An Investigation into the Desirable Level of Injection for Mandibular Anaesthesia by Comparison of the Conventional Technique and a Higher Level Technique Utilising Extra-Oral Landmarks

thesis by

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Presented to the Department of Anatomy, Faculty of Dentistry, University of Sydney for the Degree of Master of Dental Surgery

Sydney NSW 1993
In Memory of

Professor B.C.W. Barker

Scholar, Mentor and Good Friend
"The beautiful dream to eliminate pain has become fact; pain, the highest consciousness of our earthly existence, its clearest conception of the imperfections of our body, has to bow low before the powers of the human mind."

Diffenbach
ACKNOWLEDGMENTS

I wish to thank Professor Jolly and the Department of Oral Surgery, University of Sydney, for the use of the Exodontia Clinic at the United Dental Hospital to conduct this study and collate the data and to the Anatomy Department, who provided their invaluable photographic expertise.

I also express my appreciation to Dr J Collopy, who kindly allowed me the use of his surgery and his radiology equipment, and to Virginia and Neil, who helped with the radiological survey.

My thanks to Dr Peter Davies and to Dr Greg Doran for their help in completion of this Thesis.

Thanks to John Watson for the use of his photographic surveys.

Elizabeth and Sally, Megan and Val deserve special thanks for their willing help back stage. My thanks to Janet Youngson for her invaluable knowledge of the computer and typing skills.

Above all, I express my appreciation for the advice and encouragement I received from the late Professor B C W Barker, who was of immeasurable help as a source of suggestions, support and information.
SYNOPSIS

This thesis investigates the validity of the use of two Mandibular block techniques.

In depth anatomical dissections were performed to show the relative positions of the target areas. Clinical and radiographic procedures were completed to investigate the performance comparisons of both techniques.

In the clinical procedures two separate studies were performed involving students and patients and the following parameters were investigated; time of onset, first signs, depth of anaesthesia, extent of anaesthesia.
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CHAPTER I  INTRODUCTION

Regional anaesthesia is a vital tool for dentists and physicians. Its pre-eminence in pain control for restorative and surgical procedures in the mouth is demonstrated by its widespread use.

Just as much as pain itself, the fear of pain is a major factor influencing the patient-doctor relationship. From the patient's point of view, the anticipation of pain relief and the associated reduction in fear-related stress are almost as important as the alleviation of pain itself.

The immediate pre-operative prevention of pain is one of the major objectives of the dental practitioner - there seems to be general agreement that effective regional block, with the use of local anaesthetic agents can, in most cases, provide reliable protection against the pain associated with various dental procedures.

Without the availability of regional anaesthesia, much of dental treatment considered routine today would be difficult or impossible to perform.

Mandibular block anaesthesia is an extremely useful injection technique. This is because, with a single injection, all the mandibular teeth and associated soft and hard tissues on one side of the mandible can be effectively anaesthetised. However, the occasional failure to obtain successful, extensive and prolonged anaesthesia in the mandibular region has been a great source of concern to dentists.

William Halsted, at John Hopkins Hospital, U.S.A., in 1884 (23) was the first to apply a nerve block technique for the anaesthesia of the inferior alveolar nerve. Halsted used an intra-oral approach, directing the needle of the syringe posteriorly into the sulcus colli on the medial surface of the ramus of the mandible in the pterygo-mandibular space and then redirecting the needle to approach the site of the nerve from a more medial direction.

Halsted's method has since become referred to generally as the "indirect thrust technique".

A significant improvement of Halsted's approach was proposed by Ashley Lindsay in 1929 (1, 3). Lindsay used distinctive anatomical landmarks to determine the puncture point of the needle. The syringe was directed from a more medial direction in such a way that the needle tip could be placed at the intended site of deposition of the solution without the need to alter the direction of insertion.
Lindsay’s method has since become referred to as the ‘direct thrust technique’ and has been in common use in the dental profession since its introduction. Where the term ‘conventional’ is used in this thesis to describe a technique, method or approach, it refers to the ‘direct thrust technique’.

Irrespective of the method of application, occasional failures occur in attaining the depth, extent and duration of anaesthesia required. Application of the conventional technique results in a failure rate of between approximately 5% and 10% (4, 6, 19).

In 1973, George Gow-Gates (51, 52, 53) advocated a method he devised in 1945 and used as his routine technique. Gow-Gates (51) described a target area for the needle at the neck of the mandibular condyle, which is situated at a level substantially superior to the intended level of delivery with the conventional method. He stated that the inferior alveolar, lingual and buccal branches of the mandibular division of the trigeminal nerve are anaesthetised and that the effects are rapid and the anaesthesia complete. He also stated that use of the technique in 50,000 cases has produced a success rate of 100%. Gow-Gates has since modified his results and now states a failure rate of up to 5% and a time of onset of up to 10 minutes.

The results produced by Gow-Gates appear most impressive and indicate his technique to be more efficient and effective than the conventional approach. These results are in need of confirmation and there appears to be a need for a critical evaluation of the Gow-Gates technique with a view to assessing its value as a preferable alternative to methods already in clinical use.

The objective of this investigation is to perform such an evaluation by two approaches; firstly, a study by clinical results of the Gow-Gates and conventional methods are compared, and secondly, a study of the anatomical rationale for both approaches can be assessed and compared. Detailed objectives of the study are presented hereunder.

A plethora of publications exist on various aspects of inferior alveolar nerve block techniques - the majority of these have little or no relevance to the specific subject of this investigation. Only publications of relevance are referred to in this thesis.
1.1 OBJECTIVE

The overall objective of this study is to make a comparative evaluation of the two techniques of administration of the inferior alveolar nerve block: Lindsay's direct thrust (conventional) method (1, 3) and the Gow-Gates’ technique (51, 52, 53).

Three separate approaches are necessary in order to fulfil the clinical, anatomical and radiographic requirements of such an evaluation.

The objective of the clinical approach is to make a comparative assessment of the efficiency and effectiveness of the two methods by their clinical application and comparing the time of onset, extent and depth of anaesthesia obtained.

The anatomical objective is to review the results of a dissecting program, conducted by the author, of the pterygo-mandibular space to demonstrate the relationship of structures relevant to the respective target areas of the two techniques.

The objective of the radiographic study is twofold:

i) To identify the location of the needle relative to the mandible using the external landmarks devised by Gow-Gates and to demonstrate whether the external landmarks consistently indicate the target point intended by his method.

ii) To investigate the pattern of flow of the anaesthetic solution administered by the two different techniques.
CHAPTER II  REVIEW OF LITERATURE

2.1  HISTORY OF LOCAL ANAESTHESIA

Chemical regional anaesthesia followed two medical advances: the first was the development of appropriate drugs and the second, the invention of a safe and accurate means of delivering the drugs.

The first to develop chemical anaesthesia was Fredrick Wilhelm Sertumer (1, 54), who in 1803 isolated an active principle from a plant extract: opium (poppy) seed. Morphine was developed and named. This was the first step towards the isolation of chemical substances that exercise a direct anaesthetic effect on the human body.

The injection of substances directly into the bloodstream was made possible by Sir Christopher Wren’s invention of the hypodermic syringe in 1821 (1, 54). Together with Christopher Boyle, a well-known chemist of the time, Wren prepared a sharp quill and attached it to a syringe. This assembly was inserted into an incised vein in a dog’s leg. Through this assembly, opium was injected and the dog was ‘stupefied’, proving that active substances introduced into the body have a local and general effect on the system.

Although in 1827 Von Neurer (54) invented a syringe to introduce fluids into animals’ eyes, there was still no reliable method of giving hypodermic injections.

The modern hypodermic syringe was invented in 1841 by Zephor Jayne of Illinois (54). It had a hollow pointed tip but was introduced under the skin through an incision made with a lancet. Frances Rynd of Dublin (54) refined the instrument by introducing the hypodermic needle. In 1884 he used it to inject a solution of morphine acetate in order to treat a patient with trigeminal neuralgia.

In 1853 the French veterinary surgeon, Charles Gabriel Pravos (54), invented an all-metal syringe. Equipped with a small trocar and cannula, it was suitable for hypodermic injections. An injection was given by rotating a screw piston rod to allow very small doses to be given accurately.

At about the same time, Alexander Wood of Edinburgh (54) invented a glass syringe incorporating a piston rod. The end of the barrel had a conical metal adaptor with a screw on to which fitted a thick hollow needle. Wood later improved the instrument by making a more finely-bevelled, pointed needle and by marking the barrel with graduated divisions.
On October 16, 1846 Boston dentist William T.G. Morton (23), at Massachusetts General Hospital, successfully demonstrated surgical anaesthesia using the drug, nitrous oxide inhalation creating a worldwide interest in pain control.

Since that time research has progressed rapidly. The first truly effective method of producing regional anaesthesia used the drug cocaine. In 1855 Gaedche (54) isolated an alkaloid from the leaves of the cocoa plant.

In 1859 Albert Niemann (54) improved the extraction process and obtained the alkaloid in crystalline form. Newman named the drug cocaine - the ending, "ine", indicating the alkaloid nature of the chemical. General usage has turned "caine" into a suffix designating a local anaesthetic.

In 1884 Sigmund Freud (54) investigated the physiological effects of cocaine and noted its anaesthetic properties. In the same year, Carl Koller conducted a successful experiment using cocaine anaesthesia (54). Koller injected 5% solution into the eyes of rabbits and dogs and found that the cornea could be scratched without any reflex reaction.

The potential use of cocaine in dentistry was first demonstrated by William Halsted (23), a general surgeon. The inferior alveolar nerve of fellow physician, Dr. R. Hall, was blocked for the extraction of a mandibular tooth. The operation was successful. Dr. Halsted performed the mandibular block at Bellevue Hospital exactly 40 years after nitrous oxide had been used for the same purpose on Dr. H. Wells by Dr. John Riggs.

By this stage the concept of anaesthetising an area to perform minor surgery or dental work was well accepted. However, there were problems due to cocaine’s toxicity and/or addictiveness, particularly as the duration of anaesthesia was very short and it was necessary to inject large quantities of cocaine, with potentially severe side effects.

In 1901 Heinrich Brown, a German professor, discovered that epinephrine could be used as a 'chemical tourniquet', inducing the contraction of blood vessels. When added to a solution of cocaine this drug would decrease the rate of absorption, thus prolonging anaesthesia and lowering the dosage of cocaine required.

Because of cocaine’s toxicity, chemists turned their attention to the isolation of the molecules responsible for the anaesthetic effect. After developing many synthetic anaesthetics that were suitable only for topical use, Alfred Einhorn of Munich finally developed procaine in 1905 (49, 54). This discovery marked the beginning of synthetic chemical anaesthetics. Procaine was immediately accepted as the local anaesthetic of choice.
In 1943, a Swedish dentist, Nils Lofgren, synthesised lidocaine, the first amide local anaesthetic. More potent and less allergenic than procaine, this substance continues to be one of the most popular anaesthetics (54).

Concurrent with the development of better local anaesthetic drugs, there was a search for a better means of delivering the solution to the target area. In 1890, Edward Briggs introduced a high pressure syringe for pulpal anaesthesia. A series of high pressure syringes followed but this method was far from successful and the technique fell into disrepute.

In England, intraosseous injections with high pressure syringes were introduced. The best known were Genthorpe’s syringes, marketed in 1912. The intraosseous technique was found to be far more effective in obtaining adequate pulpal anaesthesia and has been in use ever since (54).

During World War I, Harvey Cook conceived the idea of a cartridge-loading syringe. Introduced circa 1921 by Cook Laboratories, it has become the most common syringe used in dentistry (1, 49, 54). Cook Laboratories followed this in 1947 by the invention of a screw-type cartridge which facilitated easy aspiration before injection.

In 1957 Cook-Waite introduced the harpoon aspirating syringe. Two years later, reports of hepatitis transmission by contaminated needles prompted the company, Cook-Waite & Roche, to market the sterile disposable needle.

2.2 CAUSES OF FAILURE IN BLOCK ANAESTHESIA

Dental literature is replete with examples and suggestions of causes of failure to achieve anaesthesia of the inferior alveolar nerve. Amongst these, the most common causes of failure are anatomical variations.

2.2.1 Anatomical Variation

Whilst the inferior alveolar nerve appears to be almost devoid of any variation and it is certain that its path through the pterygomandibular space is constant, anatomical variations involving nerve branches such as the long buccal nerve, mylohyoid nerve, lingual nerve and auriculotemporal nerve have been the subjects of much research.

Accessory innervation of the mandibular field is presented by Sutton (24), Jeffries (18), Rood (11, 12), Faier (10), Frommer, Mele Monroe (44) and Angelman (36) as a major cause of failure to achieve complete anaesthesia of the mandibular field.
In extensive studies of the long buccal nerve, Angelopoulos (28) found several alternative derivations and courses. He notes that the nerve may arise from the Gasserian ganglion and exit the cranial cavity through its own foramen. This would place the long buccal nerve in a very superior position well away from the target areas for the inferior alveolar nerve block.

Ward found that the long buccal nerve may arise as a branch of the inferior alveolar nerve, emerging from the mandibular canal by a small foramen in the alveolar bone just distal to the third molar. He comments (27) that invariably in this situation the long buccal nerve supplies the last molar tooth.

Like Angelopoulos, Lindsay (17) found the long buccal nerve to be absent in rare cases and found that in these situations a branch of the posterior superior alveolar nerve would supply the buccal field. In these situations neither an inferior nerve block technique nor a buccal infiltration would successfully anaesthetise the whole buccal field.

Angelopoulos also found that the auriculotemporal nerve sent branches to bone just lateral to the third molar. This suggests that this nerve may help in the sensory supply to this tooth.

As in his anatomical research, Lindsay found similar variations of the long buccal nerve. Despite numerous dissections, Sloman (33) was unable to find any variation in the anatomy of the long buccal nerve and found it to be a most constant structure. He also found evidence to suggest that the long buccal nerve would not supply any of the posterior mandibular teeth.

The accessory foramina on the medial and lateral surface of the bony mandible have been surveyed by Sutton (24). He determined that the mylohyoid nerve, facial nerve, lingual nerve and the transverse cervical nerve may all enter the mandible to aid sensory supply to the mandibular teeth.

Rood (11) postulates the presence of a mandibular plexus originating from the inferior alveolar nerve but being supplemented by the mylohyoid, lingual and cutaneous colli nerves.

Frommer et al. (44) have shown histologically that the mylohyoid nerve contains fewer fibre elements at its entrance to the mylohyoid muscle than it does at its origin from the inferior alveolar nerve. Their findings suggest that branches leave the mylohyoid nerve along its course and enter surrounding tissue and possibly the mandible through the many foramina visible on the lingual aspect of the body of the mandible.
As will be seen later, anatomical variations in the dimensions of the mandibular bone and a major factor in the success of the local anaesthetic technique. Also soft tissue variation such as muscle thickness, presence and extent of fatty tissues play a role in anaesthetic success or failure.

