, this method cannot be used. Most dental professionals are therefore not using the Gow-Gate and Akinosi techniques.(Johnson et al., 2007)

The Vazirani-Akinosi technique has several advantages over the Gow-Gates technique. It is useful in trismatic patients and those with ankylotic temporomandibular joint; in addition, it is less traumatic and has a lower complication rate. However, the Vazirani-Akinosi technique is less effective than the Gow-Gates technique. Recent studies have not shown any difference in the quality of pain relief with either of the approaches. This approach is contraindicated if the patient has an infection or inflammation involving the pterygomandibular region or maxillary tuberosity. The main advantages with this approach include a faster onset of action, lesser post-procedure complications, and lesser pain during injection. The patient is placed in a semisupine position or on a dental chair with the mouth closed. The operator stands on the same side as the block to be performed. Anatomic landmarks include the following:

- Gingival margin over the second and third maxillary molars
- Pterygomandibular raphe

The aim is to enter the pterygomandibular space where the IAN, lingual nerve, and mylohyoid nerve are present. This space is bordered laterally by the ramus of mandible, medially and inferiorly by the medial pterygoid muscle, posteriorly by the parotid gland, and anteriorly by buccinators muscle. The cheek is retracted with a retractor, and the patient is asked to occlude his or her teeth gently. The needle is inserted over the medial aspect of the mandibular ramus, parallel to the occlusal plane at the height of the mucogingival junction of the second and third molars. The needle is bent slightly to decrease the chance of entering the muscle belly. The needle is then advanced through the mucous membrane and buccinator muscle to enter the pterygomandibular space. The needle is

advanced until it hits the level with the distal surface of the second molar. After negative aspiration, 1.8 mL of local anesthetic is injected slowly over 1 minute.

Fischer 1.2.3 IANB Technique

The technique of Fischer 1, 2, 3, depends on anatomical features, such as the coronoid notch, external oblique ridge, buccal pad apex, the pterygomandibular raph and retro molar pad. Failure to recognize these points of reference could lead to improper anesthesia techniques and failure. During the injection process in the 1st stage three to six mm distance, 2nd stage twelve mm distance and in the 3rd stage twenty four mm of the needle to be positioned from the 42 mm long needle. Since the needle is not labelled, operators can hardly push it. This technique may lead to facial paralyses, as a result of the possibility of over infiltration. (Thangavelu et al., 2012)

Gow-Gates technique

In 1973, Gow-Gates first identified the "mandibular nerve block of Gow-Gates." The procedure seeks to place the tip of the needle on the neck of the condyle and to deliver the local anesthetic (**Fig 3 & 4 placed at Appendix-II** refers). This location is near the mandibular branch of trigeminal nerve after it exits from foramen ovale. Use a 25-gauge long needle, like the other two mandibular strategies. Determine the extra oral features before staring into the patient's mouth. Figure 5 placed at Appendix-II indicates a line from an intertragic notch to a corner of the mouth (which is inferior promptly to the tragus of the ear). Make the needle align with the plane when inserted. (Haas, 2011b, Kafalias et al., 1987)

Intraorally you can find the bony hallmark in the coronoid notch by touching the oblique external ridge of the anterior ramus area. Look at this step to turn the thumb or hand onto the coronoid loop. It is necessary to avoid this muscle when applying the needle. The temporalis muscle binds the coronoid process. Upon palpation of the landmarks, hold the syringe at the correct angle as previously established. Take the end of the needle tip to the neck of the condyle. Normally, the syringe barrel is placed in the contralateral mandibular canine or premolars. (Haas, 2011b)

Associated with that of the IANB the intraoral entry point is superior and lateral. This is on the lateral boundary of pterygotemporal depression and only on the anterior side of a temporal muscle connection (**Fig 5 placed at Appendix-II**). The upper boundary of the attachment point is the occlusal maxillary line. The needle lies typically just under the maxillary second molar mesiopalatal cusp that may be a safe landmark unless the tooth has rotated or drifted. (Khoury et al., 2011)

Ask the patient to open his mouth as broadly as possible just before needle insertion. For the effectiveness of this procedure, a small opening is necessary, which should not be taken into account for patients who cannot adequately open their mouths. Once the needle is mounted, slowly move it to the bone (condyle neck), until it hits the bone. Such touch will occur at a depth of 25 mm, even though for larger patients or those with a markedly flaring ramus, a greater depth may be required. When bone is not touched, do not administer but move the injection until the condyle's neck is reached. Replace the needle 1 mm and add a complete cartridge of local anesthetics after a negative aspiration, if contact happens. Do not give less than a complete cartridge. Gow-Gates, an Australian dentist, used 2.2 mL cartridges as the norm in Australia as he established his method. According to the 1.8mL cartridges used in the US, this volume may have led to the high success rate of this process. (Haas, 2011b, Malamed, 1981)

Instead of the anterior pterygoid muscle, lateral to the medial pterygoid muscle and medial to the ramus the final position of the needle tip is in front of the condyle neck. The Gow-Gates nerves include the inferior alveolar and its branches (mental and incisive), mylohyoid, lingual, buccal and auriculotemporal (about 75% of the time). This neurological category varies from the category anesthetized by IANB and comprises only IAN and its branches (mental and incisive) and the lingual nerve. Anesthesia of the buccal nerve eliminates the need for a separate block of the buccal nerve.

