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MAXILLARY NERVE BLOCK ANAESTHESIA

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PREFACE

Maxillary nerve block is an extremely useful technique when extensive maxillary surgery is contemplated. The oral and maxillofacial surgeon is confronted with maxillary procedures ranging from simple tooth extraction to segmental maxillary osteotomy and surgical procedures involving the maxillary antrum of Highmore. The extensive anaesthesia necessary for the more complicated procedures is best obtained using block or conduction anaesthesia.

A definition of conduction or nerve block anaesthesia was proposed by A.E. Smith, one of the pioneers of maxillary conduction anaesthesia, in his 1921 text (quoted by Kemp, 1940a). It is as follows: "Nerve blockings may be defined as the method of producing anaesthesia by inhibiting the sensory afferent impulses of the nerve trunk or trunks by the injection of a local anaesthetic solution at any point between the area of operation and the brain".

In the case of the maxillary nerve, the ideal location for conduction anaesthesia is within the pterygopalatine fossa where the main trunk of the nerve exits the cranial cavity via the foramen rotundum and then divides within the fossa.
It is the object of this thesis to examine the techniques available for conduction anaesthesia of the maxillary nerve within the pterygopalatine fossa.

Original work included in this thesis will cover:

(a) the spread of local anaesthetic solution following deposition within the pterygopalatine fossa;

(b) skull measurements in relation to needle angulation for the intraoral approach to the maxillary nerve via the pterygopalatine canal.

In addition, the anatomy of the trigeminal nerve will be reviewed, with particular reference to the maxillary nerve.
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. My wife, Christine, for understanding, patience and support without which this thesis would never have been possible.
CHAPTER ONE

HISTORY OF CONDUCTION ANAESTHESIA

OF THE TRIGEMINAL NERVE

Old actions return again,
furbished over with some new and
different circumstances.

Fuller 1902

The first and most unequivocal demonstration of the principle of regional anaesthesia and nerve blocking was given by Drs. William Stewart Halsted and Richard Hall in November, 1884 (Archer, 1959; Burket, 1952; Howe & Whitehead, 1972; Kells, 1926; McAuley, 1966; Matas, 1952). It is also interesting that the nerves chosen for this demonstration were branches of the trigeminal nerve and in particular those of interest in oral and maxillofacial surgery, the infraorbital and inferior alveolar nerves. This demonstration would not have been possible without the work of Carl Koller. Koller was studying ophthalmology in Vienna and was encouraged by Sigmund Freud to explore the use of cocaine which was isolated in its pure form by Albert Niemann in 1860 (Howe & Whitehead, 1972).

The results of Koller's work on the anaesthetic properties of cocaine were presented by Dr. Josef Brettauer of Trieste at the Ophthalmological Congress in
Fig. 1.1. William Stewart Halsted.

Heidelberg, September 15-16, 1884. A North American delegate to the Heidelberg Congress, Dr. H.D. Noyes gave a full account of the proceedings in the New York Medical Record of October 11, 1884. This was the first news of Koller's discovery to reach the U.S. medical profession with sufficient detail to justify experimentation with the new anaesthetic (Matas, 1952; Olch, 1975).

Halsted wrote (Burket, 1952a): "Within a week, or two at the most, of the arrival of Koller's first paper announcing the effect of cocaine on the conjunctiva and cornea, we began active experimentation with this drug, hoping that it might prove of use in general surgery". The results of this early experimentation by Halsted and his colleagues at the College of Physicians and Surgeons (Columbia) were reported in the New York Medical Journal, December 6, 1884 by Dr. Richard J. Hall (Burket, 1952a):

"HYDROCHLORATE OF COCAINE"

17 East Forty-Ninth Street, November 26, 1884.
To the Editor of the New York Medical Journal:
"Sir. Wishing to use the hydrochlorate of cocaine in some small operations at the Roosevelt Hospital Out-Door Department, I made some experiments on myself to determine the best mode of using it. The preparation was a 4 percent solution made by Parke, Davis & Co. Injecting subcutaneously six minims on the dorsal surface of the forearm, at the junctions
of the middle and upper thirds, near the ulnar border, caused complete loss of sensation over an area extending downward as far as the lower end of the ulna, from three quarters of an inch to an inch wide above, and half an inch wide below, obviously following the distribution of a cutaneous branch of the ulnar nerve. There was no diminution of sensibility above the point at which the needle was introduced. A number of subsequent experiments showed that the anaesthesia extended over the region supplied by the cutaneous nerves near or into which the injection was made. Thus, in a number of experiments made by Dr. Halsted and myself, we have found that, injected subcutaneously into the leg or forearm, not in the neighbourhood of any large nerve-trunk, it will cause anaesthesia for a distance of two or three inches below the point of injection. An injection into the musculocutaneous nerve of the leg, at the point where it pierces the deep fascia, caused anaesthesia over all that portion of the leg and foot supplied by this nerve. An injection of eight minims into my left ulnar nerve at the elbow had no effect. An injection of thirty-two minims into the right ulnar nerve at the elbow caused, in two or three minutes, numbness and tingling down the forearm and little finger, and in five or
six minutes anaesthesia extending down the ulnar border of the forearm and hand and over the little finger, with much reduction of the sensibility of the ulnar border of the ring-finger. There was an anaesthetic area over the olecranon and the posterior surface of the external condyle, which we should not expect to be supplied by the ulnar nerve. There was no apparent diminution of muscular power, and no anaesthesia of the skin at the point where the injection was given. We have noticed that, when the needle is thrust into the deeper layers of the subcutaneous connective tissue, there is usually no loss of sensibility at the point where the needle was introduced.

"With the anaesthesia, marked constitutional symptoms appeared; about six minutes after the injection there was giddiness, at first slight, then well marked, so that I could not walk without staggering; and finally there was severe nausea, which would have been much worse, I think, had not the stomach been empty. At the same time, the skin was covered with cold perspiration, and the pupils were dilated. The nausea passed off, with the local anaesthesia, in about twenty minutes, leaving some dizziness for an hour or so longer."
"The same evening Dr. Halsted removed a small congenital cystic tumor, situated directly over the outer third of the left supraorbital ridge, and believed to be a meningocele, the communication of which with the cranial cavity had been shut off. Nineteen minims of the 4 percent solution were given hypodermically in divided doses, one external to the tumor, and the others close to the supra-orbital notch. In about five minutes the anaesthia was complete. The incision through the skin and the earlier steps of the operation were not felt at all, but, in consequence of the close adhesions of the sac and its extensive prolongations, especially into the upper lid, the operation was somewhat protracted, and the anaesthia had passed off to a considerable extent before it was completed. I was informed of a case, occurring on the same day, in which cocaine was injected, preparatory to performing a small plastic operation, in the same region, but no anaesthia of the field of operation was produced. On inquiry I was told that the injections had been given above the point where the incisions were to be made.

"This afternoon, having occasion to have the left first upper incisor tooth filled, and
finding that the dentine was extremely sensitive, I induced Dr. Nash, of No. 31 West Thirty-First Street, to try the effects of cocaine. The needle was passed through the mucous membrane of the mouth to a point as close as possible to the infraorbital foramen, and eight minims were injected. In two minutes there was complete anaesthesia of the left half of the upper lip and of the cheek somewhat beyond the angle of the mouth (as I was in the dentist's chair, I could not determine the exact limits), involving both the cutaneous and the mucous surfaces; also of the left side border of the gums, extending from the median line to the first molar tooth. Forcing the teeth apart with a wedge caused no pain except when the wedge impinged on the unaffected mucous membrane of the posterior surface of the gums. Dr. Nash was then able to scrape out the cavity in the tooth, which had previously been so exquisitely sensitive, and to fill it, without my experiencing any sensation whatever. The anaesthesia was complete until twenty-six minutes after the injection, and sensibility was much diminished for ten or fifteen minutes longer. Piercing the mucous membrane with the needle caused pain like the prick of a pin, but its subsequent introduction until it struck the bone and the injection of the solution were not
felt. In the same way, the introduction of the needle into the ulnar nerve caused quite severe pain, with tingling down the little finger, but the injection of fluid gave rise to no sensation. In the experiment on teeth, it surprised me that the incisor tooth should be rendered insensitive, as the anterior-superior dental nerve is given off in the infraorbital canal. I can only suppose that the effect extends some distance along the nerve centrally, or that the fluid travels along the sheath of the nerve into the canal.

"We have already used this mode of administration successfully in a number of cases in the Roosevelt Hospital Out-Door Department, and it is obvious that when the limits of safety have been determined it may find very wide application. For instance, in addition to the usual application to the conjunctiva, in operations on the eye, an injection into the orbit, in the neighborhood of the ciliary nerves, would doubtless diminish the liability to a very grave accident, which I understand had already occurred several times in the city - namely, in extrusion of the lens, from blepharospasm, occurring during iridectomy performed with the aid of cocaine. We have injected twenty minims a number of times,
without causing any constitutional symptoms.

"Very truly yours,

"R.J. HALL, M.D.