2.2.2 Needle Deflection

The possible deflection of the needle as it progresses through tissue has been studied by Aldous (35) and Dover (9) as another cause of failure to effect a block. Using x-ray surveys, Aldous proved the occurrence of needle deflection through tissue and showed that deflection could be extensive, depending on the type of tissue encountered. The extent of deflection occurring through muscle tissue is naturally greater than that incurred when traversing adipose tissue. For mandibular block techniques Aldous recommended as a minimum, a 27 gauge needle and a Huber point.

2.2.3 Anaesthetic Solution

Modern anaesthetic solution contained in cartridges is of consistently good quality. However, care must be taken with storage, since heat over a long period can cause deterioration of the solution.

Whilst modern technology ensures that the incidence of defective solutions is infrequent, the possibility of such an occurrence must be kept in mind.

The incidence of intravascular injection of local anaesthetic solution is a well recorded factor in the failure of the mandibular block. Throughout literature, the variability of results reveals that a combination of anatomical variations and operator's technique produces results which vary from 3.6% to 18% positive aspirations.

Harris (19) warns that if blood is aspirated into the cartridge it should be discarded, since the local anaesthetic solution/blood mix produces precipitates that render the solution inviable. He also associates an increase in failure rate with the incidence of untoward patient reactions resulting from rapid absorption of local anaesthetic solution into the blood stream.

Frye (21) also recommends that anaesthetic solutions contaminated by blood be discarded and advocates exerting gentle pressure when aspirating, as a forceful technique may aspirate the blood vessel wall and prevent the flow of blood into the lumen of the needle. This would result in a failure to exhibit a positive aspiration and thereby deposition of the anaesthetic solution into the blood stream.
2.2.4 Psychology

Dover established other possibilities for failure arising when the patient is resistant to local anaesthetic solution or the anaesthetic solution is metabolised at a greater rate, thereby reducing the effectiveness of the solution, producing either incomplete anaesthesia or symptoms of anaesthesia of limited duration.

Another issue raised by Dover is the variable of patient subjectivity based on the part that fear and anxiety play in dentistry. He notes that a patient suffering increased stress may well interpret vibration as pain.

Under these circumstances, even though there is clinical anaesthesia of the soft and hard tissues of the mandible, the block has failed because the patient senses pain. The use of calming explanation and oral sedation or nitrous oxide sedation is of great benefit in these circumstances.

2.2.5 Physiology

An understanding of the physiology of nerve impulse progression is important to the explanation of potential causes of failure.

A popular misconception, as cited by Jeffries (18), is that the inferior alveolar nerve has a cable structure, with the inner fibres supplying more anterior structures while peripheral fibres supply more proximal structures.

Another hypothesis propounded is that nerve fibres exist in distinct fibre bundles, which supply discrete areas of the gingival tissue or parts of a tooth; that the innermost fibres of the main trunk of the nerve supply the molar teeth, and that the more superficial fibres supply the soft tissue and anterior teeth.

Jeffries states that incomplete saturation of the nerve trunk may be an important cause of failure to achieve complete anaesthesia. He suggests that complete anaesthesia cannot occur when the local anaesthetic solution does not penetrate to the innermost fibres.

In 1978 J.P. Rood (32) completed an extensive histological study of the inferior alveolar nerve. He concludes that there is extensive interconnection between funiculi of the trunk of the inferior alveolar nerve; that the funiculi arrangement is similar to other peripheral nerves and that a simple cable arrangement does not exist. He states that it is highly unlikely that sensations from the molar teeth would be propagated only by central fibres of the inferior alveolar nerve trunk.

Rood found that branches joining the main trunk are at first peripherally placed, but remain as discrete units for only short distances.
These remarks suggested that the fibres in peripheral nerves are placed irregularly within the nerve trunk.

Two other physiological phenomena have had an important influence on the successful anaesthetisation of the nerve trunk. These are described by Ward (27) and Katz (48) as 'facilitation' and 'summation'.

Facilitation occurs when the resistance of any given pathway to nerve impulse is overcome by a powerful stimulus.

Because synapse resistance is reduced, the pathway can be used with greater ease by succeeding stimuli. This phenomenon is often exhibited in dentistry as the 'hot pulp' syndrome, i.e. pulpal tissue that has become so irritated it is almost impossible to anaesthetise.

Summation is the cumulative effect of repeated stimulation on nerve tissue, ultimately allowing impulses to progress along nerve pathways.

The predominant cause of failure in physiological terms occurs when insufficient length of the nerve is bathed in local anaesthetic solution. In such circumstances, impulses, especially those influenced by summation or facilitation, may jump the blocked segment, presumably because of spread of electrical current across treated segments.

Condouris & Kiraly (37) state that the prevention of anaesthesia is a function of three elements:

a) the potency of the anaesthetic solution;

b) the concentration of the solution applied to the nerve; and

c) the length of the segment bathed in anaesthetic solution.

Rood (11) goes further to state that 1.2ml of 2% anaesthetic solution is the effective volume of solution to be applied. The concentration of 2% is, in his opinion, also an optimum value of concentration.

Rood also suggests that in the myelinated fibres within the inferior alveolar nerve, the internodal distance is 1.8mm. Considering the function of saltatory conduction, especially when influenced by summation, at least a 6mm length of nerve fibre needs to be bathed by local anaesthetic solution.

Studies by Galbreath & Eklund (8) and Berns & Sadove (6) in their radiograph studies found that when local anaesthetic solution flowed along a path that followed the nerve trunk in an inferior direction, the solution covered a considerable length of the nerve and anaesthesia was deemed successful.
The volume of local anaesthetic solution is also of importance. When isolated
erve studies were carried out in a laboratory situation, increasing the volume of
a dilute solution was shown to increase the effectiveness of the anaesthesia.
However, once the effective volume was attained, no further benefit could be
achieved.

The volume of 2% lignocaine solution with adrenalin necessary to induce a
satisfactory dental nerve block has been said to vary between 0.5%ml (58) and
2.0ml (49). Clinical studies (11) have supported 1.0ml as the minimum effective
volume, below which consistent success cannot be expected. This correlates well
with studies involving measurements of internodal lengths, in relation to volume
required and length of nerve trunk to be bathed in anaesthetic solution.

Increasing the volume of fluid injected into the pterygomandibular space beyond
1.0ml can cause a large rise of pressure within the tissue, which may allow fluid
to escape from the boundaries of the space by disrupting the tissue planes,
particularly if injected quickly.

Therefore, to achieve a successful nerve block the anatomy of the region must
be carefully considered, in conjunction with the physiology of nerve impulses and
with correct technique.

Perhaps one of the most common causes of failure in mandibular anaesthesia is
the incorrect use of the desired technique of anaesthesia.

The different reactions that occur when either a nerve, artery or vein is
contacted or perforated are described by Westwater (20). He observed, as noted
in this study, a similar reaction of the nerve to contact or perforation, i.e. the
patient will respond with sudden electric shock to the area that is supplied by
that nerve.

In these circumstances, Westwater observed, as noted in this study, that excellent
anaesthesia resulted within a short period of time. Thus, when the solution is
deposited in close proximity to the nerve, excellent anaesthesia will undoubtedly
result.

Westwater noted that a burning pain in the area of injection was experienced
when an artery was pierced. This sensation was usually followed by a blanching
of the tissue in the region of supply of that artery. The above information
suggests that, contrary to Gow-Gates' findings, arteries, including the maxillary
artery, can be punctured.

This is more likely today because of technical advances in needle construction,
relating especially to improved tips and the fact that needles are now used only
once.
According to Westwater there is no significant recordable experience of pain when veins are contacted or pierced. Westwater states that traumatisation of the pterygoid plexus of veins, which is a fragile structure, will result in extensive haemorrhaging into the tissue undoubtedly causing trismus.
2.3 MEASUREMENTS OF THE MANDIBLE IN RELATION TO THE TARGET AREA

"The degree of success in obtaining a block of the inferior alveolar nerve depends upon the accuracy with which the injection is given, and only then when the technique is followed precisely." Cook (16).

However, in the introduction of their paper concerning the inferior alveolar nerve block, Murphy & Grundy (5) comment that the dental clinician is confronted by advice which can only be described as 'wildly conflicting'.

A review of available literature adds substance to that claim. Whether they are writing about the incidence of failure, problems in locating the target area or any of the many other causes of failure, dental authorities are widely divergent in their views.

In writing about techniques for the inferior alveolar nerve block, Harvey (26) notes that the incidence of failure has been variously quoted at 29% Jeffries, 1944 (18); as 12-22% Gastein, 1969; and as 18% Glasgow Dental Journal, 1966 (26); while Bremer (4) claims a 15% failure rate.

Harvey comments that advice relating to the implementation of the alveolar nerve block cites as many as eleven different points of entry for the needle, six horizontal bearings, eight vertical bearings, eleven depths of penetration, nine positions of the foramen and twelve target areas!

Of all the many stated causes of failure: inflammation, problems with solution, faulty techniques, inco-ordination, deflection of a fine needle, intravascular injection, the weather, impatience, additional innervation, the position of the lingula and anatomical variation, it is the latter which is considered to be the most crucial.

Combined with a lack of knowledge of anatomy, Harvey contends that anatomical variation leads inevitably to faulty technique. Ward (27) states:

"The art of local anaesthesia by injection must be based on sound anatomical knowledge.

General principles may be laid down for the various techniques, but there are no rule-of-thumb methods for obtaining immediate successful anaesthesia.
The technique has to integrate individual anatomical structures and, owing to their variation, cannot be performed by measurements, but only by selecting landmarks which are correlated to each other so that their recognition makes the operator independent of their variation".

In attempts to reduce the risk of failure, many researchers (4, 5, 7, 16, 25, 26, 33) have explored the anatomy of the pterygomandibular space and making important contributions to dental anatomy by accurately measuring the dimensions of the medial surface of the ramus, which is the target area for the mandibular block injection. Some have used radiopaque dye injection techniques to discover the path of anaesthetic solution injected into the pterygomandibular space (6, 8, 29).

The research determined that three important features of the ramus of the mandible assist in achieving the correct target area for the conventional block technique:

a) Coronoid notch of the anterior border of the ramus;
b) Mandibular occlusal plane, if sufficient teeth are present; and
c) Anteroposterior width of the ramus at its narrowest point.

Studies show that the depth of the coronoid notch and the plane through the narrowest dimension of the ramus are essentially similar in their anatomical parameters.

Harvey (26) states that in a large percentage of cases, the plane passing through the depth of the coronoid notch and the narrowest part of the ramus also passes through what he describes as the lingual notch. Lying between the ramus of the mandible and the lingula, this notch is immediately anterosuperior to the mandibular foramen. Alternatively, according to Bremer (4) the coronoid notch is level with, and not above, the lingula. Bremer notes that the lingula is above of the level of the coronoid notch in only a small percentage of cases.

On examining the relationship between the target area and the mandibular occlusion plane, Bremer concludes that the occlusal plane is an extremely variable landmark to the target area. He determined that, whilst the lingula is usually an average of 4.9mm above the occlusal plane, he found that in 4.8% of cases the lingula lies higher than 10 mm above the occlusal plane. In a small percentage number of cases he has also found the lingula below the occlusal plane.

Therefore, Sicher's (14) average measurement of the lingula as 3-4mm above the occlusal plane, is unacceptable to Bremer.
In their research, Jorgensen & Hughes (7) have found that the depth of the lingual notch lies on a plane which is level with the occlusal plane. This finding is in accordance with Bremer’s opinion that the lingula lies above the level of the occlusal plane.

Harvey (26) has also found the mandibular foramen to be above the occlusal plane in 6% of cases, level with the occlusal plane in 16% of cases and below the occlusal plane in 79% of cases measured.

Dismissing the occlusal plane as a suitable landmark, Cook (16) explains that it cannot be used to determine the height of the target area. Rather, he states that by bisecting the height of the ramus the vertical position of the sulcus will be determined.

The depth of insertion has been found to be another extremely variable measurement. Jorgensen & Hughes (7) state that the distance from the anterior border of the ramus to the lingual notch varies from 10-20mm; Bremer (4) states that the distance from the mucosal surface to the mandibular sulcus is a variable measurement. He is able to express the distance only by a mean measurement of 23.6 +/- 0.17mm.

Stating that it is impossible to determine a constant for the depth of injection, Cook (16) suggests that two thirds of the width of the narrowest part of the ramus be considered the target point, but stresses that the tissue quality and thickness may vary greatly.

From several dissections of the pterygomandibular space, Murphy & Grundy (5) determined that the depth of needle penetration should be targeted to a point 1.8 to 2cm from the anterior border along the width of the ramus.

Confirming that the distance from the mandibular foramen to the anterior border of the ramus is an extremely variable measurement, Baloug & Csiba (25) have determined five different relationships between the lingula and the mandibular foramen which make the approach to the conventional target area very difficult, including cases presenting a posteriorly facing foramen or an unusually high lingula.

Research conducted by Galbreath & Eklund (8), Berns & Sadove (6) and Fox (29) reaches strikingly similar results, all remarkably close to those achieved in this study.

All the research concludes that anatomical variability affects the clinician’s ability to readily locate landmarks, rendering the ‘target area’ principle of injection problematical unless it is based on a sound knowledge of anatomy.
In their study of mandibular block injections, Berns & Sadove (6) state that they failed to achieve adequate anaesthesia in 25% of cases, even though the needle point was accurately positioned. Such findings have led to studies of the flow of anaesthetic solution. All the authorities concur that the solution adopts the path of least resistance, that path being determined largely by the fascial planes and the structures encountered.

In an anteroposterior view, the path taken by the solution is a facsimile of the pterygomandibular space. There is a tendency towards sigmoid distribution of the solution in the pterygomandibular space, with the anaesthetic progressing in a superior path posteriorly and spreading antero-inferiorly by a tail (6).

Explaining that different solution patterns are unrelated to either the needle position or the success or failure of the mandibular block, Galbreath & Eklund (8) nominate the fascial planes in the pterygomandibular space as of primary importance and describe them extensively. (See also the Anatomy Chapter 3 of this thesis, p.21.)

Both the study by Berns & Sadove (6) and that by Galbreath & Eklund (8) show that the needle point must be as close as possible to the foramen. Accurate needle placement ensures that the nerve trunk is bathed in anaesthetic solution. Fluids move from areas of high concentration or pressure to areas of lower pressure and that diffusion tends to follow fascial planes.