In addition to standard 1.8 mL of local anesthesia, it has been shown by Kohler et al. that the local anesthesia solution was insufficient in providing adequate Gow-Gates mandibular conduction block anesthesia (Kohler et al., 2008). Dr. Gow-Gates claimed that this solution would be marginally more voluminous and would lead to the high effectiveness of this technique. (Haas, 2011b)

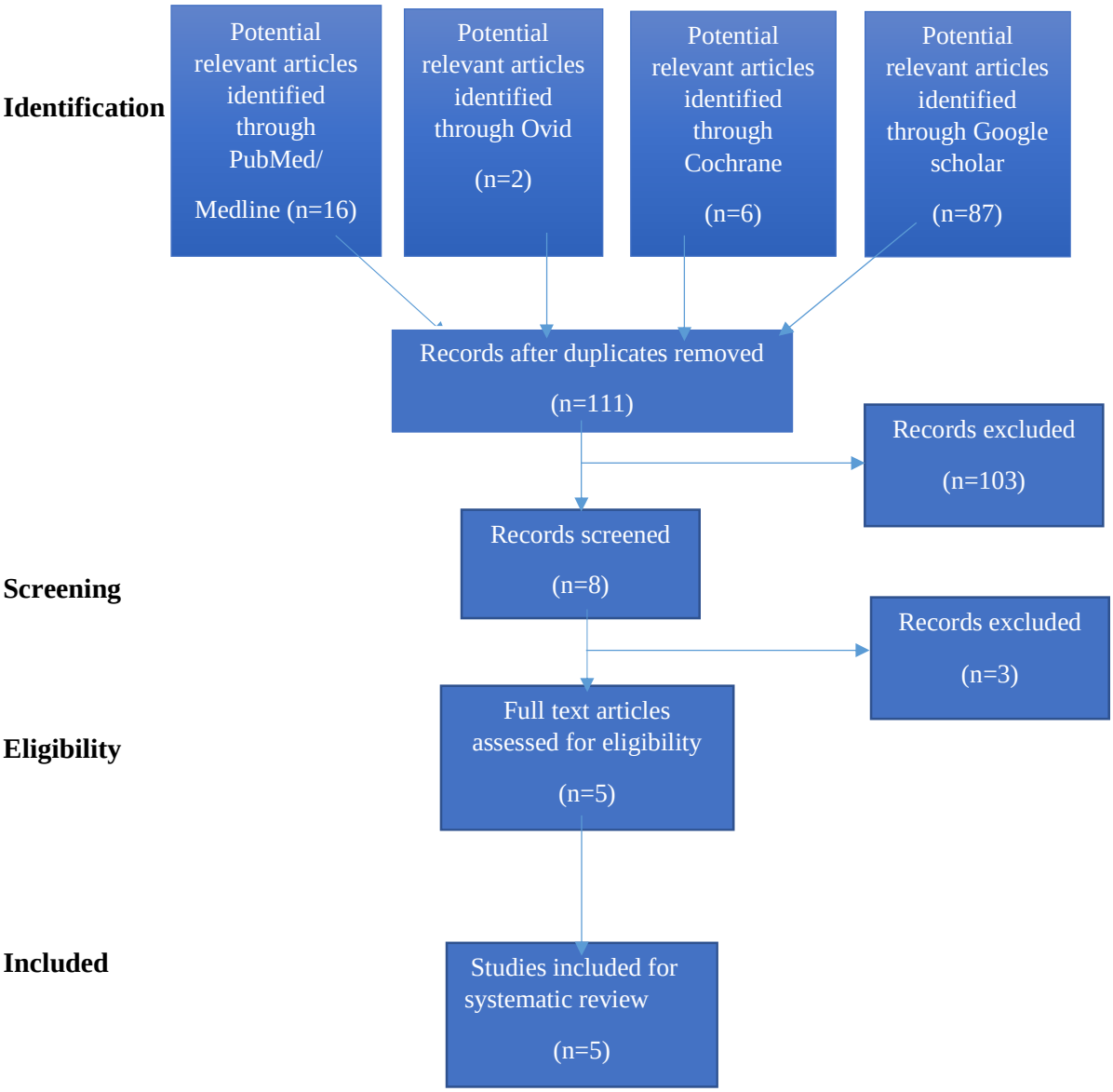
Coronoid approach

The patient is placed in a supine position with the mouth in a neutral position. The coronoid notch on the side of the block is identified by opening and closing the mouth a few times. After skin preparation, a 22-gauge needle is inserted at the middle of the notch and advanced to a depth of about 1-2 inches in a plane perpendicular to the base of the skull until the lateral pterygoid plate is reached. The tip of the needle is then withdrawn slightly and redirected posteriorly and inferiorly so that it goes beyond the lateral pterygoid plate. After redirection of the needle, paresthesias in the mandibular region are elicited at a depth of about 1 cm. After aspiration, 3-5 mL of local anesthetic solution is slowly injected.