"Postscript. December 1st. Since the foregoing was written we have made some additional experiments which seem of interest. Dr. Halsted gave Mr. Locke, a medical student, an injection of nine minims, trying to reach with the point of the needle the inferior dental nerve, where it enters the dental canal. In from four to six minutes there was complete anaesthesia of the tongue, on the side where the injection had been given, extending to the median line and backward to the base as far as could be reached with a pointed instrument. There was further complete anaesthesia of the gums, anteriorly and posteriorly, to the median line, and all the teeth on that side were insensitive to blows. The soft palate and uvula, on the same side, were anaemic and quite insensitive. Mr. Locke thought also that there was some diminution of sensibility in the domain of the auriculo-temporal nerve.

"In four or five other cases where the injection was made in the same way, from fifteen to twenty minims being used, the fluid seemed to have come nearer the lingual than the
inferior dental. In all, the tongue was affected sooner than the gums; the anaesthesia extended as far back as the epiglottis, and the sense of taste was abolished on the affected side; and the posterior surface of the gums was earlier and more completely anaesthetized than the anterior.

"This evening Dr. Halsted gave me an injection of seventeen minims, the needle being introduced along the internal surface of the left ramus until it touched the inferior dental nerve, causing a sharp twinge along the whole line of the lower teeth. In three minutes there was numbness and tingling of the skin, extending from the angle of the mouth to the median line, and also of the left border of the tongue. In six minutes there was complete anaesthesia of the left half of the lower lip, on both the cutaneous and mucous surfaces, extending from the median line to the angle of the mouth and downward to the inferior border of the jaw. A pin thrust completely through the lip caused no sensation whatever. There was also complete anaesthesia of the posterior surface of the gums and of the lower teeth on the side, exactly to the median line; hard blows upon the teeth with the back of a knife caused no sensation. The anterior surface of
the gums was anaesthetic only from the median line to the first bicuspid. There was a small area of complete anaesthesia about the middle third of the left border of the tongue, not more than an inch in diameter. A slight return of sensation began twenty-five minutes after the injection and five minutes later no complete anaesthesia remained anywhere. I should mention that fifteen to twenty minims in this region caused, in two or three cases, slight constitutional symptoms similar to those previously described."

Halsted is credited with being the first to block the inferior alveolar nerve (Kells, 1926; Matas, 1952; McAuley, 1966). In a letter to Dr. C. Edmund Kells (October 26, 1920) Halsted credits Koller with the first injection of the infraorbital nerve (Burket, 1952a).

Like many of the early workers with cocaine, Halsted became addicted to the drug and took over two years to break himself of the habit (Howe & Whitehead, 1972). Halsted was a brilliant surgical pioneer and was Professor of Surgery at the Johns Hopkins Hospital, Baltimore, for 33 years. His early work with local anaesthetic techniques paved the way to many advances in the first half of the twentieth century.

Adrenaline was added to cocaine by E. Mayer in 1901
to promote vasoconstriction, prolong the duration and intensify the depth of anaesthesia (Howe & Whitehead, 1972). Procaine, less toxic than cocaine and non-addictive, was synthesized in 1905 by Alfred Einhorn and Heinrich Braun (McAuley, 1966). The idea of a cartridge syringe was conceived by Harvey S. Hook during the 1914-1918 war.

These advances helped to establish the routine use of local anaesthesia for pain control in medicine and dentistry. As a result, clinicians developed techniques for regional anaesthesia. Early literature on the subject is limited but it appears that intraoral maxillary nerve block via the palatal approach was described first in the English literature by Mendel Nevin in 1917 (Corbett & Helmore, 1948). The buccal approach was described by A.E. Smith in his 1920 text: "Block Anaesthesia and Allied Subjects" (Szerlip, 1948). Gaston Labat was a pioneer in regional anaesthesia and his innovative 1923 text contained various techniques for extraoral and intraoral approaches to the maxillary nerve. Although no bibliography was given, some techniques were obviously drawn from the European literature, e.g. lateral route of Schlösser, intranasal route of Sluder.

The basic concept of maxillary nerve block remains unaltered since the techniques were first described. Modifications have been introduced as a result of
operator experience and research. These developments are discussed in the chapters on technique.
CHAPTER TWO

ANATOMY OF MAXILLARY ANAESTHESIA

Introduction

Any dissertation on maxillary anaesthesia should be accompanied by a chapter describing the relevant anatomy. The anatomy of the trigeminal nerve in general and the maxillary nerve in particular will be discussed in the following pages. Areas related to the maxillary nerve, namely the pterygopalatine fossa, pterygomaxillary fissure and the infratemporal fossa will also be covered.

THE TRIGEMINAL NERVE

The trigeminal (triple, divided into three) nerve is the largest cranial nerve and of great importance to the oral and maxillofacial surgeon. It is the sensory nerve of the face, greater part of the scalp, teeth, mouth and nasal cavity and the motor nerve of the muscles of mastication, tensor palati and tensor tympani muscles. It resembles a spinal nerve since it arises by separate sensory and motor roots and because the sensory root also has a ganglion (Davies, 1967d; Scott & Dixon, 1972f).

The trigeminal or fifth cranial nerve arises from the ventral surface of the cerebral pons at the boundary between its body and arm (Sicher & DuBrul, 1975d).
The sensory root is larger than the motor root and on emerging from the pons, the motor root lies anteromedial to the sensory root. The two roots enter a recess in the dura mater (Trigeminal or Meckel's Cave) situated over the tip of the petrous temporal bone and the foramen lacerum. In Meckel's cave, the ganglion of the sensory root (semilunar or Gasserian ganglion) lies above the motor root. Each of the three divisions of the trigeminal nerve (ophthalmic, \( V_1 \); maxillary, \( V_2 \); and mandibular, \( V_3 \)) arising from the ganglion leaves the base of Meckel's cave with dura mater reflected upon it. The motor root of the trigeminal nerve runs with the mandibular division. There are no somatic motor fibres associated with the maxillary and ophthalmic divisions of the trigeminal nerve (Scott & Dixon, 1972f). Each of the divisions sends a small recurrent branch to the dura mater. The first and second divisions give off their recurrent branches inside the skull whilst the recurrent branch of the third division arises in the infratemporal fossa and re-enters the skull, together with the middle meningeal artery, through the foramen spinosum.

The cutaneous areas supplied by the three divisions of the trigeminal nerve comprise the entire face with the exception of a variably large area at the mandibular angle (Fig. 2-1). The vertex-ear-chin line separates the area of the trigeminal distribution from the one supplied by the posterior and anterior branches of the upper cervical nerves (Sicher & DuBrul, 1975d).
Fig. 2.1. Cutaneous supply of the head and neck.

The ramifications of the three principal sensory branches are complex but each division may be divided into three sets of branches (Sicher & DuBrul, 1975d):
(a) Internal rami and fibres to the oral or nasal mucous membrane.
(b) Intermediate rami supply the skin on the anterior surface of the face.
(c) External rami supply the skin on the lateral surface of the face.
Table No. 2.1 contains a synopsis of the most important sensory branches of the trigeminal nerve.

The diagrammatic boundaries shown in Fig. 2.1 are crossed by several branches of the three divisions. The external nasal branch of the ophthalmic nerve supplies the skin of the nasal bridge down to the nasal tip and would appear to trespass into the area of the maxillary nerves. Maxillary and mandibular nerves send branches upward to supply the temporal region. The zygomatico-temporal branch \( (V_2) \) supplies a small anterior area of the temple and the auriculotemporal branch \( (V_3) \) supplies the larger posterior part of the temporal area.

**OPHTHALMIC DIVISION \( (V_1) \)**

The ophthalmic nerve is the first and also the smallest division of the trigeminal nerve and is a wholly sensory nerve. It arises from the anteromedial part of trigeminal ganglion as a flattened band about 2.5cm long
<table>
<thead>
<tr>
<th>DIVISION</th>
<th>INTERNAL</th>
<th>INTERMEDIATE</th>
<th>EXTERNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Ophthalmic</td>
<td>Nasociliary nerve</td>
<td>Frontal nerve</td>
<td>Lacrimal nerve</td>
</tr>
<tr>
<td>nerve</td>
<td>nerve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Maxillary</td>
<td>Pterygopalatine nerve</td>
<td>Infraorbital nerve</td>
<td>Zygomatic nerve</td>
</tr>
<tr>
<td>nerve</td>
<td>nerve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Mandibular</td>
<td>Buccal nerve and lingual nerve</td>
<td>Inferior alveolar</td>
<td>Auriculotemporal nerve</td>
</tr>
<tr>
<td>nerve</td>
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<td>nerve</td>
<td></td>
</tr>
</tbody>
</table>

Main Sensory Branches of the Trigeminal Nerve (after Sicher, 1975d).
(Davies, 1967d) and runs forward in the lateral wall of the cavernous sinus below the fourth cranial nerve in close relationship to the fourth and sixth cranial nerves and the internal carotid artery (Last, 1972b; Scott & Dixon, 1972f). Sympathetic fibres are picked up from the cavernous plexus for the dilator pupillae muscle. At the anterior end of the cavernous sinus it gives off (recurrent) meningeal branches, the tentorial nerves, which supply the supratentorial dura mater except that in the bony floor of the middle cranial fossa (Last, 1972b).

In the anterior part of the cavernous sinus just before entering the orbit through the superior orbital (ophthalmic) fissure between the lesser and greater wings of the sphenoid bone, the ophthalmic nerve divides into three branches – lacrimal, frontal and nasociliary nerves (Davies, 1967d; Last, 1972b; Scott & Dixon, 1972f).