Fox (29) has found that anaesthetic solution may leave the pterygomandibular space anteriorly, seeping between the temporalis muscle and the internal pterygoid muscle, or seeping medially between the medial pterygoid muscle and the superior pharyngeal constrictor, or posteriorly toward the pharynx. The above literature supports the view that anatomical variation significantly affects the probability of achieving successful anaesthesia.

2.4 ALTERNATIVE TECHNIQUES

Since the development of the inferior alveolar nerve block early this century, many techniques have been devised to simplify or improve the standard technique.

The most notable technical advance has been Lindsay's development of the direct thrust technique (17), well described and simplified by several authors, notably Nevin (3), Chaikin & Rubin (39) and Smith (1). All describe a technique for depositing local anaesthetic solution in the sulcus colli just above the level of the lingula, the syringe approaching the target area from the contralateral canine/premolar area.
Many variations of this ‘direct thrust’ technique have been advocated. Atkins (47) and Vazirani (43) have independently developed a closed mouth technique by which sulcus colli is entered above the target area of the conventional block and the three branches of the mandibular nerve are anaesthetised in a single straight line injection. They reach the same conclusion: that the technique is less traumatic to the tissues and to the patient. They state that this technique is of great advantage in the treatment of patients who cannot open their mouths, as in cases of accident fracture or lockjaw.

Both clinicians claim to achieve a greater success rate than with the conventional block. The technique requires the mouth to be comfortably closed, with the cheek on the side to be injected fully distended. The syringe is aligned with the maxillary gingival margin so that the barrel is parallel with the occlusal plane of the maxillary teeth. The syringe is advanced so that the needle penetrates the embrasure between the vertical ramus and the maxillary tuberosity. The needle touches bone on the posterior wall of the sulcus colli.

In a study of the dimensions of the ramus of the mandible, Menke & Gowgiel (42) determined that the overall average length from the anterior border of the ramus to the lingula is 16mm. They contend that there is no need to use a long needle, with its propensity to deflect easily and the attendant risk of piercing vulnerable structures such as the parotid gland.

In a further attempt to simplify the closed mouth technique, Aksoy (59) developed a guiding tube with a projecting lug designed to rest on the anterior surface of the ramus of the mandible. The long, 25 gauge needle is passed through the tube of the appliance until the hilt of the appliance locks over the hub of the needle. To determine the height of the injection, following palpation, the lug is gently placed against the tissue in the depth of the coronoid notch.

Aksoy recommends using a curved needle to facilitate a straight-line approach to the target area and to ensure contact with bone at the desired depth of injection.

Of particular interest to this study are techniques advocating a higher target area. In 1959, Clark & Homs (46) intimated that the major cause of failure to achieve mandibular anaesthesia was anatomical, relating to variations in the height of the lingula and the level of mandibular foramen on the medial surface of the ramus.
Their technique, as follows, was devised to overcome this problem.

"The patient is required to maintain the mouth in a wide open position. The dentist's index finger is placed on the occlusal surface of the mandibular teeth with the palmar surface facing lingually. The depth of the coronoid notch is palpated as a secondary landmark. Since the puncture point is above the level of the finger, the injection achieves a target about one centimetre higher in the vicinity of the sulcus colli the nerve lies free of the bone."

It can be assumed from their description that the needle point is then approaching the neck of the condyle approximately at the level of the Gow-Gates technique.

In 1956, Viegas (40) developed a technique using the corner of the mouth and the occlusal plane of the maxillary teeth as guides to the puncture point. He states that the point of penetration lies in the superior third of the pterygomandibular depression. Again, this technique is similar to Gow-Gates'.

In 1977, Schechtman (45) described a technique involving a higher puncture point and target area achieved by approaching the sulcus colli from the same side. The technique requires that the dentist's index finger be placed on the occlusal surface of the mandibular teeth with the patient's mouth wide open. The barrel of the syringe is placed over the index finger and the needle progresses through the pterygomandibular space to contact bone in the superior part of the condylar process. The puncture point is in the superior part of the pterygomandibular depression just medial to the internal tendon of the temporalis.

All the above techniques demonstrate the need to achieve an accurate method of injection but it was found that the techniques vary as the anatomy of the area varies, thus excluding the possibility of developing a single, reliable, unvarying technique.
CHAPTER III  ANATOMICAL REVIEW

3.1. IMPORTANCE OF KNOWLEDGE OF ANATOMY

A complete understanding of mandibular nerve anaesthesia is impossible without a knowledge of the anatomical area and structures involved. The occasional failure to obtain satisfactory anaesthesia of the region is often attributed to a lack of knowledge of the anatomy of the pterygomandibular space and the disposition of the structures involved.

The purpose of this chapter is to compare the anatomical features of the target areas of the conventional method and the higher Gow-Gates’ technique. In particular, the probable reasons for success or failure to achieve anaesthesia at the particular target area are detailed and the inherent dangers and viability discussed.

The descriptive and applied anatomy of the pterygomandibular space has been described extensively by authors such as Sicher & DuBrul (14), Barker & Davies (13) and Shields (15). Interestingly, Shields approaches the area from the medial aspect, which has been the dissection approach used by the author.

3.2 INTRA-ORAL SOFT TISSUE LANDMARKS

The pterygomandibular depression, being the injection site for both techniques, has an inverted triangular shape with the apex at the retromolar region of the mandible. The deep tendon of the temporalis muscle forms the lateral boundary of the pterygomandibular depression and is attached to the temporal crest (Crista Pharyngea) and the coronoid process [Figs. 19, 25], as described by Barker & Davies (13). In the stretched open mouth situation this structure is readily discernible and easily palpated.

As described by both Barker & Davies and Shields (15), the tendon varies in thickness and may on occasion bulge considerably, narrowing the opening into the pterygomandibular space.

The medial boundary as seen in the oral cavity is the pterygomandibular fold [Figs. 5, 6]. Immediately posterior to the fold is the medial pterygoid muscle, which extends from the medial pterygoid plate to the medial surface of the ramus of the mandible behind the third molar tooth.

The relationship between the fold and the medial pterygoid muscle changes in the vertical plane. Superiorly, the muscle lies medial to the fold, while inferiorly the muscle inclines laterally to the fold on its course to an insertion at the angle of the mandible.
The superior boundary of the pterygomandibular depression is the mucosal fold of the posterior aspect of the maxillary tuberosity.

The boundaries of the pterygotemporal depression are clearly seen when the musculature is stretched between its bony attachments in the open wide position [Fig. 6].

The puncture point for the conventional direct thrust technique is slightly medial to the deep temporalis tendon approximately midway vertically between the maxillary and mandibular arches, with the needle approaching from the direction of the canine/premolar region on the opposite side [Figs. 5, 6].

The landmarks used to determine the height of the injection site are the occlusal plane of the mandibular teeth, the depth of the coronoid notch and the buccal pad of fat.

The buccal pad is a thick submucous layer of fibrous tissue separating the buccinator from the oral mucosa situated lateral to and behind the molar teeth. It has a triangular shape, with superior and inferior margins converging at a blunt apex which closely approaches the pterygomandibular fold and which lies near the maxillary third molar teeth when the mandible is depressed.

In this position the apex of the buccal pad can lie 14 to 22mm above the mandibular occlusal plane. Applying Bremer's (4) data, it is apparent that a needle inserted at the apex may lie 10 to 15mm above the lingula approaching the target of the Gow-Gate technique, and the possibility of involving maxillary vessels is greatly increased.

In most cases, by use of the occlusal plane of the mandibular teeth, the depth of the coronoid notch and the buccal pad will locate the height of the injection as just above the lingula on the medial surface of the ramus of the mandible. However, as was shown by Bremer (4), these landmarks are not constant.

In a study involving the measurement of 88 mandibles, Bremer demonstrated that there was considerable variability in the relationship between the apex of the lingula and the occlusal plane of the mandibular teeth.

Bremer also warned that the concavity of the coronoid notch should not be considered as a totally reliable indicator of the level for needle insertion. In his study, Bremer found that in 35 mandibles the concavity coincided with the level of the lingual apex; in 35 it was above the apex; in 17 it was 1mm below the apex; and in one mandible it was 4mm below the lingula.
This suggests that care must be taken with palpation of the coronoid notch, which is the deepest point of the concavity of the anterior border of the ramus of the mandible. The concavity may be concealed to a varying degree by the attachment of the superficial temporal tendon [Figs. 19, 20, 25]. Clinical palpation often gives a level a few millimetres inferior to the deepest point of the bony concavity, producing a puncture point below the level of the lingual apex.

Fig. 5 shows the puncture point determined by the above specifications and also the angulation of the syringe used throughout the experiment.

Whilst the intra-oral features detailed above are also important for the Gow-Gates technique, his technique uses extra-oral landmarks to achieve the intra-oral puncture point. Although Gow-Gates’ landmarks clearly indicate the height of the injection, they do not give any information as to the horizontal position of the puncture point.

The alignment of the corner of the mouth in the wide open position and the superior border of the intertragic notch of the ear [Figs. 8, 9] are necessary to locate the puncture point. The puncture point lies medial to the medial tendon of the temporalis and just below the last maxillary molar tooth. If the maxillary molars are absent the puncture point lies below the maxillary tuberosity in the most superolateral corner of the triangle of the pterygotemporal depression [Fig. 10].

The syringe should approach the target area from the opposite canine-premolar region. A comparison of the two techniques shows that the Gow-Gates technique provides a superior and more lateral puncture point. The angulation of the syringe to the occlusal plane differs in the respective techniques. In the conventional technique, the syringe lies on the same plane as the mandibular occlusal plane; in the Gow-Gates technique, the syringe is aligned superiorly, away from the mandibular occlusal plane at an angle of approximately 30 degrees.

3.3 RAMUS OF THE MANDIBLE - THE BONY TARGET AREA

The medial surface of the ramus of the mandible is the target area for both techniques. The following landmarks on the medial surface of the ramus are important, as knowledge of these points assists the clinician in manipulation of the needle point to the correct bony position.

For the conventional technique the anterior border of the ramus [Figs. 2, 3) is palpated to determine the height of the puncture point. Care must be taken to avoid misinterpreting the attachment of the superficial tendon of temporalis muscle. The varying thickness of this tendon tends to obscure the depth of the coronoid notch, making it difficult to palpate correctly. The attachment of the
superficial tendon extends inferior to the concavity of the notch. Therefore the use of this landmark could result in placing the needle point at a position inferior to the level of the lingula, resulting in failure to achieve anaesthesia.

The bony ridge known as the temporal crest on the coronoid process functions as the attachment of the deep tendon of temporalis muscle. This most lateral boundary of the pterygotemporal depression is an important landmark for both techniques. The tendon is quite easily palpated and in some cases creates a visible prominence in the oral cavity [Fig. 10].

The inferior limit of the target area is represented by the lingula and the mandibular foramen. These structures give attachment to the sphenomandibular ligament and the interpterygoid fascia, which act as a barrier to local anaesthetic solution deposited inferior to that level [Fig. 17].

The lingula is a small bony projection lying anterosuperiorly to the mandibular foramen and serving as the attachment for the sphenomandibular ligament. The inferior alveolar nerve and vessels enter the mandible through the mandibular foramen and beyond this point are inaccessible to deposition of local anaesthetic solution [Fig. 17]. Since the sphenomandibular ligament is also attached to the inferior margin of the mandibular foramen, deposition of anaesthetic solution inferior to this attachment will result in failure to achieve anaesthesia.

The groove of the mandibular neck (sulcus colli) is the target area of the conventional block. In the wide open mouth position the inferior alveolar nerve lies parallel and in close proximity to the lower portion of this groove.

The nerve approaches the ramus of the mandible from the trunk of the mandibular nerve and emerges into the space from deep to lateral pterygoid muscle, gradually attaining a closer relationship to the sulcus colli [Fig. 17, 20, 21].

The area in which the anaesthetic solution is deposited is shown in Figs. 17, 28, 29. In this position the nerve can most readily be bathed in anaesthetic solution to achieve complete anaesthesia.

The anterior surface of the neck of the mandibular condyle is the target area for the Gow-Gates technique. It is separated from the sulcus colli by the ridge of the mandibular neck (crista endocondyleoida) [Fig. 17].

In the wide open mouth position, the inferior alveolar nerve has a closer relationship to the neck of the condyle in the coronal plane, but the nerve inclines medially and posteriorly on its emergence from the mandibular foramen to pass
medially to the lateral pterygoid muscle, establishing a distant relationship with the condylar neck. That is, the inferior alveolar nerve is at its most distant medial point at the level of the neck of the condyle.

The lateral pterygoid muscle is attached to the pterygoid fovea in the condylar neck region. This attachment, as can be seen in Figs. 18, 21, 26, 30, 35, can vary greatly in extent and therefore will be a structure at risk of penetration in the Gow-Gates technique. As discussed below, other structures lie in close relationship to the neck of the condyle, including the maxillary artery and some of its branches. Figs. 21, 23 show the target area for the Gow-Gates technique.
3.4 DESCRIPTION OF THE PTERYGOMANDIBULAR SPACE

3.4.1 Relations of the needle point at both target areas.

Entrance to the pterygomandibular space in both techniques involve the piercing of mucosa, buccinator muscle, the temperobuccinator band, fat and pterygotemporal fascia.

The temperobuccinator band is a mass of tissue comprising the fascia of the temporalis tendon and bundles of tendinous fibres, derived from the temporalis muscle, which are attached to the posterior surface of the buccinator muscle.

The conventional block relies for its success on the bathing of the inferior alveolar nerve with local anaesthetic solution in the sulus colli just superior to the lingula and the mandibular foramen [Fig. 28], the attachment of the sphenomandibular ligament and the interpterygoid fascia. The interpterygoid fascia serves as a pouch to contain the local anaesthetic solution within the target area.

The Gow-Gates technique, on the other hand, has a target area lying some 2-3cm above the mandibular foramen at the neck of the condyle, intended to be below the attachment of the lateral pterygoid muscle. However, as will be seen in the radiographic survey, there is some doubt as to whether the external landmarks achieve the target point as described by Gow-Gates.

3.4.2 Relations of the needle point at the mandibular foramen.

At the mandibular foramen the needle lies almost at the apex of the inverted triangular shape of the pterygomandibular space [Figs. 28, 29, 30]. The medial wall of the space is completed by interpterygoid fascia - a sheet of fibrous tissue which is of significance in limiting the spread of anaesthetic solution deposited in the space.

The interpterygoid fascia is a sheet of tissue that extends from the base of the skull, lying on the medial surface of the lateral pterygoid muscle and lateral to the medial pterygoid muscle. Posteriorly it spans the interval between the diverging margins of the two pterygoid muscles [Fig. 22]. It is attached to the mandible above the upper border of the medial pterygoid insertion and to the lingula and the margin of the mandibular foramen, and extends posteriorly to the posterior border of the mandibular ramus and anteriorly to the deep attachment of the temporalis muscle.