APPENDIX-V

FLOW-CHART OF THE STUDY SELECTION PROCESS

FLOW-CHART OF THE STUDY SELECTION PROCESS



APPENDIX-VI

LIST OF THE INCLUDED STUDIES VIZ-A-VIZ THEIR DESCRIPTION, CHARACTERISTICS & QUALITY ANALYSIS

LIST OF INCLUDED STUDIES		
Study		**Title of Study**
1	**Aggarwal et al, 2010**	Comparative evaluation of anesthetic efficacy of Gow-Gates mandibular conduction anesthesia, Vazirani-Akinosi technique, buccal-plus-lingual infiltrations, and conventional inferior alveolar nerve anesthesia in patients with irreversible pulpitis - Aggarwal et al, 2010
2	**Ghoddusi J et al. 2018**	Efficacy of IANB and Gow-Gates Techniques in Mandibular Molars with Symptomatic Irreversible Pulpitis: A Prospective Randomized Double Blind Clinical Study - Ghoddusi J et al. 2018
3	**Saatchi M et al. 2018**	Anesthetic efficacy of Gow-Gates nerve block, inferior alveolar nerve block, and their combination in mandibular molars with symptomatic irreversible pulpitis: a prospective, randomized clinical trial - Saatchi M et al. 2018
4	**Sharma R et al. 2018**	A comparative evaluation of the efficacy of different mandibular anesthetic techniques in patients with irreversible pulpitis" - Sharma R et al. 2018
5	**Afridi et al. 2019**	Comparison of anesthetic efficacy of conventional inferior alveolar nerve block and gow gates technique in patients with symptomatic irreversible pulpitis-randomized control trail" - Afridi et al. 2019

DESCRIPTION, CHARACTERISTICS & QUALITY ANALYSIS OF THE INCLUDED STUDIES

Study 1

"Comparative evaluation of anesthetic efficacy of Gow-Gates mandibular conduction anesthesia, Vazirani-Akinosi technique, buccal-plus-lingual infiltrations, and conventional inferior alveolar nerve anesthesia in patients with irreversible pulpitis"

Aggarwal et al, 2010

Description of the study

For inflamed pulps, the conventional IANB has poor efficacy. The purpose of this study was to compare the anesthetic effectiveness of four different techniques among patients with irreversible pulpitis. It was a double-blinded, randomized prospective study. Total one hundred and two subjects who presented at dental ER department were participated. Fifteen percent difference was considered in success of each group, the overall sample size was estimated as 84 subjects at 80% power of test and 5% level of significance. They predicted up to 15% drop-out rate and recruited at least 24 subjects in each group.

Subjects with good health, vigorously experiencing pain in mandibular molar, lack of any periapical radiolucency on x-rays, with the exception of an enlarged periodontal ligament; critical opening of the coronal pulpal access; and ability to understand the use of pain measures and sustained reaction to cold checking with an ice stick and an electronic pulp tester and without pain control treatment were included. The ethical approval from ethical review committee and informed consent from each subject was taken.

Before starting the treatment, the pain was assessed by using "Heft-Parker visual analog scale (HP VAS)". The pain scale was classified into four categories that "0" for no pain, "1-54 mm" as "faint, weak, or mild pain", "55-114 mm" as "moderate pain" and "114 mm" as "strong, intense, and maximum possible pain".(Claffey et al., 2004, Aggarwal et al., 2009). On the basis of random allocation 27 patients received Gow-Gates nerve block (GGNB) technique, 26 were in buccal-plus-lingual infiltrations (BL), 25 patients were in "high" Vazirani-Akinosi (VA) closed-mouth technique and about 24 patients received conventional IANB anesthesia. Each subject was asked about the numbness of lip after 15 mins of injection. If within 15 mins profound lip numbness was not noted then the technique was labelled as unsuccessful and subjects were excluded. This step was not considered for BL group. After it subjects were again rated their pain. With a rubber barrier, the teeth involved were separated and a conventional opening of access was introduced. If discomfort was felt during the procedure, patients were told to raise their hand. The procedure was

halted in the case of discomfort during the treatment and patients were asked to rate the pain on HP VAS. Success was labelled as "no pain" or "weak / mild pain" during the planning and instrumentation of the endodontic access.

The non-parametric statistical test i.e. “Mc-Nemar test” was applied to evaluate the success. The results showed that the success rate of Gow-Gates technique was statistically high as compared to IANB (52% vs 36%; $p<0.05$). Other two techniques infiltrations and Vazirani-Akinosi gave 27% and 41% success rates respectively and insignificant difference was found with IANB ($p>0.05$). The study concluded that Gow-gates nerve block may raise the success of anesthesia among patients with irreversible pulpitis when contrasted with IANB. However, not any of the procedures provided satisfactory success rates.

Characteristics of study

Aggarwal et al, 2010		
Methods	Double-blinded, prospective randomized controlled trial, 4 groups	
Participants	102 subjects, assigned into four groups: Gp#1=27, Gp#2=26, Gp#3=25 & Gp#4=24. Both gender included with overall age range of 21-32 years.	
Intervention	GGNB, VA, BL and IANB technique were employed. The pain was assessed by using “Heft-Parker visual analog scale”. The anesthetic success was noted as “none” or “weak/mild” pain.	
Risk of bias: study possess risk of; selection, allocation, accidental and detection biases.		
Item	**Reviewers’ judgment**	**Description**
Randomization	Yes	Stated
Allocation Concealment	Unclear	Not stated
Blinding of outcome assessors	Unclear	Not stated
Other: Blinding intervention providers	Unclear	Not stated
Overall Quality Assessment	The overall quality of the study is graded as poor.	