(a) The lacrimal nerve (Figs. 2.2, 2.3) is the smallest of the three branches of the ophthalmic division. It runs along the upper part of the lateral wall of the orbit where it is joined by secreto-motor fibres from the zygomatic branch of the maxillary division for the lacrimal gland. It is sensory to a small area of skin at the lateral end of the upper eyelid and to both palpebral and ocular surfaces of the corresponding conjunctiva (Last, 1972b). Occasionally the lacrimal nerve is absent and its area of supply is taken by the zygomatic branch of
Fig. 2.2 Divisions of the ophthalmic nerve.
(From: Labat, G. Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)

Fig. 2.3 Nerves of the orbit entering the right orbital cavity.
(From: Labat, G. Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)
the maxillary division. Sometimes the latter branch is absent and is replaced by a branch of the lacrimal nerve (Davies, 1967d).

(b) Frontal nerve.
The frontal nerve (Figs. 2.2, 2.3) is the largest branch of the ophthalmic division. On leaving the cavernous sinus and traversing the superior orbital fissure between the lacrimal and trochlear nerves, the frontal nerve runs forward in contact with the orbital periosteum above the levator palpebrae superioris muscle. Between the apex and base of the orbit, it divides into a small supratrochlear and a large supraorbital branch. The supratrochlear branch passes forward more medially and leaves the orbital cavity at its medial angle above the fibrous sling or pulley (trochlea) for the superior oblique muscle. It gives off a descending filament to join the infratrochlear branch of the nasociliary nerve. The supratrochlear nerve supplies the upper eyelid and conjunctiva and a narrow strip of forehead skin lateral to the midline.

The supra-orbital branch runs forward between the levator palpebrae superioris and the roof of the orbit, leaving the orbital cavity through the supra-orbital notch or foramen. The supra-orbital nerve supplies the frontal sinus, upper eyelid (skin and conjunctiva), all the forehead with the exception of
a central strip, and the frontal scalp up to the vertex.

(c) Nasociliary nerve.

The nasociliary nerve (Figs. 2.2, 2.3) is intermediate in size between the frontal and lacrimal nerves and is more medially placed. It enters the orbit through the medial part of the superior orbital fissure between the two branches of the oculomotor nerve. It crosses the optic nerve and divides into two terminal branches - the infratrochlear and anterior ethmoidal nerves.

The branches of the nasociliary nerve are as follows:

the sensory root of the ciliary ganglion - passes through the ciliary ganglion and, via the short ciliary nerves, is sensory to the whole eyeball including the cornea (not conjunctiva);

the long ciliary nerves - are distributed to the ciliary body, iris and cornea. Sympathetic fibres picked up in the cavernous sinus and supplying the dilator pupillae muscle run with the long ciliary nerves;

the posterior ethmoidal nerve - enters the
posterior ethmoidal foramen and supplies the posterior ethmoidal air cells and the adjacent sphenoidal sinus.

The final two branches or terminal branches of the naso-ciliary nerve are:

the infra trochlear nerve which is given off from the naso-ciliary nerve near the anterior ethmoidal foramen. It runs forward below the trochlea of the superior oblique tendon and supplies skin and conjunctivae of the medial and upper lid and ramifies on the skin overlying the nasal bridge above the medial angle of the eye, the conjunctiva, lacrimal sac and lacrimal caruncle.

the anterior ethmoidal nerve - passes into the anterior ethmoidal foramen below the frontal bone. Running obliquely forwards, it is in the roof of the anterior and middle ethmoidal air cells, and supplies both. It passes on to the cribiform plate of the ethmoid between two layers of dura mater and descends through the nasal slit alongside the front of the crista galli into the roof of the nose. It supplies two internal nasal branches - a medial branch to the mucous membrane of the front part of the nasal septum and a lateral branch to the
anterior part of the lateral wall of the nasal cavity. It then continues as the external nasal branch to notch the nasal bone and supply the skin of the ala, apex and vestibule of the nose.

MAXILLARY DIVISION ($V_2$)

The maxillary nerve is the second division of trigeminal nerve and like the ophthalmic nerve, wholly sensory. It is intermediate in position and size between the ophthalmic and mandibular nerves. Beginning at the middle part of the trigeminal ganglion as a flattened flexiform band (Fig. 2.4), it passes horizontally forwards along the lower part of the lateral wall of the cavernous sinus below the ophthalmic nerve. During its course through the cavernous sinus, the maxillary nerve gives off a small meningeal branch, the middle meningeal nerve, to the dura mater of the anterior half of the middle cranial fossa. It exits the skull through a short, almost horizontal canal, the foramen rotundum and passes into the upper part of the pterygopalatine fossa (Fig. 2.5). Here it becomes more cylindrical in form and firmer in texture. Crossing the upper part of the pterygopalatine fossa, the maxillary nerve inclines laterally on the posterior surface of the orbital plate of the palatine bone and on the upper part of the posterior surface of the maxilla, entering the orbit
Fig. 2.4. The maxillary nerve and its branches.
(From: Labat, G. Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)

Fig. 2.5. Course and branches of maxillary nerve.
through the inferior orbital fissure (Davies, 1967d; Last, 1972b; Scott & Dixon, 1972f).

The branches of the maxillary nerve can be divided into four groups related to the position where the branches are given off (Davies, 1967d):

(a) In the cranium
   - Middle meningeal nerve (vide supra).

(b) In the pterygopalatine fossa
   - Ganglionic branches
   - Zygomatic branches
   - Posterior superior alveolar.

(c) In the infraorbital canal
   - Middle superior alveolar
   - Anterior superior alveolar.

(d) On the face
   - Palpebral
   - Nasal
   - Superior labial.

The ganglionic branches, two in number, connect the maxillary nerve to the pterygopalatine (sphenopalatine) ganglion which lies below and suspended from the maxillary nerve in the pterygopalatine fossa. These ganglionic branches pass through the ganglion into its branches, where they mingle with the postganglionic fibres of the greater petrosal nerve and the sympathetic fibres of the deep petrosal nerve. They contain the secreto-motor fibres from the orbital periosteum and the mucous membranes of the nose, palate and pharynx (Davies,
By way of the ganglion, the maxillary nerve has five branches (Last, 1972b):

- nasopalatine (long sphenopalatine) nerve
- posterior superior lateral nasal (short sphenopalatine) nerve
- anterior palatine (greater palatine) nerve
- middle and posterior palatine (lesser palatine) nerves
- pharyngeal branch.

The distribution of the above nerves is discussed as part of the anatomy of the pterygopalatine fossa (pp. 73-79).

The zygomatic nerve arises in the pterygopalatine fossa, enters the orbit via the inferior orbital fissure, passes along the lateral wall of the orbit and divides into two branches - the zygomaticotemporal and zygomaticofacial nerves. The zygomaticotemporal nerve sends a branch to join the lacrimal nerve (see ophthalmic division) during its course through the lateral orbital walls conveying parasympathetic postganglionic fibres from the pterygopalatine ganglion to the lacrimal gland.

The main branch passes through a canal in the zygomatic bone to enter the infratemporal fossa. Ascending between bone and temporalis muscle, the nerve
arch and is distributed to the skin of the temple. The zygomaticotemporal nerve communicates with the facial nerve and the auriculotemporal branch of the mandibular nerve.

The zygomaticofacial branch passes along the inferolateral border of the orbit, emerging onto the face through a foramen in the zygomatic bone, perforating the obicularis oculi muscle to supply the skin on the prominence of the cheek. It also forms a fine plexus with the zygomatic branches of the facial nerve and the palpebral branches of the maxillary nerve.

The remaining branch given off in the pterygopalatine fossa is the posterior superior alveolar nerve. This nerve and the nerves given off in the infraorbital canal, the middle superior alveolar and anterior superior alveolar, will be discussed in detail later in the section because of their importance in maxillary anaesthesia.

The branches of the maxillary nerve given off on the face are the palpebral, nasal and superior labial nerves.

The palpebral branches ascend deep to the obicularis oculi and pierce this muscle to supply the skin of the lower eyelid. They join with the facial and zygomaticofacial nerves near the lateral angle of the eye.
eye.

The nasal branches supply the skin of the side of the nose and of the movable part of the nasal septum. They join with the external nasal branch of the anterior ethmoidal nerve.

The superior labial branches are large and numerous. Descending behind the levator labii superioris, they supply the skin of the anterior part of the cheek, the skin of the upper lip, the mucous membrane of the mouth and the labial glands. An infraorbital plexus is formed by joining with branches of the facial nerve.

SUPERIOR DENTAL PLEXUS

The maxillary teeth are innervated by a nerve plexus lying above their apices, in the base of the alveolar process of the maxilla. The plexus is formed by an exchange of fibres from the superior alveolar nerves: posterior, anterior and middle (when present). The terminal branches of the superior alveolar nerves emerge from this plexus in two sets that accompany the corresponding arteries (FitzGerald & Scott, 1958; Sicher & DuBrul, 1975e; Tonge & Luke, 1981).