The line of attachment curves backwards and upwards to the posterior border of the mandibular ramus, extending to the neck of the condyle. Here it blends with
the stylomandibular membrane, forming a fascial pouch in which lie the inferior alveolar neurovascular bundle and lingual nerve [Fig. 32].

The portion of the interpterygoid fascia extending from the spine of the sphenoid and the petrotympanic fissure is considerably thickened and forms the sphenomandibular ligament.

The buccinator muscle, temporalis tendons and the temperobuccinator band form the anterior boundaries of the pterygomandibular space and serve to contain the solution anteriorly [Figs. 28, 31].

The medial relations of the needle are the medial pterygoid muscle with the interpterygoid fascia overlying the muscle [Figs. 28, 34]. The medial pterygoid muscle is inclined postero-laterally towards its mandibular attachment and restricts the area of the pterygomandibular space inferiorly.

Also lying medial to the needle in this area is the sphenomandibular ligament.

Lying immediately medial and slightly posterior to the needle is the neurovascular bundle comprising the inferior alveolar nerve and the inferior alveolar artery and vein in that anteroposterior order [Figs. 26, 35, 37].

In this area the inferior alveolar vein may be joined by a substantial vein that drains the pterygoid plexus to form the maxillary vein. At this level the blood vessels that are at risk of being punctured are the inferior alveolar artery and vein and the vein from the pterygoid plexus. It is more likely that the veins will be pierced because the structure, of their walls, is thin while that of the artery is relatively more resilient and robust, making it more likely to be displaced than to be pierced.

The lateral relations of the needle [Figs. 23, 28] are predominantly the temporalis muscle anteriorly and the medial surface of the ramus of the mandible at the level of the sulcus colli just superior to the mandibular foramen and the lingula.

The inclination of the inferior alveolar neurovascular bundle is such that it is immediately superior and medial to the needle and then passes infero-laterally to the needle, coming in close proximity to the ramus of the mandible before descending into the mandibular foramen.

The mylohyoid nerve which branches off the inferior alveolar nerve just above the mandibular foramen is in infero-lateral relation to the needle [Figs. 20, 21].
The fibres of the mylohyoid nerve are anaesthetised along with the fibres of the inferior alveolar nerve, (subject to sufficient length of nerve being bathed in anaesthetic solution).

As stated by Rood (11), if less than 1cm of nerve fibre is bathed in local anaesthetic solution it is possible for impulses to jump across the nodes of Ranvier that may be affected by the local anaesthetic, thereby diminishing the anaesthetic effect.

The lingual nerve and the inferior alveolar neurovascular bundle are superior to the needle as they descend laterally. Then the inferior alveolar neurovascular bundle becomes an infero-lateral relation as it descends towards the mandibular foramen [Figs. 28, 30].

Within the pterygomandibular space the lateral pterygoid muscle is the most superior relation to the needle. The maxillary artery lies superior to the needle as the artery passes the neck of the condyle and passes beneath the lateral pterygoid muscle to enter the pterygomaxillary fissure [Fig. 26].

Far superior to the needle is the long buccal nerve which lies between the superior and inferior belly of the lateral pterygoid muscle. Travelling anteriorly between the two heads of this muscle, the buccal nerve then descends within the sheath of the deep tendon of temporalis muscle [Fig. 20, 35].

At the level of the conventional block the needle lies closest to the lingual and inferior alveolar nerves with little risk of piercing or damaging any vital structures such as the maxillary artery, pterygoid plexus of veins, or lateral pterygoid muscle [Figs. 27A, 28]. However, the risk of piercing the inferior alveolar artery or vein is a possibility, as is the risk of impaling the inferior alveolar nerve.

If the puncture point is placed too medially, the medial pterygoid muscle is likely to be penetrated. Given the narrowness of the anterior opening of the pterygomandibular space, it is likely that the muscle would be pierced frequently. Provided that the solution is deposited at the required site, the passage of the needle through the muscle may be inconsequential [Fig. 28, 31].

The target area for the needle is the sulcus colli. If a needle were directed too acutely toward this area it is possible that the needle may pass posterior to the sulcus and enter the substance of the parotid gland. If anaesthetic solution is deposited at this position anaesthesia of the facial nerve may occur, with its potential sequelae.
An inferiorly directed needle is a common cause of failure to achieve complete anaesthesia. This places the needle point infromedially to the mandibular foramen and sphenomandibular ligament and thus outside the pterygomandibular space. Thus, not only would the solution not be deposited into the space but, due to the nature of the ligament and the interpterygoid fascia, it would be prevented from flowing into the space.

From the horizontal histological cross section [Fig. 34] at the level of the conventional technique it can be seen that there is a clear envelope of space bounded by the ramus of the mandible laterally and by the interpterygoid fascia and the medial pterygoid muscle medially. Structures within the space at the level of the conventional block are restricted to the inferior alveolar neurovascular bundle, which is surrounded by fatty connective tissue.

As stated by Shields (15), blood vessels and nerves are merely diverted through the space, there being only a relatively small blood and nerve supply to the loose fatty and areolar tissue filling the interstices.

This section should be compared carefully with the horizontal section at the level relative to the Gow-Gates technique.

3.4.3 Relations of the needle point at the level of the Gow-Gates technique.

Gow-Gates’ ‘target zone’ is the neck of the mandibular condyle below the insertion of lateral pterygoid [Figs. 17, 21, 27, 33].

If this target zone is the desired area of deposition for local anaesthetic to be injected using the Gow-Gates’ technique, the needle must be placed in the uppermost reaches of the pterygomandibular space within the confines of the interpterygoid fascia medially, and the medial surface of ramus of mandible, laterally [Fig. 31]. There is some doubt concerning the validity of the relationship between the external landmarks described by Gow-Gates and the target zone. This is discussed in Chapter V.

As will be shown radiographically, using the Gow-Gates external landmarks consistently produces a target zone which is lower on the medial aspect of the ramus of the mandible than the point cited by Gow-Gates, and approximately 1cm above the area of deposition of the solution for the conventional block.

To reach the higher target zone, either a higher puncture point or a greater superior inclination of the needle must be used. This aspect is further discussed in the review of the radiographic study.
In describing the relations of the needle, it is necessary to consider Gow-Gates’ perception of the target zone (51). The needle, according to the directions of Gow-Gates, would come to lie just medial to the neck of the condyle and slightly anteriorly. It is approximately 2cm superior to the bony target area of the conventional block. The crista endocondyloidea of the mandibular neck [Fig. 17] lies inferior to the target zone, separating the target area from the sulcus colli in which the inferior alveolar bundle lies when the mouth is in the wide open position.

Lying at the target zone, the needle should (according to the Gow-Gates approach) be below the insertion area of the lateral pterygoid muscle but, as can be seen in Fig. 26, the attachment of the muscle in the pterygoid fovea at the condylar neck area can be very extensive. The pterygoid muscle is in a close superior relationship to the needle. In this area there is a risk of damaging the pterygoid venous plexus and also its tributary to the maxillary vein, causing a degree of bleeding in the area.

The medial pterygoid muscle lies inferior and medial to the needle, but due to its superomedial inclination it is in more distant relation to the needle [Fig. 27].

Gow-Gates states (51) that the divergence of the medial and lateral boundaries of the pterygomandibular space facilitates access to the bony target. Dissection of the area [Figs. 29, 30] reveals that this divergence encompasses the lateral pterygoid muscle. This muscle fills the upper part of the pterygomandibular space, displacing the fatty tissue found in the area around the lingula.

The maxillary artery is an important structure in this area. As described by Barker & Davies: "The maxillary artery enters the space through the interpterygoid fascia and initially lies in close relation to the neck of the condyle" (13). The artery at this site lies inferior to the attachment of the lateral pterygoid muscle [Figs. 35, 36, 37] and therefore at the site of the Gow-Gates target zone.

Barker & Davies describe how several branches arise during the artery’s progress through the upper part of the pterygomandibular space. The branches which may pass through the space comprise the middle meningeal artery as it ascends deeper to the lateral pterygoid muscle; the posterior deep temporal artery, passing up between the sigmoid fascia and the lateral pterygoid muscle; the inferior alveolar artery; a lingual branch and, in addition, small muscular branches.

The pterygoid plexus of veins surrounds the inferior head of the lateral pterygoid muscle and is confluent posteriorly with a plexus surrounding the capsule of the temporomandibular joint. A large vein emerges from the plexus to join the inferior alveolar vein or veins close to the ramus, and form the maxillary vein below the inferior border of the lateral pterygoid muscle.
As can be seen by the above anatomy, Gow-Gates’ description of the target area as a relatively avascular region is inadmissible. The inherent dangers of intravascular injection or damage to the finer vessels are greatly increased at the higher target area. Figs. 21 and 36 show the structures in close relationship to the neck of the condyle.

The auriculo-temporal nerve lies immediately superior to the maxillary artery on the medial surface of the condyle and to the medial surface of the lateral pterygoid muscle.

At this higher level, the relationship of the needle to the inferior alveolar neurovascular bundle becomes more distant, the site of deposition being lateral to the neurovascular bundle. The inferior alveolar and lingual nerves incline superomedially together away from the mandibular foramen towards the foramen ovale at the base of the skull [Fig. 23].

As can be seen in Fig. 23, the lateral pterygoid muscle lies between the stated target area and the inferior alveolar nerve. However it should be stated that the site of deposition is within the boundaries of the pterygomandibular space and contained by the interpterygoid fascia.

The possibility should also be considered that the needle may be directed inferior to the lateral pterygoid muscle through the sigmoid notch and penetrate the deep surface of the masseter muscle.

The radiographic study shows how solution deposited at the higher level flows and percolates inferiorly to surround the neurovascular bundle, thereby establishing anaesthesia. The flow patterns of both techniques are remarkably similar [Figs. 41 to 50].

In summary, the relations of the needle lying at the Gow-Gates target area are as follows:

The ramus of the mandible lies laterally at about the level of the sigmoid notch. The neck of the condyle lies posterolateral to the needle point. The lateral pterygoid muscle lies medially and superiorly. The needle may pass through the lower fibres of this muscle. Medial pterygoid muscle lies inferomedially.

The inferior alveolar neurovascular bundle and lingual nerve lie inferior to the needle by a variable distance as the nerve passes from medial to lateral towards the mandibular canal. However, the lateral pterygoid muscle may intervene between the needle at the target area and the neurovascular bundle. The maxillary artery and vein and their tributaries lie across the target area in a lateral-medial direction.
Figs. 24 to 27 depict sequentially the dissection of the pterygomandibular space, revealing the relationship between all the structures.

Fig. 25 shows the relationship between the Gow-Gates target zone and the extra-oral landmark, raising doubts concerning the accuracy of locating the neck of the condyle using the extra-oral landmarks. It should be noted that the cadaver is in the open-mouth position.

Figs. 31 and 32 demonstrate sections along the line passing through the corner of the mouth and the upper border of the intertragic notch. This line passes through the ramus below the sigmoid notch. Very importantly, the presence of fibres of the lateral pterygoid muscle should be noted. This muscle constricts the pterygomandibular space, rendering it vulnerable to penetration by the needle.

Of great concern is the location of the maxillary artery and of its branches immediately anterior to the approach to the target area, and a maxillary vein closely medial to the target area.

The inferior alveolar nerve and lingual nerve are quite distant medially, with the lingual nerve isolated by the interpterygoid fascia. The buccal nerve is in a very distant anterior relationship to the needle.

It must be reiterated that the higher target area abounds with structures that, if traumatised, may cause great discomfort to the patient. This fact has been ratified by the subjective information received from the student population.
CHAPTER IV  

METHOD

4.1 CLINICAL EVALUATION

The study was conducted exclusively at the Exodontia Clinic at the United Dental Hospital, Sydney.

The subjects were selected from patients of the Dental Hospital and from dental students at the University of Sydney.

The subjects were arranged into three samples:

Sample 1: 72 patients were administered the conventional block

Sample 2: 73 patients were administered the block as proposed by Gow-Gates

Sample 3: 25 students were administered both the conventional and the Gow-Gates blocks.

For the purpose of comparison, all data obtained from the above samples were divided into two groups:

Group A: Patients and students administered the conventional block

Group B: Patients and students administered the block as proposed by Gow-Gates.

4.2 SELECTION OF SUBJECTS

Patients were assessed for suitability in relation to age, general and dental health, number of teeth present and ability to communicate.

A minimum age of 16 years was set, as it was felt that a younger patient could not be relied upon to make accurate judgements in supplying subjective information.

The general health of the patient was taken into consideration in selection of subjects. Patients complaining of any medical condition that required the alteration of the anaesthetic solution used were excluded from the study.
The general condition of the oral cavity was taken into account. Reasonably healthy teeth were required for the successful use of the pulp tester. The presence of at least one incisor or canine and one premolar and molar tooth was essential to fulfil the requirements of the pulp test study.

It was essential that the overall gingival condition be generally healthy, since it was felt that the presence of gingival inflammation would affect the possible accuracy of the pulp test readings and would hinder the "probe prick" test.

Patients with excessive inflammation in the third molar region were excluded as results could be altered by inflammatory by-products and because excessive swelling would make the determination of landmarks more difficult. Furthermore, those patients could be expected to have difficulty in obtaining the wide open mouth position necessary for both block techniques, especially the Gow-Gates technique. Also excluded from the study were patients whose visible distress suggested they might be incapable of providing the subjective information necessary for accurate results.

All these factors were taken into consideration as part of the experimental procedure fundamental to providing, as nearly as possible, a standardised situation for the testing and evaluation of both techniques although, in normal clinical practice, these factors would not preclude the use of either technique.

Students were selected in accordance with the same criteria used for selection of the other patients, with the same procedures being followed.

4.3 CLINICAL PROCEDURES

4.3.1 Patient Study

The method of the experiment described below was strictly adhered to in order to maintain control of the experiment. A single operator administered all the injections, rigidly following the techniques. There was no attempt to alter or modify the routine or the solutions or the armamentarium.

The syringe used was the standard 3cc luer-lock glass syringe as used at the Exodontia Clinic at the United Dental Hospital, Sydney at the time of the investigation [Fig. 12].

The advantage of this syringe is that it affords positive aspiration pressure, enabling accurate aspiration in every case. In this investigation, if positive aspiration occurred, the syringe would have been removed and the solution totally discarded.
As will be demonstrated in the results presented, there is a close correlation between positive aspiration and failure to achieve complete anaesthesia.

A full medical and dental history was taken. Each patient was advised that the efficiency of local anaesthetics was being tested.

To ensure that the patients' subjective interpretation would not be affected, they were not advised that a new technique was being used.