Quality Analysis

Detail was not given regarding the concealment of allocation which makes it liable to selection/allocation bias. The potential unknown covariates impact was not balance among groups which may lead to accidental bias on the outcome. The exclusion criteria is also not clearly mentioned. The double blinded study has been mentioned but no details regarding the blinding has been given in the article, it is unclear that patient and outcome assessor are blinded or experimenter and patients are blinded, which may leads to detection bias in results. The “Heft-Parker visual analog scale” was used for the assessment of pain. The reliability and validity of scale was not measured and mentioned. The overall quality of the study is graded as poor and better methodology is required to address the possible biases. No registration of trial and funding source details given.

Study 2

"Efficacy of IANB and Gow-Gates Techniques in Mandibular Molars with Symptomatic Irreversible Pulpitis: A Prospective Randomized Double Blind Clinical Study"

Ghoddusi J et al. 2018

Description of the study

The goal of the study was to compare the success of IANB and GGNB in patients with symptomatic irreversible pulpitis.

It was a parallel-grouped, randomized, double-blind clinical trial in which total 80 healthy subjects of age 18-50 years with "moderate to severe pain" in mandibular molar, vital coronal pulp on access opening, positive response to an "electric pulp tester" and prolonged response to "cold testing" with cold spray were included and randomly divided into 2 groups i.e. 40 subjects in GGNB and 40 subjects in IANB using 2 percent lidocaine with 1:100000 epi. The patients with active site of pathosis in area of injection, periapical radiolucency, allergy to adrenalin and/or lidocaine, severe systemic disease, pregnancy, usage of medicine that might influence anesthetic assessment, inability to understand the visual analogue scale (VAS) and lack of ability to give informed consent were excluded from the study.

The ethical approval from ethical review committee and informed consent from each subject was taken. The severity of pain in both groups was assessed before, during access cavity preparation and after anesthesia induction. VAS score 1-3 was labelled as mild pain, 4-6 as moderate, 7-9 as severe pain and 0 as no pain. The changes in heart rate were noted every 30 second from two min earlier primary injections to five min post-secondary injections by means of a pulse oximeter.

During primary injections, aspiration was done using the two tested techniques. The case was recorded for subsequent comparison if aspiration was high.

Independent t-test, paired *t*-test and the Mann-Whitney *U*-test were used to compare the outcomes between groups.

The efficacy of anesthesia in the IANB and GGNB techniques were 42.5% and 50%, respectively with insignificant difference ($p>0.562$). The significant reduction in severity of pain was noted in supplementary infiltrations in all subgroups ($P<0.05$) whereas lingual infiltration resulted in a significantly more reduction in severity of pain in the IANB group than in the Gow-Gates group ($P<0.05$). Insignificant difference in positive aspiration or heart rate results was witnessed between groups ($P>0.05$).

Hence the study concluded that IANB and GGNB anesthetic techniques was comparable in symptomatic irreversible pulpitis and supplementary lingual and buccal infiltration significantly decreased severity of pain.

Characteristics of study

Ghoddusi J et al. 2018		
Methods	A parallel-grouped, randomized, double-blind clinical trial, two groups	
Participants	80 subjects, assigned into two groups: Gp#1=40 & Gp#2=40. The age range was 18-50 years and gender was not explained	
Intervention	GGNB and IANB technique were employed. The pain was assessed by using "Visual analog scale". VAS score 1-3 was labelled as mild pain, 4-6 as moderate, 7-9 as severe pain and 0 as no pain.	
Risk of bias: Study possess risk of; accidental bias		
Item	**Reviewers' judgment**	**Description**
Randomization	Yes	Stated
Allocation Concealment	Yes	Stated
Blinding of outcome assessors	Yes	Stated
Other: Blinding intervention providers	No	Stated
Overall Quality Assessment	The overall quality of the study is graded as good.	

Quality Analysis

Detail are given regarding the concealment of allocation which makes it exempt to selection/allocation bias. The potential unknown covariates impact was not balance among groups which may lead to accidental bias on the outcome. The exclusion criteria is clearly mentioned. The double blinded study has been mentioned, in which patient and outcome assessor were blinded whereas experimenter who gave intervention wasn't blinded, which may have decrease the risk of detection bias in results. The "Visual analog scale" was used for the assessment of pain. The reliability and validity of scale was not measured and mentioned. The overall quality of the study is graded as good. The potential effect modifiers and side effects should be address to overcome the possible accidental biases. No funding source details given.

Study 3

"Anesthetic efficacy of Gow-Gates nerve block, inferior alveolar nerve block, and their combination in mandibular molars with symptomatic irreversible pulpitis: a prospective, randomized clinical trial"

Saatchi M et al. 2018

Description of the study

The goal of the trial was to evaluate and compare the efficacy of IANB, GGNB and GGNB with IANB for patients with symptomatic irreversible pulpitis.