The first group of terminal branches are the dental nerves. Their number corresponds to the number of roots of the maxillary teeth. These nerves enter the tooth
through the apical foramen of the root and divide into many small branches within the dental pulp. Pulpal innervation of all maxillary teeth is derived from the dental nerves.

The second group of terminal branches of the superior alveolar nerves are the interdental, or perforating branches and the interradicular branches. Each interdental branch runs through the entire height of the interradicular (or interalveolar) septum between two adjacent teeth giving off numerous branches to the periodontal ligaments of the adjacent teeth through the alveolar bone. At the height of the crest of the interradicular septum, the interdental nerves emerge into the gingiva to provide innervation to the interdental papilla and the buccal or labial gingiva.

The interradicular branches run the entire height of the interradicular septum, providing sensory innervation to the periodontal membranes of the adjacent teeth. The interradicular nerves terminate in the periodontal ligament at the furcation of the roots (Sicher & DuBrul, 1975e; Malamed, 1980a).

The presence of a superior dental plexus was established in forty eight percent of the specimens examined by McDaniel (1956). The plexus was not present in twenty two percent of the specimens and in a further twenty two percent the existence of a dental plexus was
not established. In a further eight percent of specimens the plexus was believed to be present but not definitely shown due to poor decalcification.

In three of McDaniel's dissections (1956), sensory ganglia appeared to be associated with the nerve plexus. In one case, the ganglion was found between the posterior superior alveolar and middle superior alveolar nerves. This corresponds to the ganglion of Valentin found over the upper second premolar tooth (Robinson, 1922: quoted by McDaniel, 1956). In another case the ganglion was found between the secondary branches of the anterior superior alveolar and the posterior superior alveolar nerves. The third case demonstrated a ganglion between the secondary branches of the anterior superior alveolar nerves. The latter ganglion has been called the ganglion of Bochdalek when found between the anterior and middle superior alveolar nerves (McDaniel, 1956).

The superior dental plexus has also been termed the outer nerve loop of the maxilla (Roberts & Sowray, 1979c). As discussed, it supplies the teeth and their labio-buccal supporting tissues (bone and gingiva). An inner nerve loop comprising an anastomosis of the greater palatine and long sphenopalatine nerves in the canine region is responsible for innervation of the palatal supporting tissues.

FitzGerald and Scott (1958) speculate on the
contribution of the long sphenopalatine nerve to the anterior superior alveolar branches of the superior dental plexus. This point remains uncertain on consideration of morphological and developmental grounds.

(a) Posterior Superior Alveolar Nerve
The posterior superior alveolar (dental) nerve arises from the maxillary nerve within the pterygopalatine fossa. The nerve may exist of one or two trunks (Jorgensen & Hayden, 1972) or more usually two (Malamed, 1980a). These trunks descend through the pterygopalatine fossa to emerge through the pterygomaxillary fissure and pass forward within the infratemporal fossa to foramina on the infratemporal surface of the maxilla – the posterior superior alveolar foramina. The trunks of the posterior superior alveolar nerve divide into a variable number of branches at a variable distance from the origin of the nerve and may happen before reaching the maxillary tuberosity, on reaching the tuberosity (most frequent) or after entering the posterior superior alveolar foramina. The number of branches varies between one and four. Table No. 2.2 summarizes the findings of the various authors.

A branch of the posterior superior alveolar nerve often pierces the buccinator muscle and supplies the posterior gingiva and adjacent buccal mucosa and cheek (Sicher & DuBrul, 1975e). This branch arises
Table No. 2.2

<table>
<thead>
<tr>
<th>AUTHOR</th>
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<tr>
<td>Wood Jones, 1939</td>
<td>3 or 4</td>
</tr>
<tr>
<td>McDaniel, 1956</td>
<td>1 in 45% of cases</td>
</tr>
<tr>
<td></td>
<td>2 or 3 in 55% of cases</td>
</tr>
<tr>
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<td>2 or 3</td>
</tr>
<tr>
<td>Westwater, 1960</td>
<td>3</td>
</tr>
<tr>
<td>Last, 1972b</td>
<td>3</td>
</tr>
<tr>
<td>Sicher &amp; DuBrul, 1975e</td>
<td>2 or 3</td>
</tr>
<tr>
<td>Heasman, 1984</td>
<td>1 in 1 specimen</td>
</tr>
<tr>
<td></td>
<td>2 in 13 specimens</td>
</tr>
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<td></td>
<td>3 in 5 specimens</td>
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</table>

Number of Branches of Posterior Superior Alveolar Nerve.
from the main trunk of the nerve before it enters the posterior superior alveolar foramina (Last, 1972b). In some cases, this branch may replace the buccinator/long buccal nerve (Turner, 1867: quoted by Wood Jones, 1939). Rudinger (quoted by Wood Jones, 1939) has designated this nerve as the ramus maxillaris externus. Other authors have designated it as the nervous buccalis which may lead to confusion with the long buccal/buccinator nerve.

The dental branches proper of the posterior superior alveolar nerve are usually derived from two main branches. The upper and smaller branch runs in a canal in the lateral wall of the maxillary sinus at the level of the malar tuberosity (zygomatic process of the maxilla). The larger inferior branch runs in a canal parallel to the transverse facial part of the canal for the anterior superior alveolar nerve, between the upper posterior branch and the alveolar margin. The canal for the inferior branch has been traced as far forward as the root of the canine tooth (Wood Jones, 1939; Jorgensen & Hayden, 1972). Such an anterior extension of the posterior superior alveolar nerve would imply that it plays some part in innervating the premolar teeth (Adatia, 1976). This has been noted in twenty-six percent of cases in McDaniel's study (1956).

Heasman (1984) traced the posterior superior
alveolar nerve antero-superiorly in fifteen out of nineteen dissections and direct communication with the anterior superior alveolar nerve was made as it descended infero-medially below the infraorbital foramen towards the pyriform aperture.

The distribution of the posterior superior alveolar nerves is to the upper first, second and third molar teeth and associated periodontal ligaments, surrounding alveolar bone and gingiva, adjacent cheek (from the main trunk) and mucosa of the maxillary sinus. The palatal roots of the molars and the disto-buccal root of the first molar tooth are supplied by the posterior superior alveolar nerve. Innervation of the mesio-buccal root of the first molar is by the middle superior alveolar nerve when present (Roberts & Sowray, 1979c; Malamed, 1980a). The premolar teeth may also be supplied by the posterior superior alveolar nerve in the absence of the middle superior alveolar nerve (McDaniel, 1956; Adatia, 1976).

(b) Middle Superior Alveolar Nerve

The middle superior alveolar nerve is variable in both its presence and course. When present, it is a branch of the infraorbital trunk of the maxillary nerve and forms part of the superior dental plexus (Sicher & DuBrul, 1975a). There is a great diversity in opinion as to the presence of the
nerve. Wood Jones (1939) stated: "I have so far been unable to identify a classic middle superior dental nerve in dissections or to trace the canal, in which it is said to run, in dry ones. Its occurrence must, I think, be a matter of some infrequency, and it is to be doubted if its retention in normal descriptive anatomy is altogether desirable".

However, the literature since 1939 tends to cast some doubt on Wood Jones's statement. The incidence of the middle superior alveolar nerve appears to vary between twenty and eighty percent. Table No. 2.3 lists the findings of numerous authors since 1939. Scott and Dixon (1972g) state that the middle superior alveolar nerve may be present unilaterally or bilaterally in the same individual.

The site of origin from the infraorbital trunk varies. It may leave the trunk in the pre-orbital portion (i.e. within the pterygopalatine fossa) in ten percent (FitzGerald and Scott, 1958) and eleven percent (FitzGerald, 1956) of cases. Within the infraorbital canal, the nerve may originate as a separate structure in any part of the canal as far forward as the origin of the anterior superior alveolar nerve. The fibres of both nerves may be bound together for a short distance in seventeen percent (FitzGerald, 1956) and fifteen to twenty
Table No. 2.3

<table>
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<tr>
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<td>FitzGerald &amp; Scott, 1958</td>
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<tr>
<td>Scott &amp; Dixon, 1972g</td>
<td>50</td>
</tr>
<tr>
<td>Sicher &amp; DuBrul, 1975e</td>
<td>50</td>
</tr>
<tr>
<td>Roberts &amp; Sowray, 1979c</td>
<td>50</td>
</tr>
<tr>
<td>Malamed, 1980a</td>
<td>20-40</td>
</tr>
<tr>
<td>Heasman, 1984</td>
<td>37</td>
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</table>

Incidence of Middle Superior Alveolar Nerve.
percent of cases (FitzGerald & Scott, 1958). The course of the middle superior alveolar nerve is variable and depends on the origin of the nerve (FitzGerald, 1956; FitzGerald & Scott, 1958). FitzGerald (1956) classified the mode of presentation of the middle superior alveolar nerve as follows:

Type 1: nerve arises prematurely (pre-orbital portion) and pierces the posterior maxillary bone a few millimetres lateral to and below the commencement of the infra orbital groove. Types 2, 3 and 4 originate from the infra orbital nerve in the posterior, middle or anterior portions of its course and run in the posterior, lateral and anterior walls of the antrium respectively.

Type 5: joint origin of the middle superior alveolar and anterior superior alveolar nerves from the infraorbital nerve.