The procedure was explained to each patient, as were the differences between tingling, paraesthesia and complete anaesthesia.

The patients were shown the areas where the first signs of sensation of anaesthetic might be expected to appear, i.e. the lip, side of tongue, side of cheek and ear lobe. They were informed that they would receive the local anaesthesia necessary for the extraction of the tooth in question and would greatly assist the study if they provided relevant information.

Following these explanations, the teeth on the side to be injected were isolated with cotton rolls attached to Garma clamps and the teeth dried [Figs. 13, 38]. The teeth were then tested with the electric pulp tester [Fig. 14]. The results are described below.

After the pulp test, the cotton roles were removed. The site of the injection was dried and sterilised with tincture of iodine before topical xylocaine paste was administered. After a period of two to three minutes to allow the paste to take effect, the appropriate injection was given.

To ensure a complete random selection of technique used for each patient, the two techniques were used alternately.

For ten minutes from the commencement of the injection, a stop watch was used to time the proceedings. Each patient was informed that they might feel signs of anaesthesia before the needle was withdrawn and that they should signify the recognition of those symptoms by placing a finger on the area as soon as any change was detected.

The time and place of the occurrence of the first signs of anaesthesia were noted on the result sheets (page 73) as soon as the patient signalled.

Ten minutes after the completion of each injection, a second series of readings was taken of all the standing teeth that were eligible for use. The same routine with the pulp tester was followed. At this stage the probe prick was used to evaluate which branches of the mandibular division were anaesthetised and to
discover the extent of the anaesthesia on the lingual and inferior alveolar and buccal distribution. The probe was placed in the gingival sulcus on the buccal and lingual aspect of all teeth present to determine the extent of anaesthesia.

After all testing had been completed, the patient was asked the following questions:

i) How much discomfort did you feel on insertion and during injection?

ii) How much of your face is numb?

iii) How deep does the anaesthesia feel and is it uncomfortable?

iv) Did you feel any sensation at the site of the extraction during the procedure, e.g. pressure/pain?

These questions were asked in order to obtain subjective information regarding the sensation experienced during and post injection.

After the extraction, the patient was given the usual advice and information and dismissed in the usual way.

4.3.2 Student Study

The 25 students were administered both types of block technique, two weeks apart. The blocks were given randomly without the students being informed as to the type of method being used. The two-week interval between injections allowed the tissues in the pterygomandibular space to heal prior to the second block being administered.

This method avoided the potential problem of variations in anatomy and tissue condition, which could complicate the comparison of techniques. Anatomical variations, as a factor influencing the success rate, are discussed later in the text. Accurate and knowledgeable subjective information could be obtained from this group.

The students were able to compare the techniques and to supply accurate information on all aspects, such as:

i) ease or difficulty of injection technique;

ii) amount of discomfort felt during injection;

iii) duration of anaesthesia;

iv) amount of discomfort, tenderness or muscle trismus observed post-operatively;

v) extent/depth of sensations during period of anaesthesia.

The total number of patients tested was 170, including 25 students [Table 1].
4.3.3 Pulp Testing

The electric pulp testing was conducted on eligible patients in the following manner. The electrical stimulator used was the Malek (Dentotest) [Fig. 14]. After administration of inferior alveolar block injections by both techniques, the Dentotest was used to record the changes in sensitivity of mandibular teeth, as compared to a control reading taken before the injection. This was done in order to assess the quality and extent of anaesthesia that could be delivered.

The procedure adopted for each patient before and after injection was identical. All patients were informed that the tests were being conducted to assess that sufficient depth of anaesthesia had been attained before treatment proceeded.

The pulp tester records a range of one to ten, extending from maximal sensitivity to minimal sensitivity. Base line recordings were taken prior to administration of the injection. Ten minutes post commencement of the injection, comparative readings were taken.

The teeth were isolated using cotton rolls and Garma clamps and then dried with air (32) [Fig. 38]. To conduct the pulp test procedure, the cathode of the tester was applied to each tooth via a connecting graphite tip and a lubricating paste (56).

The current was increased slowly until the patient indicated a sensation. This was noted and recorded (Result Sheet Pg. 70). If no response was elicited at the base testing from any of the four tooth groups specified as a requirement of the method, the patient was excluded from the study.

4.4 PARAMETERS

The parameters used as the basis of data were:

   i) Time of onset of a sensory alteration in any area of sensory distribution of the mandibular nerve.
   ii) Time of awareness of lip anaesthesia (complete numbness as indicated by the patient).
   iii) Depth of anaesthesia as measured by the electric pulp tester after an interval of ten minutes from the time of injection.
   iv) Extent of anaesthesia of the inferior alveolar nerve was assessed by probing of the gingival sulci at the distal aspect of the canine and the lateral incisor and the central incisor teeth.
   v) Extent of buccal anaesthesia was tested by probing the buccal gingival sulci of the premolar and molar teeth.
Extent of anaesthesia was assessed by determining the particular tooth to which soft tissue anaesthesia had progressed.

4.5 ARMAMENTARIUM

The instruments used in the investigation were:-

a) Luer-lock glass syringe [Fig. 12]

b) Lignocaine, 2%, 1:80,000 adrenalin, 2.2ml anaesthetic solution [Fig. 12]

c) Dentotest electric pulp stimulator [Fig. 14]

d) Sterile No. 6 probe [Fig. 15]

e) Xylocaine topical anaesthetic, 2%./tweezers [Fig. 15]

f) Conventional stop watch [Fig. 14]

g) Garma clamps [Fig. 14]

4.6 ANAESTHETIC TECHNIQUES

4.6.1 Method A - Technique of Conventional Block

The administration of local anaesthetic solution by the conventional technique has not changed since 1929, when Dr. Ashley W. Lindsay (1) developed the direct thrust technique. That technique, as described in this chapter, was applied.

4.6.1.1 Landmarks

The tissue landmarks used to direct the needle to the target area must be defined. The area of the puncture point is the pterygogasser depression (13, 14) [Fig. 6]. This tissue landmark is a triangular area with its apex pointing downwards towards the retromolar region.

The pterygogasser depression requires palpating in order to define its outlines. During palpation a fine vertical cleft between the folds formed by the temporalis and medial pterygoid muscle layers is frequently encountered. The author found this cleft to be an important horizontal landmark of the puncture point. If the needle traverses this cleft it should be unimpeded by any tissue.

The cleft is often clearly palpable and lies between the internal temporalis muscle tendon and the pterygomandibular fold, but lies laterally in the space closer to the internal oblique ridge of the mandible. This cleft is the space between the medial pterygoid muscle medially and temporalis muscle laterally.
The medial boundary of the pterygotemporal depression is the pterygomandibular fold, which extends from the mandible to the medial pterygoid plate. The lateral boundary comprises the internal and external oblique ridges to which are attached the internal and external tendons of the temporalis muscle.

The site of attachment of the external tendon not only indicates the lateral extent of the space, but aids in determining the height of the puncture point in the conventional block technique due to the curvature of the attachment determining the depth of the coronoid notch (Lindsay 1, 13) [Figs. 2, 3, 4].

This coronoid notch may be located by firmly palpating the anterior border of the ramus to find its deepest concavity.

If the index finger is placed in the coronoid notch with the plane of the fingernail aligned vertically, the height of the puncture point can be found by bisecting the fingernail. The author suggests a simpler approach is to place the index finger flat on the occlusal surfaces of the mandibular teeth and palpate the deepest part of the coronoid notch or of the pterygotemporal depression. This indicates the correct vertical position and the needle can be placed along the fingernail to the target. At all times and in both techniques, care must be taken with the angulation of the syringe in the vertical plane; the wrong target area will be achieved if the syringe is angled in a downward direction towards the target, which is now a common occurrence with patients in the supine position.

Whilst other landmarks such as the apex of the buccal pad of fat and the occlusal plane of the maxillary teeth were also used as guidelines, to maintain uniformity in the technique only the concavity of the anterior border of the ramus was used to provide a constant indicator to the height of the puncture point.

(Refer to Anatomical Section (Chapter III) for description of all landmarks.)

Care must also be taken with palpation technique since, as stated by Barker & Davies (13), the varying thickness of the temporalis tendons can give a false indication of the depth of the coronoid notch.

4.6.1.2 Clinical Application

The patient was seated with the head positioned horizontally so that the mandibular occlusal plane was parallel to the floor. The operator was positioned in front and to the right of the patient. The left index finger palpated the anterior border of the ramus of the mandible in a vertical direction until the greatest depth of the anterior border of the ramus was identified, i.e. the coronoid notch. This notch is commonly in a direct line with the mandibular sulcus and indicates the height of the lingula in the mandibular sulcus [Fig. 3].
The soft tissue in line with the coronoid notch and overlying the internal oblique line, the buccal pad, the pterygotemporal depression and the pterygomandibular fold was tensed by moving the index finger buccally to give better exposure to the target area [Fig. 4].

A syringe with a 1-5/8" long, 27 gauge needle was inserted from the contralateral side of the mouth over the canine-first bicuspid region [Fig. 5]. The intended target area in the mandibular sulcus immediately above the lingula was located by bisecting the fingernail of the index finger, which rested in the depths of the coronoid notch, and by choosing a point intermediary between the internal oblique ridge and the pterygomandibular fold, aided by the aforementioned cleft.

In the open mouth position the inferior alveolar bundle, i.e. nerve, artery, vein lies in close proximity and parallel to the mandibular sulcus colli (13, 14, 55) [Figs. 26, 27].

The injection site was first sterilised with tincture of iodine, as used by the United Dental Hospital, and was anaesthetised by applying 2% topical xylocaine gel.

The needle penetrated the soft tissues until it gently contacted the bony target on the internal surface of the ramus of the mandible. Monheim (49) has identified this position as above the lingula and in the area of the mandibular sulcus, which funnels into the mandibular foramen.

After the needle had been withdrawn approximately 1mm to 2mm, aspiration was performed. If negative, the whole 2.2ml of local anaesthetic solution was deposited slowly at the rate of approximately 1ml per minute. If aspiration proved positive, the needle was withdrawn fully and the anaesthetic solution discarded.

The solution was discarded to avoid any further positive aspiration being disguised by the already-coloured solution and to guard against the situation cited by Harris (19) as causing formation of precipitates which, in turn, cause the solution to deteriorate and lose efficacy, resulting in the possible failure or reduction of anaesthetic quality of any technique.

If a positive aspiration was obtained the procedure was repeated using a puncture point lateral to that previously used, thereby achieving a slightly more anterior target point on the medial surface of the ramus of the mandible.
The inferior alveolar bundle has a distribution of nerve, artery and vein in an
anterior-posterior alignment respectively, thus a more anterior positioning would
achieve a closer relationship with the inferior alveolar nerve and avoid the
inferior alveolar artery or vein, thus minimising the incidence of positive
aspiration (13, 55).

4.6.2 Method B - Technique of Gow-Gates Block

The Gow-Gates technique was applied exactly as described in his 1973
publication and as demonstrated by George Gow-Gates to the author. Whilst
the location of the landmarks is essential to this technique, Gow-Gates has never
given definite landmarks for the exact placement of the puncture point in the
oral cavity. Rather, his puncture points are located at the juncture of horizontal
and vertical planes defined as follows:-

4.6.2.1 Horizontal Plane

The puncture point lies in the pterygotemporal depression, just medial to the
medial (internal) tendon of the temporalis. The tendon is readily palpated, as
explained above. If it is present, the palatal cusp of the second maxillary molar
tooth is used as a guide when the needle is directed from the opposing canine
area [Fig. 10].

4.6.2.2 Vertical Plane

The vertical plane is determined by a line drawn between the corner of the wide-
open mouth and the upper border of the intertragic notch of the ear [Figs. 8, 9].
Again the maxillary second molar tooth may be used as a guide to the height of
the puncture point when the needle is directed immediately below the palatal
cusp.
These landmarks place the puncture point in the most superolateral corner of
the triangle of the pterygotemporal depression [Fig. 10]. If the injection is
intended for the right side of the patient, the syringe is held in the right hand
while the left hand distends the patient’s cheek and aids in maintaining the wide-
open mouth position. For the left side, the procedure is reversed.

Several visits were made to Dr. Gow-Gates’ surgery to observe the procedures of
the technique and to obtain advise regarding the procedure.
4.6.2.3 Clinical Application

The patient was seated in a supine position throughout the technique, with the headrest adjusted so that the patient's face lay in a horizontal plane. Consequently, the line connecting the angle of the mouth with the intertragic notch of the ear presented an upward inclination.

The patient was instructed to open the mouth as widely as possible so that the condyle could assume a more anterior position in closer relation to the mandibular nerve (7, 13, 14, 60).

The operator was positioned in front of and to the right side of the patient, whose head was inclined slightly toward the operator. This allowed a correlation between the intra-oral puncture point and the external landmarks. The needle was directed to a higher puncture point than used in the conventional technique [Figs. 10, 11].

The use of external landmarks is crucial to ensuring that the target area for deposition of the anaesthetic solution is at a level specified in this technique.

Following identification of the axial landmarks, the needle was inserted approaching from the contralateral side of the mouth, approximately over the canine/first premolar region. During the experiment, a nurse placed an instrument handle in the intertragic notch, thereby facilitating alignment of the syringe, especially for the left side injection [Fig. 8].

Gow-Gates has suggested the use of the angle of the ear to the side of the face as a possible aid in determining the inclination of the syringe in the horizontal plane. Due to the extreme variability in the anatomical form of the ear and its surrounding tissue, the author did not make use of this landmark.

The needle was advanced through buccinator muscle, penetrating tissue until bone was contacted. The syringe was withdrawn approximately 1 mm. Aspiration was conducted.

If aspiration was negative, 2.2 ml of anaesthetic solution was deposited as in the conventional block. The same conditions for positive aspirations were followed in this technique as with the conventional technique.
4.7 ANATOMICAL SURVEY

Five dissections were performed to demonstrate the anatomical features of the region of deposition of anaesthetic solution. The specimens were provided by and the dissections were performed in the Department of Anatomy, University of Sydney.

The dissections performed were as follows:

i) Dissection of the pterygomandibular space from a lateral approach.

ii) Dissection of a specimen sectioned along a plane determined by the landmarks specified by the Gow-Gates method.

iii) Dissection of a specimen sectioned in a horizontal plane at the level of the conventional block.

iv & v) Two dissections of blocks of tissue incorporating the medial area of the infratemporal region using sagittally sectioned specimens.

4.8 RADIOGRAPHIC SURVEY

The purpose of the radiographic survey was to compare the target zones of both the conventional block and the Gow-Gates techniques.

Importantly, radiographs were used to assess the accuracy of the external landmarks in the Gow-Gates technique in regard to consistency to achieve the desired target area at the neck of the mandibular condyle.