It was a randomized clinical trial, prospective in which total 150 adult subjects of age more 18 years with "active pain" in mandibular molar, nonappearance of any periapical radiolucency on radiographs, persistent response to "cold testing" with cold spray, vital pulp on access opening and ability to understand VAS were included. Exclusion criteria for the research involved resistance of local anesthetics; pregnancy; use of any drugs such as antianxiety, sedatives, analgesics or antidepressants that might affect the perception of pain; history of significant medical problems; occurrence of active pathosis in the injection area. Each patient therefore had a mandibular molar with a clinical diagnosis of irreversible symptomatic pulpitis.

The ethical approval from ethical review committee and informed consent from each subject was taken. Before starting the treatment, the pain was assessed by using "Heft-Parker visual analog scale (HP VAS)". The pain scale was classified into four categories that "0" for no pain, "1-54 mm" as "mild pain", "55-113mm" as "moderate pain" and "severe pain" as "114-170 mm". Patients with pain score more than 54 were enrolled in the study.

Subjects were randomly divided into three groups i.e. 50 subjects in GGNB, 50 subjects in IANB and 50 in IANB+GGNB using random number table. Profound lip numbness was labeled as a subjective condition for nerve block attainment. Each subject was asked about the numbness of lip after 15 mins of injection. If within 15 mins profound lip numbness was not noted then the technique was labelled as missed and subjects were excluded. With a rubber dam, the teeth involved were separated and preparation of access cavity was introduced. Patients were advised by the operator administering the injections to score any discomfort encountered when preparation of the access cavity or inserting the initial file in the same manner.

The procedure was immediately suspended if the patient felt pain, and the patient reported pain intensity using the HP-VAS. The anesthesia success was described as the HP-VAS scores "0" without pain or with mild pain "1-54 mm".

Kruskal-Wallis, ANOVA and the chi-sq test were used to compare the outcomes between groups. The study results reported the anesthetic efficacy as 40% in GGNB technique, 44% in IANB technique and 70% in GGNB+IANB technique respectively. Statistically significant difference was observed between GGNB+IANB technique and IANB and GGNB technique ($p<0.05$). Study revealed that a combination of IANB and GGNB could improve the effectiveness of anesthesia in mandibular molars with symptomatic irreversible pulpitis, nonetheless it would still need supplemental anesthesia.

Characteristics of study

Saatchi M et al. 2018		
Methods	A randomized clinical trial, prospective, three groups	
Participants	150 subjects, assigned into three groups: Gp#1=50, Gp#2=50 & Gp#3=50. Participants of age over 18 year and both gender included	
Intervention	GGNB, IANB and GGNB+IANB technique were employed. The pain was assessed by using "HP-VAS". The anesthesia success was described as the HP-VAS scores "0" without pain or with mild pain "1-54 mm".	
Risk of bias: study possess risk of; selection, allocation, accidental and detection biases.		
Item	**Reviewers' judgment**	**Description**
Randomization	Yes	Stated
Allocation Concealment	Unclear	Not stated
Blinding of outcome assessors	Unclear	Not stated
Other: Blinding intervention providers	Yes	Stated
Overall Quality Assessment	The overall quality of the study is graded as fair.	

Quality Analysis

Detail was not given regarding the concealment of allocation which makes it liable to selection/allocation bias. The potential unknown covariates impact was not balance among groups which may lead to accidental bias on the outcome. The study has mentioned about operator blinding whereas it is unclear that patient and outcome assessor are blinded or not, which may leads to detection bias in results. The "Heft-Parker visual analog scale" was used for the assessment of pain. The reliability and validity of scale was not measured and mentioned. The overall quality of the study is graded as good and better methodology is required to address the possible biases. No funding source details given.

Study 4

"A comparative evaluation of the efficacy of different mandibular anesthetic techniques in patients with irreversible pulpitis"

Sharma R et al. 2018

Description of the study

The aim of the study was to determine efficacious anesthetic technique in irreversible pulpitis by comparing the efficacies of GGNB, VA, IANB with buccal infiltration and conventional IANB using 2 percent Lidocaine with 1:80,000 epi as the anesthetic agent in mandibular1st molars.

It was a randomized clinical study in which 120 systemically, healthy adult patients with irreversible pulpitis of mandibular 1st molars who were experiencing pain and not on medication that would alter perception of pain were selected for the study. Thirty patients were randomly divided into four groups.

Subjects vigorously experiencing pain in mandibular molar, sustained reaction to cold testing with an ice stick and an EPT, lack of any periapical radiolucency on x-rays, with the exception of an enlarged periodontal ligament; critical opening of the coronal pulpal access; and ability to understand the use of pain measures were included. The ethical approval from ethical review committee and informed consent from each subject was taken.

Before starting the treatment, the pain was assessed by using "Heft-Parker visual analog scale (HP VAS)". The pain scale was classified into four categories that "0" for no pain, "1-54 mm" as "faint, weak, or mild pain", "55-114 mm" as "moderate pain" and "114 mm" as "strong, intense, and maximum possible pain".