The percentages of origins and courses of the middle superior alveolar nerve are shown in Table No. 2.4. Fig. 2.6 gives a schematic representation of the origins and causes of the middle superior alveolar nerve.

Wherever the origin, the nerve always makes its way to the premolar dental plexus. When there is no middle superior alveolar nerve trunk, fibres from the anterior superior alveolar, posterior superior
Table No. 2.4

<table>
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<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Absent</td>
<td>18</td>
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Total  100

Incidence of Various Types of Middle Superior Alveolar Nerve (FitzGerald, 1956).
Fig. 2.6 Scheme of the modes of presentation of the middle superior alveolar nerve.

(From: FitzGerald, M.J.T. J. Anat. (Lond) 90:520-522, 1956.)
alveolar trunks or both supply the premolar region. The middle superior alveolar nerve therefore overlaps the territory of the anterior and posterior superior alveolar nerves (FitzGerald, 1956; FitzGerald & Scott, 1958).

From the foregoing discussion, it can be concluded that routine conduction anaesthesia of the middle superior alveolar nerve is impossible due to the variability of presence, origin and position of the nerve (FitzGerald & Scott, 1958).

(c) Anterior Superior Alveolar Nerve

The anterior superior alveolar nerve is the largest of the three superior alveolar nerves. Its origin from the infraorbital canal of the maxillary nerve trunk is variable (Wood Jones, 1939).

FitzGerald and Scott (1958) found that it arose from the anterior third of the infraorbital nerve trunk in sixty percent of cases, the middle third in thirty percent of cases and from the posterior third in ten percent of cases. Malamed (1980a) states that it arises from the infraorbital nerve trunk six to ten millimetres before the infraorbital foramen. Tonge and Luke (1981) consider that the point at which the anterior superior alveolar nerve leaves the maxillary trunk is variable and, although it often arises within a few millimetres of the
foramen, in about one third of cases it comes from the posterior section of the infraorbital course of the maxillary nerve.

Wood Jones (1939) found that the origin from the parent trunk is generally posterior to the midpoint of the infraorbital canal and on average, some fifteen millimetres or more behind the infraorbital foramen. It is not uncommon for the nerve to be separate from the infraorbital trunk at the posterior end of the canal.

In a recent study of nineteen dissections, Heasman (1984) found the anterior superior alveolar nerve originated from the infraorbital trunk within five millimetres of the infraorbital foramen in six specimens, whereas four nerves branched at distances greater than twenty millimetres from the foramen, two of which were within two millimetres of entering the infraorbital canal. The remaining nine dissections demonstrated branching five to ten millimetres from the foramen in four cases and ten to twenty millimetres in five cases.

The anterior superior alveolar nerve arises from the lateral aspect of the parent trunk (Fig. 2.7) and may have a single branch or two or three smaller branches. It is at least one third the size of the infraorbital trunk. On leaving the parent trunk,
Fig. 2.7 The floor of the left orbit showing separate canal for the anterior superior alveolar nerve.

(From: Wood Jones, F., J. Anat. (Lond.), 73:583-591, 1939.)

Fig. 2.8 The canalis sinuosus.

(From: Wood Jones, F., J. Anat. (Lond.), 73:583-591, 1939.)
the nerve (and accompanying blood vessels) runs forward in the canalis sinuosus, a large and constant structure (Fig. 2.8).

At a point seven or eight millimetres lateral to the infraorbital foramen and just below the zygomatico-maxillary suture, the nerve turns downward and swings transversely across the anterior wall of the antrum to the lateral wall of the nasal cavity ending at the anterior end of the inferior turbinate bone (the transverse facial course) (Fig. 2.9). In seventy five percent of cases, the canalis sinuosus is roofed by the floor of the infraorbital foramen. The posterior wall of the canalis sinuosus is frequently deficient in the anterior wall of the antrum with the nerve lying against the sinus mucosa.

Between the medial aspect of the canine alveolus and the nasal margin of the maxilla, the canal turns abruptly downwards and in this region gives a dental branch to the canine and sometimes premolar teeth and smaller branches to the incisor teeth (superior dental plexus). The canal descends along the narial margin to the floor of the nasal cavity continuing medially to the nasal septum. The canal may open at the septum to form the foramen septale (Fig. 2.10) near the root of the anterior nasal spine. Through the foramen, the terminal branches of the
Fig. 2.9 Transverse facial course of the anterior superior alveolar nerve.

(From: Wood Jones, F., J. Anat. (Lond.), 73:583-591, 1939.)

Fig. 2.10 The narial margin to show the paraseptal ridge and foramen septale.

(From: Wood Jones, F., J. Anat. (Lond.), 73:583-591, 1939.)
anterior superior alveolar nerve and artery emerge (Wood Jones, 1939).

The bony course of the anterior superior alveolar vessels and nerves is some 55mm in length (15mm - orbital floor, 20mm - curved transverse facial course, 20mm - curved circumnarial course) (Wood Jones, 1939; Jorgensen & Hayden, 1972).

The anterior superior alveolar nerves supply the maxillary incisor and canine teeth, associated periodontal tissues, buccal bone and mucous membrane and mucosa of the maxillary sinus (Davies, 1967d; Jorgensen & Hayden, 1972; Scott & Dixon, 1972g; Malamed, 1980a). A nasal branch supplies the mucous membrane of the anterior part of the lateral wall of the nose as high as the ostium of the maxillary sinus and the floor of the nasal cavity. The terminal branch supplies the nasal septum adjoining the root of the anterior nasal spine (Davies, 1967d).

If a middle superior alveolar nerve is not present, the anterior superior alveolar nerve may supply the premolar teeth and mesiobuccal root of the first permanent molar teeth (Malamed, 1980a). McDaniel (1956) noted that in twelve percent of cases, the anterior superior alveolar nerve was traced to premolar region. When the middle superior alveolar
nerve was absent, McDaniel (1956) found secondary branches of the anterior superior alveolar nerve supplied the premolar region in twenty-four percent of cases.

MANDIBULAR DIVISION (V₃)

The mandibular nerve is the third and also the largest division of the trigeminal nerve. It is a mixed nerve with two roots; a large, sensory root and a small motor root. Embryologically it is the nerve of the first (mandibular) pharyngeal arch. Leaving the inferior part of the trigeminal ganglion the division passes down to the foramen ovale accompanied by the small motor root of V which passes beneath the ganglion and joins the sensory root at (Last, 1972b) or outside the foramen (Davies, 1967d; Scott & Dixon, 1972b). The short trunk formed passes into the infratemporal fossa between the upper head of the lateral pterygoid muscle and the tensor palati muscle which lies on the lateral wall of the pharynx. Two branches are given off the short trunk before it divides into a small anterior branch (mainly motor) and a large posterior branch (mainly sensory). Fig. 2.11 represents the branches diagrammatically. Branches from the short main trunk are:

(a) a meningeal branch (nervus spinosus), a recurrent nerve, which passes back through the foramen ovale or occasionally the foramen spinosum (Last, 1972b).
Fig. 2.11 The mandibular nerve and its branches.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)
In another section of the same text, Last (1972a) states that the nervus spinosus re-enters the middle cranial fossa via the foramen spinosum or sometimes the foramen ovale. Before entering the skull, small twigs supply the cartilaginous part of the Eustachian tube. In the middle cranial fossa, branches supply the dura mater of the posterior half. Passing between the squamous and petrous parts of the temporal bone, through the petro-squamous suture, branches supply the mastoid air cells and mastoid antrum (Last, 1972a,b).

(b) the nerve to the medial pterygoid which runs forward to the deep surface of the muscle, giving off the motor root to the otic ganglion which lies on the tensor palati muscle. This root passes near (Last, 1972b) or through the ganglion (Davies, 1967d) without synapse and supplies the two tensor muscles, tensor palati and tensor tympani.

The anterior and posterior divisions of the mandibular branch of the trigeminal nerve have been likened to a "cat of nine tails" by Last (1972b), there being six anterior branches and three posterior branches.

The anterior division of the mandibular nerve is motor except for the long buccal nerve. The six nerves of the anterior division are:
i. two nerves to the lateral pterygoid muscle which enter the deep surface of the muscle and supply each head.

ii. two deep temporal nerves (anterior and posterior) both of which pass laterally (Romanes, 1964) or above (Last, 1972b; Davies, 1967d) the upper border of the lateral pterygoid muscle, turn above the infratemporal crest and enter the deep aspect of, and supply, the temporalis muscle. A third or middle branch is occasionally present (Last, 1972a).

iii. the nerve to the masseter muscle passes laterally, above the upper head of the lateral pterygoid muscle, in front of the temporomandibular joint, behind the tendon of temporalis and through the posterior aspect of the mandibular (sigmoid, semilunar) notch to enter the deep surface of the muscle. The masseteric nerve gives an articular branch to the temporomandibular joint in accordance with Hilton's Law: the skin over, and the muscles to, a joint are innervated from the same trunk (Last, 1972c).

iv. the long buccal/buccal nerve is the only sensory branch of the anterior division and is the only nerve to pass between the two heads of
the lateral pterygoid muscle. After passing forward between the heads of the lateral pterygoid, the long buccal nerve passes inferiorly, deep to, or through the lower part of temporalis. Emerging from under cover of the ramus of the mandible and the anterior border of the masseter, the nerve unites with the buccal branches of the facial nerve. On reaching the buccinator, a cutaneous branch is given off which supplies a small area of skin over the cheek immediately below the zygomatic bone. The nerve then pierces the buccinator supplying the oral mucous membrane and terminates by supplying the vestibular (buccal) gingiva and the muco-buccal fold of the three mandibular molar teeth. Secretomotor fibres from the otic ganglion pass with the long buccal nerve to supply the molar and buccal accessory salivary glands. Although the long buccal nerve passes through the buccinator muscle, it does not contain motor fibres as the buccinator muscle derives its motor supply from a branch of the facial nerve.