A further survey was conducted using Omnipaque 320 (Non-ionic contrast medium) to determine whether there is any significant difference between the techniques in respect of the pattern or timing of diffusion of anaesthetic solution in the pterygomandibular space.

The radiographic approach used extensively was the lateral skull. This technique was used to determine the veracity of the landmarks and to demonstrate flow patterns in an antero-posterior direction.

Antero-posterior (AP) radiographs were used to determine the latero-medial flow patterns of local anaesthetic solution.

The radiographic survey was performed at the time of injection and at five minutes and 15 minutes post-injection.
To obtain an overall view of the distribution of the solution in the space, an Orthopantamograph (OPG) radiograph was also taken after 15 minutes. Two subjects were used in this survey.

In the survey to determine the accuracy of the landmarks, the subjects were prepared in the following manner:-

For one survey, small radio-opaque strips of lead foil were taped to the skin to accurately trace the intertragic notch of the ear and the corner of the mouth in the wide-open position.

On a subsequent survey, a length of lead foil was taped to the side of the face, connecting the corner of the mouth and the upper border of the intertragic notch [Fig. 40].

For the radiograph the subject was asked to lie down with the face parallel to the film. The marked side of the face was placed closest to the film to lessen any distortion that might occur. A true lateral radiograph was taken.

Three subjects were asked to undergo three separate radiographs:-

i) The first showing the needle placed in the position for the conventional technique,

ii) The second with the position following the external landmarks of the Gow-Gates technique,

iii) The third with the position of the needle point approaching the neck of the condyle.

Lateral skull radiographs were taken of each position.

In general, the following parameters were used 63 KV, 300 MA and 0.4 SEC exposure time. Film cassette used was Kodak cassette with intensifying screen (Lanex regular), IMG-RA-1 film and Kodak automatic developing unit were consistently used.
CHAPTER V  RESULTS AND DISCUSSIONS

The following facts can be deduced from the raw scores obtained:

5.1  THE SAMPLE

A study of the sample taken showed a similar distribution of age and sex of patients used in both techniques.

As can be seen from Table 1, the larger part of the sample came from the 11-30 age group in both sexes. 45.3% males and 21.3% females were administered the conventional block, while those administered the Gow-Gates block comprised 51.3% males and 25% females.

The fact that the greater percentage of the sample was fairly young suggests that the patients were likely to have been healthy and presenting sound tissue. Patients were selected randomly and the criteria for selection stated in the methods of experiment were adhered to rigidly.

5.2  POSITIVE ASPIRATION

The incidence of positive aspiration provides a clue to the type of tissue that is penetrated by the needle. The vascularity of the tissue is an important factor relating not only to the issue of intravascular injection, but also to the rapidity of absorption of the local anaesthetic via capillary activity. The greater the absorption of the local anaesthetic solution into the blood stream, the less effective and more transitory will the technique appear.

Two forms of positive aspiration have been recorded by the author. The first and true aspiration is a definite stream of blood into the cartridge. The stream appears to jet into the local anaesthetic cartridge under pressure and quickly colours the anaesthetic solution. Under these circumstances there is no doubt that the needle point is lying in the lumen of a blood vessel. The needle must be withdrawn and the cartridge or anaesthetic solution replaced in accordance with procedure discussed Chapter IV (Method).

The technique was repeated with a more superficial target area by rotating the syringe so that it approached the target area from the second bicuspid region.

The second or false aspiration appeared as a cloud-like infusion of blood discoloration. This occurs when there has been trauma to a blood vessel and there is weeping of blood into the surrounding tissue. Under these circumstances the technique may be completed without interruption.
Contrary to Gow-Gates' statement that the higher target point is a relatively avascular area, the author has found, both clinically and by anatomical dissection of the whole of the pterygomandibular space, that in fact the higher target area has a greater vascularity [Figs. 51, 52].

At the level of the lingula, the major structures present are the inferior alveolar nerve, artery and vein in order antero-posteriorly. Surrounding these is fatty connective tissue with a limited capillary network.

Conversely, at the level of the neck of the condyle, as shown in the anatomical description, there lies a major artery - the maxillary artery and at least two of its branches. Contrary to popular belief, and due to developments in the production of hypodermic needles, it is possible to penetrate the arterial wall, thereby achieving intra-arterial as well as intravenous injections of local anaesthetic.

Also found in the area of the higher level mandibular block is the pterygoid plexus of veins. This structure, which can be extensive (as described in Chapter III - Anatomical Review), is predominantly associated with the lateral pterygoid muscle. The plexus consists of fine to medium sized veins closely associated with the musculature and extending into the surrounding connective tissue.

The fine veins may easily be ruptured, causing extensive haematoma which is limited by the confines of the pterygomandibular space, resulting in considerable discomfort to the patient and possible trismus and restricted jaw-opening movements. The medium-sized veins may be penetrated, allowing intravascular injection of local anaesthetic solution.

The suggested increase in vascularity of the higher target area was also shown clinically.

With the conventional technique of a population of 75 injections, there occurred four positive aspirations. This is a percentage of 5%.

With Gow-Gates' technique 20 positive aspirations occurred in a population of 76, a percentage of 20% [Graph 1].

This reveals increased risk of intravascular complications with the Gow-Gates technique and greater care and knowledge must be applied with this technique. Another clinical and anatomical complication of the higher target area is the increased incidence of trauma to the lateral pterygoid muscle.
An investigation of the many dissections performed, revealed that the extent of both the attachment and the distribution of the belly of lateral pterygoid may vary considerably [Fig. 26].

It was determined, by post-operative examination and discussions with both students and patients, that the injected area using the higher target area was considered to be more painful and uncomfortable post-operatively than the conventional target area. Increased incidence of trismus was also recorded.

There may be two separate causes for these sequelae: the first could be trauma to the pterygoid plexus of veins, causing a haematoma to develop with associated bruising, discomfort and trismus; the second might occur if the needle pierced the lateral pterygoid muscle, causing bruising and trismus and resulting in a restricted opening movement. These symptoms have been shown to occur with less frequency when the conventional technique is applied accurately.

5.3 TIME OF ONSET

The time which elapsed before onset of symptoms of anaesthesia was determined as the time in seconds from the commencement of injection of local anaesthetic to the moment the patient was able to determine the sensation of "pins and needles" in any of the areas of distribution of the mandibular nerve division of the trigeminal nerve.

The change of sensation was described to each patient, who was asked to signify the occurrence of this state by indicating with a finger the exact area on their face where the change had occurred. It was hoped that this procedure would reduce the subjectivity that is required in obtaining such information.

The procedure also proved beneficial in that on a number of occasions the sensation of paraesthesia occurred before the completion of the injection; by pointing, the patient did not have to communicate verbally while the injection was in progress.

In his early articles Gow-Gates stated that complete anaesthesia of the mandibular division is achieved upon completion of injection of the local anaesthetic solution and that the operative procedures required could be commenced immediately (51).

In later articles (53) he reconsiders this alleged advantage of his technique and states that up to ten minutes is required for complete anaesthesia to be obtained. This is twice the average time for complete anaesthesia as recommended for the conventional technique, which takes approximately 4.5 to 5 minutes, as verified by Monheim (49).
In fact the average time until onset of clinical signs of anaesthesia varies very little between techniques. For the conventional technique the average time recorded before onset of symptoms was 41 seconds. The shortest period recorded to achieve clinical symptoms was 14 seconds. The longest period was 85 seconds.

No statistical relationship was observed between time of onset of clinical symptoms and success or failure to achieve complete clinical anaesthesia.

For the Gow-Gates technique, the average time of onset of clinical signs of anaesthesia was 44 seconds, with the shortest time being 12 seconds and the longest being 104 seconds. Again, there was no correlation between time of onset and success or failure to achieve clinical anaesthesia (Table II).

5.4 OCCURRENCE OF FIRST SIGNS

The anatomical area indicated by the patient at the time of onset of anaesthesia was also noted and recorded.

As can be seen in Graphs 2 and 3, the first signs of anaesthesia occurred predominantly in the anatomical distribution of the inferior alveolar nerve. The symptoms were detected usually along the vermilion border of the lower lip, to the midline.

It is interesting to note that no case has ever been recorded which shows altered clinical symptoms across the midline of the lower lip. The probe prick test and the electric pulp tester showed no alteration of sensation on the opposite side after the administration of either block technique.

Wedgewood (61) stated in 1966 that there was no evidence to show that transmedian innervation occurs. Following her studies using Wallerian degeneration to track the course of the inferior alveolar nerve and its branches, she has been able to state categorically that no fibres of the inferior alveolar nerve were found to supply teeth on the contralateral side of the mandible.

In terms of the occurrence of first signs, there was no statistical difference between the two techniques. Of the total population, the conventional technique showed 43 cases with first signs exhibited in the distribution of the inferior alveolar nerve, while with the Gow-Gates technique, 44 cases occurred.
The lingual nerve showed the next largest occurrence of first signs. With the conventional block there were 31 cases out of the total population, while with the Gow-Gates technique there were 20 cases. There is no significant statistical difference between the techniques in respect of the lingual nerve.

As expected, the buccal nerve and the auriculotemporal nerve exhibited the lowest incidence of first signs of anaesthesia. These nerves are most distant from the target area for both techniques and in fact, both have an anatomical feature in common in that the lateral pterygoid muscle lies between the nerves and the respective target areas. Their anatomical position would suggest that the spread of local anaesthetic solution would take the longest time to reach the limits of these structures. (Refer to radiographic/injected dye results.)

As the results show [Graphs 2, 3], clinical signs of anaesthesia appeared first in the buccal nerve in only one case of the total population to whom the conventional block was administered. No clinical observations were made relating to the auriculotemporal nerve.

However, the Gow-Gates technique resulted in 8 cases of first signs occurring in the buccal nerve and 4 cases of first signs in the auriculotemporal nerve of the sample population.

A possible explanation of this result is, of course, the higher target area and the related fact that pressure in that area may cause the solution to be forced into the upper reaches of the pterygomandibular space and to spread along the roof and through a superior recess between the lateral pterygoid muscle and the temporalis muscle (13), thus reaching both the buccal nerve and the auriculotemporal nerve.

Another consideration is the increased possibility of piercing fibres of the lateral pterygoid muscle, thus injecting some local anaesthetic solution into the lateral pterygoid muscle which is outside the confines of the pterygomandibular space.

Furthermore, because the buccal nerve passes between the two heads of the lateral pterygoid, the possibility of anaesthetising the long buccal nerve increases, given such a situation.

There is a statistical difference between the two techniques in respect of the occurrence of first signs in the buccal nerve and in the auriculotemporal nerve.

5.5 **BUCCAL NERVE ANAESTHESIA**

Central to this thesis is the consideration of whether the two techniques differ significantly in regard to achieving anaesthesia for the long buccal nerve. This is one of the advantages stressed by Gow-Gates in advocating his technique. In
assessing the validity of this claim, it must be remembered that in administering the conventional block a separate additional infiltration for the long buccal nerve was not given during this study.

The results show [Graphs 4, 5] that there is a significant difference in achieving long buccal anaesthesia using the higher target area. With the Gow-Gates technique, 75% success was achieved. That is a raw score of 57 of a population of 76 cases. The conventional technique yielded a success rate of 56%, i.e. 42 cases of a population of 75.

Thus, while Gow-Gates' higher target area realises a higher percentage of success in achieving long buccal anaesthesia (51), this feature is not unique to Gow-Gates' technique.

The 56% success rate in achieving buccal anaesthesia by conventional methods suggests that there may be no practical reason to infiltrate the buccal sulcus unless lengthy protracted clinical procedures dictate the need for anaesthesia in the buccal region.

5.6 AURICULOTEMPORAL NERVE ANAESTHESIA

The occurrence of auriculotemporal anaesthesia did not differ significantly between techniques. While the conventional block achieved 32% anaesthesia, the Gow-Gates block achieved 49% anaesthesia. Neither percentage is remarkably high [Graphs 4, 5]. This is advantageous. Auriculotemporal anaesthesia is not a desirable feature as it causes the patient considerable discomfort, and is not necessary for any procedure.

Clinical experience suggests that patients dislike of the numb feeling, especially when it extends beyond the area being treated.

5.7 EXTENT OF ANAESTHESIA

Gow-Gates states (51, 53) that the high level block technique achieves complete anaesthesia of the mandible on the side injected, i.e. anaesthesia of both hard and soft tissue through to the midline of the mandible and to the mesial of the mandibular central incisor.

As can be seen in Graphs 6, 7, 8, 9 there is a strong similarity in the extent of soft tissue anaesthesia in the lingual and inferior alveolar nerves achieved by both techniques. Complete anaesthesia of the inferior alveolar nerve to the mesial of the mandibular central incisor was achieved by the Gow-Gates technique in 85% of cases, while 78% was achieved by the conventional technique.
Both techniques showed a higher incidence of complete anaesthesia in the lingual nerve and extending to the midline, as the conventional technique achieved 62 cases (83%) of a population of 75, and the Gow-Gates technique achieved 71 cases (96%) of a population of 76.

There was a similar and proportional decline in the number of cases that achieved soft tissue anaesthesia only as far as the mesial of the lateral canine and first premolar teeth.

While there was no significant statistical difference between the two techniques in relation to success in achieving soft tissue anaesthesia, very definite boundaries to the extent of soft tissue anaesthesia were noted.

Since the probe prick test elicited pain to within only a fraction of a millimetre beyond the midline, the theory of cross-over of nerve fibres was discounted.

5.8 DEPTH OF ANAESTHESIA

The depth of anaesthesia achieved was a difficult result to tabulate and correlate. A major obstacle to any attempt to compile statistics was the fact that the number of teeth present was not constant.

Table III shows the number of teeth present for each case. The similarity in the two samples, both taken at random, is apparent.

Table IV shows the numbers of individual teeth that achieved a 10+ reading on the electric pulp tester without eliciting a pain reaction from the tooth. Teeth that responded at any level to the pulp tester stimulus were not considered to be anaesthetised.

There is a strong correlation between the number of teeth in each group that achieved complete anaesthesia. The trend in each technique is almost identical. The percentage of teeth anaesthetised as related to teeth present was recorded. Except for the second bicuspid tooth, which showed a significant difference, the response from the groups of teeth was remarkably similar for the two techniques.

Thus, there was no significant difference in either technique achieving depth of anaesthesia in individual tooth groups, or in the extent of soft tissue anaesthesia. Where the major difference emerges is in the effect of Gow-Gates' technique on hard tissue.
A close examination of the results reveals a very close similarity in the extent to which both the conventional block and the Gow-Gates technique effect anaesthesia for the tissues of the mandible.