Profound lip numbness was labeled as a subjective condition for nerve block attainment. Each subject was asked about the numbness of lip after 15 mins of injection. If within 15 mins profound lip numbness was not noted then the technique was labelled as unsuccessful and subjects were excluded. With a rubber dam, the teeth involved were separated and preparation of access cavity was introduced. Patients were advised by the operator administering the injections to score any discomfort encountered when preparation of the access cavity or inserting the initial file in the same manner. The procedure was immediately suspended if the patient felt pain, and the patient reported pain intensity using the HP-VAS. The anesthesia success was described as the HP-VAS scores "0" without pain or with mild pain "1-54 mm".

No response from the patient was used as the criterion for pulpal anesthesia at the maximum output current flow from the pulp tester.

Patients were advised to raise their hand if they felt any discomfort during the preparation for endodontic access. The treatment was stopped in the case of pain and patients were asked to rate the pain on HP VAS. Anesthesia was considered effective when "no pain" or "mild pain" occurred.

The chi-square/Fisher exact was applied to compare the efficacy between four groups. Study results showed that anesthetic efficacy was 66.7% in GGNB, 60% in VA, 46.7% in IANB with buccal infiltration of 2% lignocaine with 1:80,000 epi and 46.7% in conventional IANB. However, there was insignificant difference between the groups studied ($p>0.05$).

Characteristics of study

Sharma R et al. 2018		
Methods	A randomized clinical study, four groups	
Participants	120 subjects, assigned into two groups: Gp#1=30, Gp#2=30, Gp#3=30 & Gp#4=30. Participants with average age 30 year and both gender included.	
Intervention	GGNB, VA and IANB with buccal infiltration and conventional IANB technique were employed. The pain was assessed by using "Heft-Parker visual analog scale". The pain scale was classified into four categories that "0" for no pain, "1-54 mm" as "faint, weak, or mild pain", "55-114 mm" as "moderate pain" and "114 mm" as "strong, intense, and maximum possible pain".	
Risk of bias: study possess risk of; selection, allocation, accidental and detection biases.		
Item	**Reviewers' judgment**	**Description**
Randomization	Yes	Stated
Allocation Concealment	Unclear	Not stated
Blinding of outcome assessors	Unclear	Not stated
Other: Blinding intervention providers	Unclear	Not stated
Overall Quality Assessment	The overall quality of the study is graded as poor.	

Quality Analysis

Detail was not given regarding the concealment of allocation which makes it liable to selection/allocation bias. The potential unknown covariates impact was not balance among groups which may lead to accidental bias on the outcome. The study has not mentioned the details regarding blinding, it is unclear that experimenter, patient, outcome assessor and data analyst are blinded or not, which may leads to detection bias in results. The "HP visual analog scale" was used for the assessment of pain. The reliability and validity of scale was not measured and mentioned. The overall quality of the study is graded as poor and better methodology is required to address the possible biases. No funding source and trial registration details given.

Study 5

"Comparison of anesthetic efficacy of conventional inferior alveolar nerve block and gow gates technique in patients with symptomatic irreversible pulpitis-randomized control trail"

Afridi et al. 2019

Description of the study

The objective of the study was to compare the anesthetic efficacy of IANB and GGNB for patients with symptomatic irreversible pulpitis and find out a superior technique.

It was a randomized controlled trial in which 106 patients with symptomatic irreversible pulpitis in mandibular posterior teeth were enrolled in the trial. The age range of the subjects was 18 to 45 years nonappearance of any periapical radiolucency on radiographs and neither taking any medicine nor medically compromised patients were included in the study. The study excluded pregnant women, allergic to local anesthesia, and patients with no response to EPT.

The ethical approval from ethical review committee and informed consent from each subject was taken. The patients were randomly allocated into GGNB or IANB groups using lottery method. Before starting the treatment, the pain was assessed by using VAS. The score of "0" was labelled as "No pain", 0-4 was labelled as "Mild pain", 4-7 was labelled as "moderate pain" and >7 was defined as "Severe pain".

After local anesthesia was given, anesthesia was induced for about 10 minutes. This was confirmed on the Electric Pulp Tester (EPT) by achieving lip numbness, interdental testing, and no response to maximum reading (80). In the Performa, this data was recorded.

A rubber dam was then used to isolate the tooth, and endodontic access was made. No pain or mild pain indicated by the patient was recorded using VAS in the Performa during the preparation of endodontic access. Treatment was stopped when the patient experienced moderate to severe pain and pain was reported in Performa and additional injections (intraosseous injection, intrapulpal injection or intraligamental injection) were administered and emergency treatment was completed and no further records were collected. Pulpal anesthesia was considered successful at the maximum output (80 reading) of the EPT if there was no pain on interdental probing and no response from the subject.

Chi-square test was used to compare effectiveness of anesthesia technique. Study results showed that anesthetic efficacy was 85% in GGNB and 72% in IANB group. However, no statistically significant difference was observed between the both groups ($p>0.05$). Study concluded that GGNB and IANB was similar in efficacy for patients with symptomatic irreversible pulpitis.