The posterior division of the mandibular nerve is sensory except for the mylohyoid branch of the inferior alveolar (dental) nerve. The three branches of the posterior division are:
(a) the auriculotemporal nerve arises by two roots which embrace the middle meningeal artery (Last, 1972a). The roots join to form a single nerve behind the artery and run posteriorly between the neck of the mandible and the spine of the sphenoid (MacIntosh & Ostlere, 1967a).

Winding posteriorly to the neck of the condyle below the attachment of the joint capsule, the nerve passes upwards to enter the glenoid lobe of the parotid gland. Leaving the gland, the nerve crosses the root of the zygomatic arch in front of the tragus and behind the superficial temporal artery. The auriculotemporal nerve supplies the temporo-mandibular joint, the skin and fascia of the temporal region and lateral aspect of the scalp, the upper and anterior part of the lateral aspect of the pinna, the mucous membrane of the external auditory canal and part of the outer surface of the tympanic membrane. Postganglionic parasympathetic secretomotor fibres from the otic ganglion supply the parotid gland (Davies, 1967d; Last, 1972b).

(b) the inferior dental nerve emerges below the lower head of the lateral pterygoid muscle and curves downwards on the medial pterygoid muscle. Its passage lies lateral to the sphenomandibular ligament in the pterygomandibular space. Entering the mandible at the mandibular foramen, in front of
the corresponding artery and vein, the inferior dental nerve runs forward in the inferior dental (inferior alveolar or mandibular) canal and innervates the molar and second premolar teeth on that side of the lower jaw (Last, 1972a). At the mental foramen, a mental branch is given off which supplies the mucous membrane and skin of the lower lip and chin and the buccal and labial gingivae associated with the mandibular first premolar, canine and incisor teeth. The incisive branch of the inferior dental nerve continues in the canal supplying the first premolar, canine and incisor teeth. Cross innervation normally occurs between the right and left incisive branches, usually extending only to the central incisor but occasionally to the lateral incisor. Branches of the inferior dental nerve may be given off before entering the mandibular foramen. These branches enter the bone through auxiliary foramina in front of and above the mandibular foramen. It is thought that these branches supply the third molar tooth and this aberrant nerve supply occasionally causes failure of inferior dental nerve blocks (Sicher & DuBrul, 1975e).

Before entering the mandibular foramen, the inferior dental nerve gives off the only motor branch of the posterior division – the mylohyoid nerve. This nerve pierces the sphenomandibular ligament and runs
downwards and forwards between the medial pterygoid muscle and the ramus, grooving the bone to enter the inferolateral aspect of the mylohyoid muscle, which it supplies. Branches continue forward to supply the anterior belly of the digastric muscle (Davies, 1967d; Last, 1972b). The mylohyoid nerve also provides a cutaneous branch giving sensory innervation to the skin on the inferior and occasionally the anterior surface of the point of the chin. In about ten percent of cadavers examined by Sicher and DuBrul (1975d), a twig of the sensory branch of the mylohyoid nerve enters the mandible in the mental region and may participate in the innervation of the lower incisor teeth.

(c) The lingual nerve is smaller than the inferior dental nerve and proceeds inferiorly anterior to the inferior dental nerve, medial to the lateral pterygoid muscle and then between the medial pterygoid muscle and the mandible. Passing under the free lower border of the superior constrictor, the lingual nerve continues anteriorly above the mylohyoid muscle, grooving the lingual plate of the mandible just below the third molar tooth. A gingival branch is given off which supplies the gingivae on the lingual aspect of the mandible to the midline. Dipping below the submandibular or Wharton's duct, the lingual nerve ascends on the hyoglossus to the anterior two-thirds of the tongue.

54
which it supplies with common sensation and taste, the latter via the chorda tympani fibres. The chorda tympani joins the lingual nerve deep to the lower border of the lateral pterygoid muscle. The secretomotor fibres of the chorda tympani (nervus intermedius) are given off to the submandibular ganglia, relaying to the glands in the floor of the mouth. Branches of the lingual nerve also supply the mucosa of the floor of the mouth. In the latter part of its course, the lingual nerve is in close relation with the submandibular duct, passing from above, downwards and forwards on the lateral aspect and then, winding below it, runs upwards and forwards on its medial side. The lingual nerve communicates with fibres from the inferior alveolar nerve and the hypoglossal nerve (Romanes, 1964; Davies, 1967d; Last, 1972b).

THE INFRATEMPORAL FOSSA

The infratemporal or zygomatic fossa (Seldin, 1942) is an irregularly-shaped space lying beneath the base of the skull between the side wall of the pharynx and the ascending ramus of the mandible. It is bounded anteriorly by the posterior wall of the maxilla and posteriorly by the styloid apparatus and the carotid sheath which lie in front of the prevertebral fascia (Fig. 2.12). It has no anatomical floor and is continuous with the tissue spaces alongside the pharynx.
Fig. 2.12 Base of skull and infratemporal fossa.
and oesophagus.

The space is continuous through the superior mediastinum into the posterior mediastinum (Last, 1972a). The medial wall is formed by the lateral pterygoid plate. The infratemporal fossa communicates with the temporal fossa through the gap between the zygomatic arch and the side of the skull. Medial to this gap, the roof is formed by the infratemporal surface of the greater wing of the sphenoid and a small part of the squamous temporal. The posterior, inferior and lateral aspects of the fossa are freely open (Davies, 1967a).

The anterior and medial walls meet inferiorly but are separated superiorly by the pterygomaxillary fissure through which the infratemporal fossa communicates with the pterygopalatine fossa. The upper end of the pterygomaxillary fissure is continuous with the posterior end of the inferior orbital fissure, thus connecting the infratemporal fossa with the orbit.

The foramen ovale, transmitting the mandibular division of the trigeminal nerve, emissary vein and meningeal artery, opens into the roof of the fossa through the greater wing of the sphenoid. Posterolateral to foramen ovale, in the roof the fossa, lies the foramen spinosum transmitting the middle meningeal artery and nervous spinosus, a branch of the mandibular division of the trigeminal nerve.
The infratemporal fossa is occupied by the two pterygoid muscles around and between which pass the branches of the mandibular nerve, maxillary artery and the pterygoid venous plexus (Fig. 2.13). The lower part of the temporalis muscle passes laterally through the fossa to be inserted into the coronoid process (Davies, 1967a; Last, 1972a).

(a) The lateral pterygoid is a short, thick muscle with two parts or heads: an upper from the infratemporal surface and infratemporal crest of the greater wing of the sphenoid bone, and a lower from the lateral surface of the lateral pterygoid plate. The two heads, lying edge to edge, converge and fuse into a short, thick tendon with fibres running backwards and laterally to be inserted into a depression on the anterior surface of the neck of the mandible—the pterygoid pit. The upper fibres of the tendon pass back into the articular disc and anterior part of the capsule of the temporomandibular joint (Last, 1972a).

The lateral pterygoid assists in opening the mouth by pulling forward the condylar process of the mandible and the articular disc, while the head of the mandible rotates on the articular disc. During closing, the slow relaxation of the lateral pterygoid controls the backward gliding of the articular disc and mandibular condyle. In
Fig. 2.13 Infratemporal and submandibular regions.

conjunction with the medial pterygoid of the ipsilateral side, the lateral pterygoid advances the condyle of that side so that the jaw rotates about a vertical axis through the contralateral condyle. When the medial and lateral pterygoids of both sides act together, the mandible is protruded (Davies, 1967b).

(b) The medial pterygoid is a thick, quadrilateral muscle arising from the medial surface of the lateral pterygoid plate and the grooved surface of the pyramidal process of the palatine bone. A more superficial part of the muscle, the inferior head, arises from the lateral surfaces of the pyramidal process of the palatine bone and tuberosity of the maxilla. Passing over the lower margin of the lower head of the lateral pterygoid muscle, the inferior head fuses with the main muscle mass. In this way the two heads, unequal in size, embrace the lower edge of the lateral pterygoid muscle. The fibres of the muscle pass inferiorly, laterally and posteriorly at forty-five degrees and insert by a strong tendinous lamina to the inferior and posterior part of the ramus and angle of the mandible, as high as the mandibular foramen and nearly as far anteriorly as the mylohyoid groove.

The pull of the muscle on the angle of the mandible is upwards, forwards and medially. Thus the medial
pterygoid assists in elevating the mandible. In conjunction with the lateral pterygoids, the mandible is protruded. When the two pterygoid muscles of one side are in action, the corresponding side of the mandible is swung forwards and to the opposite side, while the head of the mandible on the other side undergoes a slight degree of rotation. By an alternating action of the pterygoid muscles of both sides, side-to-side movements necessary for the trituration of food are effected (Last, 1972a; Davies, 1967b).