Both techniques have negative and positive features. Anatomical variations have a strong influence on both techniques and are a principal reason for failure of either technique.

Whilst the fact that the conventional block technique does not routinely achieve buccal anaesthesia, has been cited as a disadvantage (4, 51), it is questionable whether buccal anaesthesia is necessary unless surgical procedures are required. The incidence of enervation of the teeth by the buccal nerve is not significant.

Some advantages of his technique claimed by Gow-Gates (51) have either been disproved or discredited as distinctly disadvantageous clinically. Gow-Gates has himself revised the period for achieving anaesthesia from immediate to approximately 10 minutes - a duration considerably longer than for the conventional block. This study showed that, in fact, both techniques have similar onset times.

Gow-Gates claims as beneficial the fact that his block is longer-lasting, deeper and more extensive in area of anaesthesia. In clinical terms these features may not be regarded as beneficial. In most instances a very extensive or deep anaesthesia which lingers for long periods is inappropriate and unwelcome. It is essential to achieve sufficient anaesthesia to be able to complete the necessary procedures with a minimum of discomfort. However, this does not dictate the need for extensive anaesthesia.

The obvious time for the Gow-Gates technique is when oral surgical procedures on the mandible render deep and long-lasting insensitivity a distinct advantage.

The conventional technique has a more general application. If carefully, thoughtfully and knowledgably administered, it will always yield good results. On the other hand, the Gow-Gates technique is an excellent adjunct to everyday dentistry and should be kept in the repertoire of all dentists, as long as it is conducted carefully.

5.9 RADIOLOGICAL SURVEY

The radiological survey comprised the following:

1. A series of lateral plate x-rays taken of different subjects with the intertragic notch and the corner of the wide open mouth marked.
2. OPG taken of a patient with the needle inserted according to the Gow-Gates technique.

3. A lateral plate x-ray of a cadaver head horizontally sectioned through the co-ordinates given as external landmarks by Gow-Gates. This section is shown in Fig. 15.

4. A series of both lateral plate and antero-posterior x-rays taken of local anaesthetic impregnated with radiopaque dye injected into the pterygomandibular space using both techniques. X-rays were taken at the time of injection, at five minutes and at ten minutes duration.

The results of these surveys allowed the author to draw several concrete conclusions regarding the position of the target area of the Gow-Gates technique and of the flow patterns of local anaesthetic solution in both techniques.

From the lateral plate x-rays showing the accurate positions of the intertragic notch, the corner of the mouth and the condyle and ramus in the wide-open mouth position, it was possible to deduce that in general, using these landmarks, the bony target area achieved is well below the neck of the condyle.

The position achieved, in general, lay 1cm to 1.5cm above the radiographic position of the mandibular foramen. It was not possible to identify the lingula on any x-ray, but the opening to the mandibular foramen on the medial surface of the ramus was extremely clear on each survey taken.

Of the five surveys taken, four, Figs. 51, 52, 53, 54, clearly show that a line (A) drawn from the corner of the mouth to the lower border of the intertragic notch passes through the ramus at a position lower than the neck of the condyle. Fig. 54 shows a position slightly higher than in Figs. 51, 52 and 53. Fig. 55 shows the line passing through a position just below the neck of the condyle.

At the very least, it can be stated that the landmarks used to achieve the target area of the Gow-Gates technique are prey to the same variations in anatomical form as are those for the conventional technique.

It is interesting to note that a line (B) drawn along the occlusal plane of the mandibular teeth will pass just below the opening of the mandibular foramen. Fig. 55 illustrates the occurrence of variation of anatomical form; the occlusal plane is well below the mandibular foramen. Thus, here again "a finger’s width above the occlusal plane" (Gow-Gates 51) may not always be sufficient to gain the accurate conventional target area.
The OPG x-ray (Fig 16) of a syringe placed according to the Gow-Gates technique, shows the needle point contacting bone well below the neck of the condyle and, as in other x-rays, below the sigmoid notch.

The lateral plate of the sectioned cadaver head shows very similar results. The needle lying in the tissue is impinging on bone at a point below the neck of the condyle and approximately 1cm above the mandibular foramen.

The radiopaque dye survey shows a great similarity in solution flow patterns in both techniques. Fig. 41, an anteroposteriorview, shows the syringe in position for the conventional technique just after the solution had been deposited.

The immediate upward flow of the solution and the spread medially below the belly of the lateral pterygoid should be noted. Also noteworthy is the fact that the solution reaches superiorly toward the neck of the condyle. There is also the commencement of a rainlike fall of the solution inferiorly within the pterygomandibular space, closely adhering to the medial surface of the ramus.

Fig. 42 shows the spread of the solution five minutes post injection. There has been minimal superior spread, but there is a continuing inferomedial spread of solution. There also appears to be some slight movement of solution medial to the lateral pterygoid.

Fig. 53, a lateral plate x-ray, shows the distribution of the solution fifteen minutes post injection. The spread of solution along the inferior surface of the lateral pterygoid should be noted - most importantly, how anteriorly the solution has propagated.

Of great importance is the collection of solution at the mandibular foramen and then the postero-inferior movement of the solution. This demonstrates the limiting function of the spheromandibularligament, aided by the attachment of the medial pterygoid muscle. The OPG survey, also taken at fifteen minutes, shows a similar view (Fig. 44). The anaesthesia achieved with this block injection was a grade III - the lingual, inferior alveolar and buccal nerves were completely anaesthetised.

The same radiographic survey was conducted for the Gow-Gates technique. The outcome was remarkably similar. Fig. 45 shows the position of the needle just prior to injection. The local anaesthetic/radiopaque dye solution can be seen within the syringe.
Fig. 46 is an antero-posterior view, showing the solution immediately after injection. The solution is bunched in the superior recesses of the pterygomandibular space. It was assumed that considerable antero-posterior flow occurred, as is corroborated by Fig. 48.

Both Fig. 47, an antero-posterior view, and Fig. 48, a lateral plate view, were taken after an interval of five minutes. The considerable medial flow of the solution is noticeable as it closely follows the contour of the belly of the lateral pterygoid.

There is superior flow of the solution both medial and lateral to the lateral pterygoid muscle. Again there appears to be a rainlike fall of solution inferiorly.

The solution is noticeably descending along a path following the sulcus colli along the medial surface of the ramus.

The spread of the solution fifteen minutes after the injection is illustrated in Fig. 49. The extensive postero-superior flow of the solution should be noted. Most of the solution appears to have followed the downward path of the inferior alveolar neurovascular bundle.

Fig. 50, the OPG survey, shows the full extent of flow of the solution. Again, there was grade III anaesthesia for all branches of the mandibular nerve.

These surveys reveal the considerable similarity of flow patterns for both blocks. The limiting factors appear to be anatomical.
CHAPTER VI  STATISTICAL REVIEW

6.1  INTRODUCTION

Two methods, A and B, of administering local anaesthetic to one side of the lower jaw were compared. The study subjects consisted of 50 patients for Method A and 51 patients for Method B together with 25 student volunteers to whom both treatments were applied on separate occasions some weeks apart.

6.2  DATA

The response variables considered to be of interest were:-

i) Incidence of positive aspirations.
ii) Time to onset of first signs.
iii) Site of first signs.
iv) Extent: tooth number.
v) Incidence of buccal nerve anaesthesia.
vi) Incidence of auriculotemporal nerve anaesthesia.
vii) Incidence of anaesthesia to 10+ on teeth 1, 2, ... 8.

The study design and confirmatory analysis assured satisfactory matching for age and sex of patients in the two treatment groups.

6.3  ASSESSMENT OF ASSOCIATION OF RESPONSES IN STUDENTS

Because each student received both treatments, it is appropriate to examine student data for association of response to the two treatments and to use any such association in any analysis comparing treatments. However, results of the analyses summarised in the following tables showed no significant association for any of the response variables.
### 6.4 INCIDENCE OF TRUE ASPIRATIONS

Number of students - observed and filled values

<table>
<thead>
<tr>
<th></th>
<th>METHOD A</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUE ASPIRATION</td>
<td>NO TRUE ASPIRATION</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>METHOD B</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUE ASPIRATION</td>
<td>NO TRUE ASPIRATION</td>
<td></td>
</tr>
<tr>
<td>0.72</td>
<td>8.28</td>
<td>9</td>
</tr>
<tr>
<td>1.28</td>
<td>14.72</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>

The fitted values are those obtained under a no associations model. There is no significant association between responses. (Fisher’s exact test: $p = 1.0$). However, there are insufficient true responses to Method A to adequately test association in these data.

### 6.5 TIME TO ONSET

A scatterplot of the data follows. The correlation of 0.08 between times to onset for Methods A and B indicates no evidence of association.
6.6 SITE OF FIRST SIGNS

Observed and fitted values

<table>
<thead>
<tr>
<th>METHOD B</th>
<th>IA</th>
<th>L</th>
<th>B</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>IA</td>
<td>L</td>
<td>B</td>
<td>T</td>
</tr>
<tr>
<td>A</td>
<td>4 (5.2)</td>
<td>4 (3.1)</td>
<td>4 (3.1)</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>6 (4.4)</td>
<td>2 (2.6)</td>
<td>1 (1.6)</td>
<td>2 (1.3)</td>
</tr>
<tr>
<td>B</td>
<td>-- (0.4)</td>
<td>-- (0.2)</td>
<td>1 (0.2)</td>
<td>-- (0.1)</td>
</tr>
<tr>
<td>T</td>
<td>-- (-)</td>
<td>-- (-)</td>
<td>-- (-)</td>
<td>-- (-)</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

($\chi^2 = 4$ on 6 df, n.s. numbers are small and an exact test should be used but has not been calculated; it would clearly confirm the $\chi^2$ test result.)

There is no evidence of site association for A and B.

6.7 EXTENT: TOOTH NUMBER

There are insufficient data for an adequate test. The number of students in whom anaesthesia did not extend to tooth no. 1 was:

<table>
<thead>
<tr>
<th>Treatment A</th>
<th>IA</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>5</td>
</tr>
<tr>
<td>Treatment B</td>
<td>IA</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>2</td>
</tr>
</tbody>
</table>
6.8 INCIDENCE OF BUCCAL NERVE ANAESTHESIA

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes 13 (12.2)</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td></td>
<td>No 6 (6.8)</td>
<td>3 (2.2)</td>
</tr>
<tr>
<td>A</td>
<td>19</td>
<td>6</td>
</tr>
</tbody>
</table>

Observed and fitted numbers ($x^2 = 0.6$, n.s.). There is no evidence of association between A and B.

6.9 INCIDENCE OF AURICULOTEMPORALNERVE ANAESTHESIA

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes 6 (5.3)</td>
<td>0 (0.7)</td>
</tr>
<tr>
<td></td>
<td>No 16 (16.7)</td>
<td>3 (2.3)</td>
</tr>
<tr>
<td>A</td>
<td>22</td>
<td>3</td>
</tr>
</tbody>
</table>

Observed and fitted numbers (Fisher's exact test: $p = 0.42$)

6.10 COMPARISON OF TREATMENT EFFECTS

As there were no significant associations found in No.3 of this report, the comparison of treatments can ignore the pairing of A, B results for students. Accordingly, the data were treated as if from a 2 x 2 factorial experiment.

\[
\begin{array}{ccc}
\text{Treatments} & \text{B} & \text{A} \\
\text{subject type} & x & \text{patients} \\
\end{array}
\]

a preliminary inspection of the data having indicated some differences between patients and students.
6.11 INCIDENCE OF POSITIVE ASPIRATIONS

<table>
<thead>
<tr>
<th></th>
<th>No + ve</th>
<th>No. of Subjects</th>
<th>%</th>
<th>Fitted (Multiplication model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Patients</td>
<td>2</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Students</td>
<td>2</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>Patients</td>
<td>11</td>
<td>51</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Students</td>
<td>9</td>
<td>25</td>
<td>36</td>
</tr>
</tbody>
</table>

There were significant differences between treatments A and B and between patients and students.

A multiplicative model with response rate ratios of 5:1 for B vs A and 1.8:1 for students vs patients with no interaction, fitted the data well.
6.12 TIME OF ONSET

The following table summarises the times of onset in the four groups:

<table>
<thead>
<tr>
<th></th>
<th>MEDIAN</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>36</td>
<td>22,85</td>
</tr>
<tr>
<td>A</td>
<td>40.5</td>
<td>14,85</td>
</tr>
<tr>
<td>B</td>
<td>44</td>
<td>13,104</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>12,90</td>
</tr>
</tbody>
</table>

There were no significant differences among median (or mean) times of onset. Among the patients the two medians (A, B) were almost identical. There was however, a tendency for B patients and students to have greater variability in time to onset than the A groups. This is evidenced by the fact that the five greatest onset times: 87, 90, 90, 95, 104 seconds, were for subjects receiving treatment B, while five of the six shortest times also received treatment B.

These differences in variability are statistically significant but may not be very relevant to the evaluation of treatment efficacy.

A problem which commonly occurs in data collection was observed with times of onset, namely digit preference. Despite a reasonably wide range of times (12 - 104 secs), there was a strong tendency for 0.5 to be preferred as the final digit when recording times. The digit frequencies were:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>19</td>
<td>12</td>
<td>14</td>
<td>36</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>151</td>
</tr>
</tbody>
</table>

These preferences indicate the need for more careful measurement of times but should not in this instance seriously affect the comparisons.
6.13 SITE OF FIRST SIGNS

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>A</th>
<th>B</th>
<th>B</th>
<th>(Fitted values assuming these 3 groups equal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patients</td>
<td>Students</td>
<td>Patients</td>
<td>Students</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>30</td>
<td>13</td>
<td>34</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>20</td>
<td>11</td>
<td>14</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>---</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>---</td>
<td>---</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

There were no significant site distribution differences among the three groups Ap, As, Bp, but the Bs group (treatment B students) had a significantly increased number of first signs at B and T than the other three groups.

iv. Extent: Tooth Number

<table>
<thead>
<tr>
<th>Tooth No.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A Students</td>
<td>21</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A Patients</td>
<td>37</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>1.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Students</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Patients</td>
<td>40</td>
<td>8</td>
<td>3</td>
<td>--</td>
<td>1.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>A Students</td>
<td>20</td>
<td>2</td>
<td>3</td>
<td>--</td>
<td>1.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>A Patients</td>
<td>42</td>
<td>6</td>
<td>2</td>
<td>--</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B Students</td>
<td>22</td>
<td>1</td>
<td>2</td>
<td>--</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B Patients</td>
<td>49</td>
<td>1</td>
<td>1</td>
<td>--</td>
<td>1.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IA B extends further than A
S extends further than P

L B extends further than A
P extends further than S

There is no interest in the comparison L vs IA, but results are broadly similar.
6.14  BUCCAL NERVE ANAESTHESIA

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>% anaesthetised</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Students</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Patients</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>B</td>
<td>Students</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Patients</td>
<td>38</td>
<td>13</td>
</tr>
</tbody>
</table>

There are no significant differences between students and patients in either treatment group.