Characteristics of Study

Afridi et al. 2019		
Methods	A randomized controlled trial, two groups	
Participants	106 subjects, assigned into two groups: Gp#1=53 & Gp#2=53. Participants of age 10-45 year and both gender included.	
Intervention	GGNB and IANB technique were employed. The pain was assessed by using "VAS". The score of "0" was labelled as "No pain", 0-4 was labelled as "Mild pain", 4-7 was labelled as "moderate pain" and >7 was defined as "Severe pain".	
Risk of bias: study possess risk of; selection, allocation, accidental and detection biases.		
Item	**Reviewers' judgment**	**Description**
Randomization	Yes	Stated
Allocation Concealment	Unclear	Not stated
Blinding of outcome assessors	Unclear	Not stated
Other: Blinding intervention providers	Yes	Stated
Overall Quality Assessment	The overall quality of the study is graded as fair.	

Quality Analysis

Detail was not given regarding the concealment of allocation which makes it liable to selection/allocation bias. The potential unknown covariates impact was not balance among groups which may lead to accidental bias on the outcome. The study has mentioned about operator blinding whereas it is unclear that patient and outcome assessor are blinded or not, which may leads to detection bias in results. The "Visual analog scale" was used for the assessment of pain. The reliability and validity of scale was not measured and mentioned. The overall quality of the study is graded as poor and better methodology is required to address the possible biases. No funding source and trial registration details given.

SUMMARY OF RESULTS OF INCLUDED STUDIES

The overall evaluation of the reviewed studies is fair to poor, some have a high risk of bias and some have inappropriate methodology and a low reporting quality. The cardinal characteristics of these studies and the opinion of the reviewer bias risk judgements are tabulated hereunder:

Summary of methodological quality of included studies

Criterion	Reported/ Yes	Reported / No	Unclear
Randomization	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-	-
Allocation Concealment	Ghoddusi J et al. 2018	-	Aggarwal et al, 2010, Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019
Blinding of participants	Ghoddusi J et al. 2018	-	Aggarwal et al, 2010, Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019
Blinding of intervention providers	Saatchi M et al. 2018, Afridi et al. 2019	Ghoddusi J et al. 2018	Aggarwal et al, 2010, Sharma R et al. 2018
Blinding of data collectors/ outcome assessors	Ghoddusi J et al. 2018	-	Aggarwal et al, 2010, Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019

Reviewer's judgment of risk of bias

Type of bias	Low Risk	Medium Risk	High risk
Selection Bias	Ghoddusi J et al. 2018	Aggarwal et al, 2010, Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-
Reporting Bias	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-	-
Detection Bias	-	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Afridi et al. 2019	Sharma R et al. 2018
Analytical Bias	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-	-
Attrition Bias	-	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-
Funding Bias	-	Aggarwal et al, 2010, Ghoddusi J et al. 2018 Saatchi M et al. 2018, Sharma R et al. 2018, Afridi et al. 2019	-

APPENDIX-VII

ELABORATED DETAILES OF KEY FINDINGS

ELABORATED DETAILES OF KEY FINDINGS

The review is based on the highest level of evidence. All the studies are randomized control trial. The validity and reliability of the included studies included is appropriate. This is due to the appropriate study design and accuracy of the study in measuring the efficacy of the selected anesthetic techniques. There is lack of knowledge regarding allocation, concealment and blinding of the interventions. The details of allocation have not been mentioned by most researchers, leading to ambiguous results. The existing literature provides enough evidence to set Gow-Gates nerve block as a benchmark. The policy guidelines for Gow-Gates nerve block for irreversible pulpitis, however, should be developed to enable dental surgeons or dentists to develop appropriate support strategies. It recommends dentist training to use suitable anesthetic technique. The exhaustive search for literature, the explicit selection criteria used and the validity evaluation of the included trials show a thoroughness and a systematic approach to the conclusion reached.

Three studies used "Visual Analog Scale Heft-Parker" for pain assessment and two studies used "Visual Analog Scale" for pain assessment. Studies by Aggarwal et al., 2010, Ghoddusi J et al. 2018, Saatchi M et al. 2018 and Sharma R et al. 2018 included patients over 18 years of age, while Afridi R et al. 2019 included patients between 10 and 45 years of age, making the outcome less generalizable to the pediatric population.

Two studies had recruited patients from emergency pain management that require immediate treatment to relieve the pain. Saatchi M et al. 2018 and Sharma R et al. 2018 carried out randomized control trial. Saatchi M et al. randomized the sample size into three groups. The first group of patients were administered two cartridges of lidocaine 1:80000 through Gow gates nerve block technique, second group of patients were administered two cartridges of lidocaine 1:80000 via blocking inferior alveolar nerve technique and third group of patients were given one cartridge of lidocaine 1:80000 via Gow gate nerve block technique and other cartridge of lidocaine 1:80000 were given by blocking inferior alveolar nerve technique. The results showed combination of different anesthetic technique were more efficacious in anaesthetizing the region. The author recruited patients of 18 to 64 years and results might be reflected as pain threshold varies patient to patient and author did not specify what medical problems were excluded as efficacy of

anesthesia is affected with different medical conditions and old-age related problems like bone loss, gingival recession, lesser blood supply to the pulp. The results could be stratified among different age groups. One patient was found not effective with lip numbness. Also the tooth were not specified which could be reflected as a bias.