(c) The maxillary artery is a terminal branch of the external carotid. It enters the infratemporal fossa by winding around medial to the neck of the mandible and passing forwards between the neck of the mandible and the sphenomandibular ligament. It runs either superficial or deep to the lower head of the lateral pterygoid to enter the pterygopalatine fossa, via the pterygomaxillary fissure, between the two heads of that muscle.

The artery is divided into three parts. The branches of the first and third parts all enter foramina and are termed "bony" branches. The branches of the second part supply muscles and are termed "soft" branches.

The five branches of the first or mandibular part
are distributed as follows:

The inferior alveolar (dental) artery supplies the mandibular teeth, the mandible, and its periosteum. Access is gained to the mandible via the mandibular foramen.

The middle meningeal artery passes through the foramen spinosum to supply the bone of the vault of the skull.

The accessory meningeal artery passes through the foramen ovale and supplies branches to the trigeminal ganglion, dura mater and bone.

The deep auricular artery passes through the squamotympanic (petrotympanic) fissure supplying the external auditory meatus and also giving a branch to the temporomandibular joint.

The anterior tympanic artery also passes through the squamotympanic fissure to join the circular anastomosis around the tympanic membrane.

The branches of the second or pterygoid part are distributed as follows:

The deep temporal branches, an anterior and a
posterior, supply the temporalis muscle and anastomose with the middle temporal artery.

The pterygoid branches are irregular in number and origin and supply the pterygoid muscles.

The masseteric artery passes through the mandibular (sigmoid) notch to the deep surface of the masseter. In the substance of that muscle it anastomoses with the masseteric branches of the facial artery and with the branches of the transverse facial artery.

The buccal artery runs forward with the buccal nerve to the outer surface of the buccinator, to which it is distributed, anastomosing with branches of the facial and infraorbital arteries.

The third or pterygopalatine part of the maxillary artery divides in the pterygopalatine fossa into five branches which accompany the five branches of the pterygopalatine ganglion. The branches are distributed as follows:

The posterior superior alveolar (dental) artery is given off as the maxillary artery enters the pterygopalatine fossa. Descending upon the infratemporal surface of the maxilla, it
divides into branches supplying the molar and premolar teeth, the lining of the maxillary sinus and the maxillary gingivae.

The infraorbital artery often arises in conjunction with the posterior superior alveolar artery. It enters the orbital cavity through the posterior part of the inferior orbital fissure, runs along the infraorbital groove and canal with the infraorbital nerve to emerge with the nerve on the face. In the canal it gives off: (a) orbital branches which assist in the supply of the inferior rectus and inferior oblique muscles and the lacrimal sac; (b) anterior superior alveolar branches which supply the upper incisor and canine teeth and the mucous membrane of the maxillary sinus. On the face, branches of the infraorbital artery anastomose with the branches of the facial, ophthalmic, transverse facial and buccal arteries.

The greater palatine artery descends through the pterygopalatine fossa and greater palatine/pterygopalatine canal with the greater palatine nerve (Fig. 2.14) from the pterygopalatine ganglion to appear on the hard palate through the greater palatine foramen (Davies, 1967e). It gives off two or three lesser
Fig. 2.14 The greater palatine nerve in the pterygopalatine canal.

(Illustration from a specimen prepared by the late B.C.W. Barker.)
palatine arteries which pass through the lesser palatine canals to supply the soft palate and tonsil and to anastomose with the ascending palatine artery. On the hard palate, the artery runs forward in a groove near the alveolar border of the hard palate to the incisive foramen where it anastomoses with the terminal branches of the artery of the opposite side and the long sphenopalatine (nasopalatine) artery. Branches are distributed to the gingivae, the palatine glands and the mucous membrane of the roof of the mouth. Nasal branches of the greater palatine artery enter the lower posterior part of the nasal cavity by piercing the vertical plate of the palatine bone.

The pharyngeal branch is very small and runs backwards through the pharyngeal (palato-vaginal) canal with the pharyngeal branch of the pterygopalatine ganglion. It is distributed to the mucosa of the roof of the nose, pharynx, sphenoidal air sinus and auditory tubes.

The artery of the pterygoid (Vidian) canal may frequently be a branch of the greater palatine artery. It passes backwards along the pterygoid canal at the base of the pterygoid
plates to the foramen lacerum. The artery is distributed to the mucous membrane of the upper part of the pharynx, the auditory tube and the tympanic cavity.

The sphenopalatine artery is really the terminal part of the maxillary artery. It passes through the sphenopalatine foramen into the nasal cavity at the posterior part of the superior meatus. Here it gives off its posterior lateral nasal branches, which ramify over the conchae and meatuses, anastomose with the ethmoidal arteries and the nasal branches of the greater palatine artery, and assist in supplying the frontal, maxillary, sphenoidal and ethmoidal sinuses. The sphenopalatine artery ends on the nasal septum as the posterior septal branches, which anastomose with the ethmoidal arteries. One branch descends in a groove on the vomer to the incisive canal and anastomoses with the terminal ascending branch of the greater palatine artery, and with the septal branch of the superior labial artery (Davies, 1967c; Last, 1972a; Scott & Dixon, 1972c).

(d) The pterygoid venous plexus is a network of very small veins that lie around and within the lateral pterygoid muscle and as such are also in close
relationship to the temporalis and medial pterygoid muscles (Last, 1972a; Scott & Dixon, 1972a,c).

The veins draining into the pterygoid venous plexus correspond with the branches of the maxillary artery. The pterygoid plexus has both deep and superficial communications. It communicates with the cavernous sinus within the cranial cavity through the foramen ovale and the foramen of Vesalius if present. The foramen of Vesalius is an inconstant foramen in the greater wing of the sphenoid bone. The plexus also communicates with the ophthalmic veins through the pterygopalatine fossa and inferior orbital fissure. The plexus is drained from behind along the maxillary vein, which joins the superficial temporal vein within the capsule of the parotid gland to form the posterior facial vein. It also drains forwards into the anterior facial vein along the deep facial vein which runs with the buccal artery and nerve on the surface of the buccinator muscle. Below, the pterygoid plexus communicates with the pharyngeal plexus deep to the medial pterygoid muscle on the surface of the superior constrictor muscle. The veins draining the maxillary and mandibular teeth and their supporting structures enter the pterygoid plexus. Because of the widespread communications of the pterygoid venous plexus particularly with the cavernous sinus, it is important not to introduce
infection into the area when administering a maxillary nerve block.

The sphenomandibular ligament is a flat band of tough fibrous tissue extending from a narrow attachment on the spine of the sphenoid, superficial to the medial pterygoid muscle to the lingual and lower margin of the mandibular foramen (Last, 1972a; Romanes, 1978). The ligament is of considerable developmental interest as it is the remnant of part of the first branchial arch cartilage (Meckel's cartilage) and develops from the perichondrium during early foetal life (Romanes, 1978). It is sometimes referred to as an accessory ligament of the temporomandibular joint but it is doubtful if it plays any important part in the mechanics of mandibular movement (Scott & Dixon, 1972e). Between it and the neck of the mandible pass the auriculotemporal nerve and the maxillary artery and vein. Between it and the ramus of the mandible the inferior alveolar vessels and nerve converge to the mandibular foramen. It is pierced by the mylohyoid nerve which, branching from the inferior alveolar nerve, lies in the groove on the mandible at the margin of attachment of the medial pterygoid muscle. The mylohyoid artery, a similar branch of the inferior alveolar artery also pierces the ligament and ends in the medial pterygoid muscle.
The mandibular nerve emerges from the foramen ovale and enters the infratemporal fossa between the tensor palati muscle on the side wall of the nasopharynx and the upper head of lateral pterygoid muscle. The tiny otic ganglion is sandwiched between the nerve and tensor palati (Last, 1963). Two branches, a meningeal branch, the nervus spinosus and the nerve to the medial pterygoid are given off from the short main trunk of the nerve before it divides into a small anterior (mainly motor) division and a large posterior (mainly sensory) division. Details of the distribution of branches from the main trunk and the anterior and posterior divisions of the mandibular nerve are contained in the section on the anatomy of the trigeminal nerve (pp.47-55).

The maxillary nerve appears briefly in the upper part of the infratemporal fossa as it traverses from the pterygopalatine fossa to the inferior orbital fissure. Along with the maxillary nerve, other deeper contents of the infratemporal fossa include the middle meningeal artery, chorda tympani, otic ganglion and the tensor palati muscle.

The tensor palati muscle is thin and triangular and arises from the scaphoid fossa at the root of the medial pterygoid plate and from the postero-medial margin of the greater wing of the sphenoid as far
posteriorly as the spine of the sphenoid. It lies in the uppermost part of the lateral wall of the pharynx between the groove for the auditory tube medially and the foramen spinosum and foramen ovale laterally. Running antero-inferiorly it joins with a small tendon hooking around the pterygoid hamulus to spread medially into the soft palate to form the palatal aponeurosis with the tendon of the opposite side. The action of the tensor palati muscle is to tense the anterior part of the soft palate (Romanes, 1978). The posterior part of the infratemporal fossa is in contact with the prevertebral fascia, carotid sheath, side wall of the pharynx and the muscles of the styloid apparatus (Last, 1972a).