Overall, the percentage anaesthetised in group B (75%) is significantly higher than in group A (56%).

6.15  AURICULOTEMPORALNERVE ANAESTHESIA

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>% anaesthetised</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Students</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Patients</td>
<td>186</td>
<td>32</td>
</tr>
<tr>
<td>B</td>
<td>Students</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Patients</td>
<td>15</td>
<td>36</td>
</tr>
</tbody>
</table>

Treatment B students showed a significantly increased incidence compared with the other three groups which were not significantly different.
6.16 PERCENTAGE OF ANAESTHETISED TEETH PRESENT (TO 10+)

<table>
<thead>
<tr>
<th>Tooth No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Students</td>
<td>0(0/25)</td>
<td>16(4/25)</td>
<td>48(12/25)</td>
<td>75(18/24)</td>
</tr>
<tr>
<td>A Patients</td>
<td>15(7/47)</td>
<td>33(16/48)</td>
<td>46(21/46)</td>
<td>73(24/33)</td>
</tr>
<tr>
<td>B Patients</td>
<td>13(6/48)</td>
<td>29(15/51)</td>
<td>45(22/49)</td>
<td>77(27/35)</td>
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There is no tendency for a difference between A and B, nor between students and patients, for teeth 1 - 8. Slight differences between students and patients for teeth 1 - 2 are not significant.

6.17 GENERAL COMMENTS

Some results have been presented without formal analysis. In more cases a chi-squared test is sufficient to demonstrate differences but more formal models, of the type used in analysis of positive aspiration data, could be fitted. These would not change the general conclusions.
CHAPTER VII

CONCLUSIONS

This thesis has set out to investigate and compare, anatomically and clinically, the conventional and the Gow-Gates techniques of inferior alveolar nerve block.

The results for the two techniques are very similar. By observing many clinicians administering the conventional technique, the author has determined that most will achieve a puncture point in the pterygomandibular depression slightly higher than recommended.

The error occurs with the inclination of the syringe. Having the patient in the supine position appears to allow clinicians to incline the syringe in a downward direction. Even though they have the correct puncture point, the final bony target area is far inferior to that desirable.

The advantages of the higher technique, as cited by Gow-Gates, are the rapid onset of an anaesthesia which is deep, extensive and prolonged. Of these benefits, Gow-Gates has himself changed his conclusions relating to the onset of anaesthesia. He now states that ten minutes must be allowed for complete anaesthesia to take effect. This is considerably longer than for the conventional block.

This study has shown that there is no significant difference in the depth of anaesthesia achieved by the two techniques.

In general practice one of the major complaints made by patients, is the length of time that the uncomfortable feeling exists. Therefore, for routine procedures it is not an advantage to gain very extensive and profound anaesthesia.

This is not to deny the place of the Gow-Gates technique in dentistry. On the contrary, it is of obvious use, especially to oral surgeons. The high level block is a beneficial technique to have in any dentist's repertoire and is important in situations when the mandibular field is very difficult to anaesthetise.

This study has shown that the conventional block technique produces better results than might be expected.

As long as it is applied with great care, far better anaesthesia can be achieved with the conventional block. Any technique used is totally reliant on anatomical form and variation as well as the physiological and psychological state of each patient. Knowledge, awareness and care are essential partners in dentistry.
Given the difficulties which may beset the clinician, it is clear from all the research undertaken that it is impossible to set strict guidelines or to provide specific measurements in order to pinpoint a single target for the inferior alveolar nerve block. A sound knowledge of anatomy and the careful appraisal of all available landmarks is essential. It is crucial that each individual case be assessed and the technique adapted in accordance with that assessment.

It is equally clear that administration of the Gow-Gates technique must be similarly plagued with variability of the anatomy of each individual.
RESULT SHEET

Name: 

Age: 

Sex: 

PMH & PDH: 

Comments: 

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<td>Vazirani S J</td>
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<td>Dental Digest 66, January 1960, pp 10 - 13</td>
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POSITIVE ASPIRATIONS

METHOD A

METHOD B

PERCENTAGE OF OCCURRENCE

TOTAL POPULATION

STUDENT POPULATION

GRAPH I
OCCURRENCE OF FIRST SIGNS OF ANAESTHESIA

METHOD A

METHOD B

PERCENTAGE OF OCCURRENCE

NERVE BRANCH

GRAPH II
OCCURRENCE OF FIRST SIGNS OF ANAESTHESIA
STUDENTS

PERCENTAGE OF OCCURRENCE

METHOD A

METHOD B

NERVE BRANCH

GRAPH III
EXTENT OF ANAESTHESIA
INFERIOR ALVEOLAR NERVE

METHOD A

METHOD B

PERCENTAGE OF OCCURRENCE

CENTRAL INCISOR

LATERAL INCISOR

CANINE

PREMOLAR

TOOTH

GRAPH VI
EXTENT OF ANAESTHESIA
INFERIOR ALVEOLAR NERVE
STUDENTS

PERCENTAGE OF OCCURRENCE

CENTRAL INCISOR  LATERAL INCISOR  CANINE

TOOTH

METHOD A

METHOD B

GRAPH VII
EXTENT OF ANAESTHESIA
LINGUAL NERVE
STUDENTS

PERCENTAGE OF OCCURRENCE

CENTRAL INCISOR  LATERAL INCISOR  CANINE  PREMOLAR

METHOD A  

METHOD B  

TOOTH
Fig 1

The mandibular field.
Fig 2  Index finger palpating the depth of the coronoid notch - lateral view - dentate jaw.
Fig 3  Index finger palpating the depth of the coronoid notch - medial view - edentulous jaw.

Note the relation to level of lingular and mandibular foramen. A needle passed along this plane would be placed in the sulcus colli.
Fig 4  Finger palpating coronoid notch intra-orally.
Fig 5  Pterygotemporal depression showing distinctly the pterygomandibular raphe medially and the deep tendon of the temporalis laterally.

Note the presence of a diminutive buccal pad of fat. The needle is placed at the puncture point.
Fig 6  The pterygotemporal depression showing the boundaries and demonstrating the puncture point.
Fig 7  Base of skull showing close relationship of foramen ovale, the exit point of the mandibular nerve tunnel and the articular eminence, being the position of the condyl in the open mouth position.
Fig 8  Aligning the needle with the Gow-Gates extra-oral landmarks.
Fig 9  Needle approaching the Gow-Gates target area. A more anterior view.
Fig 10    The Gow-Gates puncture point.

Note the lateral and superior position of the needle point.
Fig 11  The needle lies in the plane of and at the puncture point of the Gow-Gates technique. The finger indicates the position of the coronoid notch. The conventional block puncture point lies just above the finger nail.
Fig 12  3 ml Luer lock glass syringe
27 gauge, 1 5/8 long needle
vial of 2% Lignocaine with
1:80,000 Adrenalin
Fig 13  Xylocaine topical gel
No. 6 probe
Garma clamps
Fig 14   The Malek pulp tester used.
Fig 15  Cadaver head sectioned horizontally through Gow-Gates extra-oral landmarks. Needle has been placed in position against target area.

Note that the target point is considerably inferior to the area suggested by Gow-Gates.
Fig 16  OPG of needle aligned to Gow-Gates extra-oral landmarks.

Note that target point is inferior to that suggested by Gow-Gates.
Fig 17  Medial surface of ramus of mandible.

Note target points of both techniques. Gow-Gates' target area lies on lateral aspect of neck.
Fig 18  Pterygomandibular space - lateral view showing structures in relation to medial surface of ramus.

Note conventional block target area is relatively free of structures while the Gow-Gates target area is obscured by a jungle of structures. Also note the size of the lateral pterygoid muscle belly separating the Gow-Gates target area from the inferior alveolar nerve. The lateral pterygoid muscle in this case would most certainly have been pierced. Note maxillary artery crossing neck of condyl.
Fig 19  Pterygomandibular space - anterior view.

Note size of lateral pterygoid muscle. Gow-Gates' puncture point would pass just lateral to deep tendon temporalis muscle in close proximity to maxillary artery and branches, pterygoid and temporal veins and buccal nerve.

The success of achieving buccal nerve anaesthesia may be attributed to solution's flowing anteriorly along path of needle back to the puncture point.
Fig 20  Pterygomandibular space - antero-lateral view.

Note position of neck of condyl and the structures that must be traversed to achieve the Gow-Gates target area.
Fig 21  Pterygomandibular space - postero-medial view.

Note structures lying at level of the Gow-Gates target area at the neck of the condyl.
Fig 22  Pterygomandibular space - posterior view.

Note structures at neck of condyl, formation of interpterygoid fascia. Solution may escape through space created by auriculo-temporal nerve and descend anteriorly to reach inferior alveolar nerve bundle medial to lateral pterygoid muscle.
Fig 23 Pterygomandibular space - anterior view.

Note relation of buccal nerve and artery to lateral pterygoid and temporalis muscles and structures lying in path of needle for Gow-Gates technique.
Fig 24  Pterygomandibular space - Dissection 1
Masseter muscle intact. Condyl lying just on posterior aspect of articular eminence. Line drawn through Gow-Gates' extra-oral landmarks.
Fig 25 Pterygomandibular space - Dissection 2
Masseter muscle removed. Tendons of
temporalis muscle revealed.

Demonstrates difficulty in palpating coronoid notch.
Fig 26  Pterygomandibular space - Dissection 3
Coronoid process and anterior part of
ramus removed down to level of mandibular
foramen. Temporalis muscle removed.

Note course of maxillary artery.
Fig 27  Pterygomandibular space - Dissection 4
Lateral pterygoid muscle removed.
Needle placed in line with Gow-Gates'
extra-oral landmarks.

Note lateral pterygoid muscle would have been
pierced. Note position of maxillary artery.
Fig 28  Pterygomandibular space - superior view at level of conventional block.
Fig 29  Pterygomandibular space - lateral view.

Demonstrates needle position of conventional block.
Fig 30  Pterygomandibular space - anterior view.

Demonstrates angulation of needle to achieve position of conventional block.

Note position of lateral pterygoid muscle.
Fig 31  Cross-section of pterygomandibular space at level of Gow-Gates technique. cf Fig 15 but close up.

Note 1  Fibres of lateral pterygoid muscle.
2  Maxillary artery lying anterior to Gow-Gates' target area.
3  Pterygoid vein lying just lateral to target area.
4  Outline of interpterygoid fascia.
Fig 32  Cross-section of pterygomandibular space at level of Gow-Gates technique. Overview showing extra-oral landmarks. Structures have been dissected.
Fig 33  Cross-section of pterygomandibular space at level of Gow-Gates technique.

Demonstrates needle point lying at target area.

Note numerous blood vessels in close proximity.
Fig 34  Cross-section of pterygomandibular space at level of conventional technique.

Demonstrates distribution of structures involved.
Fig 35  Cross-section of pterygomandibular space - lateral aspect.

Demonstrates course and distribution of buccal nerve.

Note extent of lateral pterygoid muscle.
Fig 36  Lateral dissection of pterygomandibular space with condyle and ramus removed to level of mandibular foramen.

Demonstrates complexity of structures lying in close proximity to the condylar neck.
Fig 37  Lateral dissection of pterygomandibular space.

Note size and position of maxillary artery. Danger of impinging artery here due to its being bound by ramus and lateral pterygoid muscle.
Fig 38  Isolation of teeth during pulp testing procedure.
Fig 39  Outline of Gow-Gates' extra-oral landmarks with lead wire prior to radiographic survey.
Fig 40  Lead wire placed between Gow-Gates' extra-oral landmarks prior to radiographic survey.
Fig 41  Antero-posterior radiograph taken at time of injection of radiopaque dye at level of conventional technique.

Operator: P Mouser  Subject: G Silberstein

Note solution flowing superiorly to follow contour of inferior surface of belly of lateral pterygoid muscle.
Fig 42  Antero-posterior radiograph taken five minutes post-injection by conventional technique.

Note medial flow of solution around lateral pterygoid muscle.

Note rain-like flow of solution inferiorly along path of inferior alveolar neurovascular bundle.

Grade 1 ? anaesthesia was achieved in this case.
Fig 43  True lateral radiograph fifteen minutes post-injection by conventional technique.

Note flow anteriorly of solution along belly of lateral pterygoid muscle.

Note extent of superior flow of solution.

Solution has almost filled the pterygomandibular space.
Fig 44   OPG taken fifteen minutes post-injection by conventional technique.

Note antero-posterior flow of solution.
Fig 45  True lateral radiograph of syringe prior to injection. Position attained by Gow-Gates' extra-oral landmarks.
Fig 45a  True lateral radiograph of syringe prior to injection. Needle lying at neck of condyl.
Fig 46  Antero-posterior radiograph immediately after injection of radiopaque dye.

Note upward flow of solution.
Fig 47  Antero-posterior radiograph five minutes post-injection using Gow-Gates' technique.

Note 1  Flow of solution medially around belly of lateral pterygoid muscle.

Note 2  Solution flowing superiorly and inferiorly along medial surface of ramus.
Fig 48  True lateral radiograph five minutes post-injection using Gow-Gates' technique.

Note 1  Supero-inferior flow of solution.

Note 2  Anterior flow along inferior surface of belly of lateral pterygoid muscle.

Note 3  Radioluscent area in solution maybe maxillary artery.
Fig 49  True lateral radiograph fifteen minutes post-injection using Gow-Gates' technique.

Note 1  Further flow superiorly.

Note 2  Rain-like flow of solution antero-inferiorly to fill the pterygomandibular space.
Fig 51  True lateral radiograph showing
Gow-Gates' extra-oral landmarks.

Position A: Conventional block target area
Line B:  Gow-Gates' block

Note line B does not pass through neck of condyl
but appears to be approximately one centimetre
above lingula.
Fig 52  True lateral radiograph showing Gow-Gates' extra-oral landmarks.

Position A: Conventional block target area
Line B:  Gow-Gates' technique

Again note that line B does not pass through neck of condyl but appears to be approximately one centimetre above lingula.
Fig 53   True lateral radiograph showing Gow-Gates' extra-oral landmarks.

Position A: Conventional block target area
Line B:   Gow-Gates' technique

Again note that line B does not pass through neck of condyl but appears to be approximately one centimentre above lingula.
Fig 54  True lateral radiograph showing Gow-Gates' technique with lead wire between landmarks.

Here Line B approaches neck of condyl (CN).
Fig 55  True lateral radiograph showing Gow-Gates' technique with lead wire between landmarks.

Here Line B approaches neck of condyl (CN).