Sharma R et al. randomized patients into groups 1 to 4 namely, Gow-Gates block, Vazirani Akinosi closed mouth technique, Inferior alveolar nerve block with buccal infiltration of 2% lidocaine with 1:80,000 epinephrine and inferior alveolar nerve block respectively. The results showed that Gow gates technique has highest success in anesthetizing the pain followed by Vazirani Akinosi technique. In both studies, both techniques were used. However, one study showed higher success of Gow gates and other showed higher success of combination of two techniques. This could be due to age, pain threshold, and other systemic factors which were responsible for difference in anesthetic efficacy in both studies.

Aggarwal et al., 2010 also compared 4 types of anesthetizing technique to determine success of anesthesia. One group of patients were given Inferior alveolar nerve block with articaine 4%with 1:100,000 epinephrine, second group of patients were administered anesthetic solution via Gow-Gates mandibular block anesthetic technique, third group of patients were given anesthetic solution via Vazirani Akinosi closed-mouth technique and last the fourth group were administered buccal and lingual infiltrations with articaine 4% with 1:100,000 epinephrine. The study showed that inferior alveolar nerve block was most effective in reducing pain intensity after 15 minutes of the injections followed by buccal and lingual infiltrations. However, the study also showed that the highest success rate of type of anesthesia during whole treatment was with Vazirani Akinosi technique followed by Gow gates technique than inferior alveolar nerve technique and lastly buccal and infiltration technique. This is worth noticing that Gow gates was not much effective during initial stages of reducing pain as compare to other techniques however it lasted until the completion of the procedure in comparison with other techniques. It is because articaine penetrates in the bone and other two solutions wer not mentioned specifically.

On the other hand, Ghoddusi J et al. 2018 compared two techniques in terms of pain severity. The patients recruited had moderate to severe nature of pain in lower mandibular molar. The results showed that Gow gates nerve block technique subsided pain in more number of teeth as compare to inferior alveolar nerve bock technique. This is also worth noting that lip anesthesia was also effective with both techniques among patient having moderate to severe pain of irreversible pulpitis. The study also found that during treatment there was a need of supplementary buccal and lingual infiltration which could be due to severity of pulpitis pain. The importance of supplementary infiltration seems to have great impact in reducing pain severity and found statistically significant. The study also shows that anesthetize tooth responded to the pulp test resulting in vitality of the tooth. However, Afridi R et al. 2019 recruited patients between ages 19 to 45 years. The patients were randomized into two groups one group received inferior alveolar nerve block while other group Gow gates block. Both groups were administered 1.8 mL of 2% lidocaine with 1:100,000 epinephrine. The anesthesia was established by lip numbness, interdental probing, and electric pulp tester (EPT). The results showed that Gow gates technique is found better than inferior alveolar nerve technique. Both groups experienced lip numbness and absence of pain on interdental probing.

Patients who receive either of these two mandibular nerve blocks i.e., there is a difference in the pain experienced i.e. Gow-Gates nerve block or IANB. There is evidence of a higher efficacy of the Gow-Gates technique than the IANB. Each of the two techniques is equally easy to execute with training. Nevertheless, the technique required supplementary injections of infiltration during the treatment. The value of knowing how to perform the Gow-Gates nerve block is that the Gow-Gates technique will most likely provide satisfactory anesthesia for a specific patient in situations where the IANB will not. Knowing how to perform only one method to block the inferior alveolar nerve limits the ability of the dentist to provide consistently successful anesthesia and makes it more difficult for all patients to achieve the goal of pain-free dentistry. Knowing how to perform Gow-Gates technique, on the other hand, increases the likelihood that patients may be pain-free when undergoing mandible dental procedures

Patients who receive either of these two mandibular nerve blocks i.e. Gow-Gates nerve block or IANB, there is a difference in the pain experienced. There is evidence of a higher efficacy of the

Gow-Gates technique than the IANB. Each of the two techniques is equally easy to execute with training. The value of knowing how to perform the Gow-Gates nerve block is that the Gow-Gates technique will most likely provide satisfactory anesthesia for a specific patient in situations where the IANB will not. Knowing how to perform only one method to block the inferior alveolar nerve limits the ability of the dentist to provide consistently successful anesthesia and makes it more difficult for all patients to achieve the goal of pain-free dentistry. Knowing how to perform Gow-Gates technique, on the other hand, increases the likelihood that patients may be pain-free when undergoing mandible dental procedures.

When meticulously followed, both techniques give adequate anesthesia in posterior mandibular region. Gow-Gates technique requires greater skill compared to the standard technique. We feel that patient attempting to close the mandible or move the mandible during injection may have affected the outcome of the Gow-Gate technique and hence we recommend that a mouth prop can be placed on opposite side to maintain the fixed mouth opening during the procedure. Time taken for onset of anesthesia in Gow-Gates technique was greater than inferior dental technique and in some cases it was approximately 20 minutes so it is advisable for the operator to have patience and not to repeat the block. Postoperative comfort and patient's satisfaction was greater in Gow Gates compared to inferior dental nerve block technique. In all of the cases using Gow-Gates technique lingual, long buccal and inferior alveolar branches were anesthetized and single branch failure was not observed, signifying that once the Gow-Gates block becomes effective no supplementary block or infiltration required