PTERYGOMAXILLARY FISSURE

The pterygomaxillary fissure, also known as the pterygopalatine fissure/hiatus, sphenomaxillary fissure/hiatus, is a sickle-shaped opening between the maxillary tuberosity and the anterior border of the pterygoid process of the sphenoid bone, which connects the infratemporal and pterygopalatine spaces (Davies, 1967a; Sicher & DuBrul, 1975a). (Fig. 2.15) It transmits the terminal (third) part of the maxillary artery to the pterygopalatine fossa where it divides to accompany the five branches of the pterygopalatine ganglion (Davies, 1967a). In company with the maxillary artery are its corresponding veins and the inferior ophthalmic veins
Fig. 2.15 Pterygomaxillary fissure. (arrowed)
passing back from the orbit to the pterygoid venous plexus (Last, 1963).

In its uppermost part it gives passage to the maxillary nerve which appears for a short part of its course in the upper part of the infratemporal fossa, before entering the inferior orbital fissure (Davies, 1967a). The posterior superior alveolar nerves may be seen passing from the pterygopalatine fossa, through the pterygomaxillary fissure to the posterior superior alveolar foramina on the posterior wall of the maxilla (Last, 1972a).

PTERYGOPALATINE FOSSA

The pterygopalatine fossa, also known as the sphenomaxillary or pterygomaxillary fossa (Seldin, 1942), is a narrow, funnel-shaped space below the cranial base (Figs. 2.15, 2.16). It is bounded anteriorly by the medial part of the maxillary tuberosity, posteriorly by the anterior or sphenomaxillary surface of the pterygoid process of the sphenoid bone and medially by the lateral surface of the vertical plate of the palatine bone. The roof is formed by the roof of the greater wing of the sphenoid bone. Laterally, the pterygopalatine fossa communicates with the infratemporal fossa through the pterygomaxillary fissure (Sicher & DuBrul, 1975a).

The fossa is widest superiorly and narrows inferiorly and continues into the greater palatine
Fig. 2.16 Pterygopalatine fossa.

Fig. 2.17 Pterygopalatine fossa: lateral view.
(Anterior wall arrowed)
(pterygopalatine) canal between the medial surface of the maxilla and the lateral surface of the vertical plate of the palatine bone, opening into the oral cavity through the greater palatine foramen (Davies, 1967a; Sicher & DuBrul, 1975a). Cook (1950) states that the antero-posterior dimension of the fossa is approximately one and a half centimetres.

There are five passages leading from the pterygopalatine fossa. The maxillary nerve enters the fossa through the foramen rotundum in the greater wing of the sphenoid bone. The pterygoid canal, lying below and medial to the foramen rotundum, runs forward from the foramen lacerum and transmits the nerve of the pterygoid canal (Vidian nerve) and the artery of the same name. Infero-medially to the foramen rotundum, the pharyngeal or palatinovaginal canal transmits the pharyngeal nerve and artery backwards emerging at the roof of the nose and supplying the mucous membrane of the nasopharynx (Last, 1972a; Davies, 1967a).

The sphenopalatine foramen lies on the medial wall of the fossa and transmits the nasopalatine/long sphenopalatine and posterior superior lateral nasal/short sphenopalatine nerves and accompanying blood vessels to the nasal cavity. The fifth foramen, the greater palatine or pterygopalatine, is placed inferiorly at the junction of the anterior and posterior walls and leads into the greater palatine (pterygopalatine) canal.
transmitting the greater and lesser palatine nerves and blood vessels.

The most important contents of the fossa are the maxillary nerve, pterygopalatine (sphenopalatine) ganglion and the terminal part of the maxillary artery (Davies, 1967a). The maxillary nerve, a wholly sensory nerve, emerges into the upper part of the pterygopalatine fossa from the foramen rotundum. It has a short course below the roof of the fossa, deviating laterally, to divide at the inferior orbital fissure into its two terminal branches, the zygomatic and infraorbital nerves. Both nerves enter the orbit and are distributed to the skin of the face (Last, 1972a).

In the fossa, the pterygopalatine ganglion is suspended by two short branches from the maxillary nerve (ganglionic branches) and a little further forward the three posterior superior alveolar nerves are given off. They pass through the pterygomaxillary fissure to the posterior wall of the maxilla (Last, 1972a).

The pterygopalatine/sphenopalatine ganglion is the largest of the peripheral ganglia of the parasympathetic system. Deeply placed in the pterygopalatine fossa, it is close to the sphenopalatine foramen and anterior to the pterygoid canal (Davies, 1967a). It is somewhat flattened, reddish-grey in colour and is suspended from the maxillary nerve by that nerve's ganglionic branches.
The ganglion is functionally connected with the facial nerve but is anatomically intimately related to the maxillary nerve and its branches (Davies, 1967d; Last, 1972b).

The pterygopalatine ganglion is a relay station between the superior salivatory nucleus in the pons and the lacrimal gland and mucous and serous glands of the palate, nose and paranasal sinuses. The autonomic root is the nerve of the pterygoid canal (Vidian nerve) formed in the foramen lacerum by union of the greater petrosal nerve, containing parasympathetic secreto-motor fibres, with the deep petrosal nerve, containing sympathetic vasoconstrictor fibres.

Ganglionic branches of the maxillary nerve are sensory and pass through the ganglion without relay. The only cell bodies in the ganglion are parasympathetic (secreto-motor). There are five branches of the pterygopalatine ganglion, each branch carrying a mixture of all three kinds of fibres: sensory, secreto-motor and sympathetic (Last, 1972a).

The distribution of the five branches of the sphenopalatine ganglion is as follows (MacIntosh & Ostlere, 1967a; Last, 1972a):

The nasopalatine (long sphenopalatine) nerve passes through the sphenopalatine foramen, crosses the roof of
the nose to run downwards and forwards to innervate the nasal septum. On reaching the floor of the nose, it passes through the incisive canal to innervate the anterior part of the hard palate and the alveolar margin in the region of the incisor teeth.

The posterior superior lateral nasal (short sphenopalatine) nerves enter the nose through the sphenopalatine foramen and run forward to supply the postero-superior quadrant of the lateral wall of the nose. Twigs from these nerves to the mucous membrane of the postero-superior part of the nasal cavity complete the innervation of the septum and roof of the nose (mainly supplied by the anterior ethmoidal and nasopalatine nerves).

The greater palatine (anterior palatine) nerve descends vertically through the greater palatine (pterygopalatine) canal, turning forward at the greater palatine foramen to supply the mucous membrane of the hard palate and palatal aspects of the alveolar margin, the nerve supply overlapping in the canine region with the nasopalatine nerve (Fig. 2.14, p.65). Nasal branches supply the postero-inferior quadrant of the lateral wall of the nose. Branches also supply the medial wall of the maxillary sinus.

The lesser palatine (middle and posterior palatine) nerves, usually two in number, pass behind the greater
palatine nerve to emerge through the lesser palatine foramina behind the crest of the palatine bone. They pass back to supply the soft palate and the mucous membrane of the supratonsillar recess. The greater and lesser palatine foramina are located medial to the last molar tooth at the junction of the horizontal plate of the palatine bone and the palatal aspect of the maxillary tuberosity (alveolar process of the maxilla).

The pharyngeal nerve passes medially through the pharyngeal (palatinovaginal/palatovaginal) canal emerging at the roof of the nose and supplying the mucous membrane of the nasopharynx.

The maxillary artery enters the pterygopalatine fossa via the pterygomaxillary fissure. In the fossa it gives off five branches that pass with the five branches of the pterygopalatine ganglion. The main trunk of the artery passes through the inferior orbital fissure and accompanies the infraorbital nerve along the orbital floor to emerge on the face through the infraorbital foramen. Veins accompanying these arteries pass through the pterygopalatine fossa and emerge at the pterygomaxillary fissure to drain into the pterygoid venous plexus (Last, 1972a).
CHAPTER THREE

INTRODUCTION TO MAXILLARY NERVE BLOCK ANAESTHESIA

(A) Indications

The maxillary nerve may be blocked for surgical, therapeutic and diagnostic purposes. The following list outlines specific indications.

(a) Surgical indications

- Extensive dental therapy
  - multiple maxillary extractions (Dickson & Coates, 1945; Stebbins & Burch, 1961; Moore, 1969; Poore & Carney, 1973; Malamed & Trieger, 1983)
  - multiple restorations (Corbett & Helmore, 1948; Mercuri, 1979; Malamed & Trieger, 1983)
  - endodontic procedures (Stebbins & Burch, 1961; Mercuri, 1979)
  - periodontic procedures (Poore & Carney, 1973; Mercuri, 1979)

- Surgical procedures
  - apical surgery (Malamed & Trieger, 1983)
  - impacted teeth (Labat, 1928; Seldin, 1942b; Rankow, 1943; Jorgensen & Hayden, 1972; Malamed, 1980b)
  - alveolectomy (Rankow, 1943)
- maxillary sinus procedures including Caldwell-Luc antrostomy (Seldin, 1942b; Rankow, 1943; Stebbins & Burch, 1961; Topazian & Simon, 1962; MacIntosh & Ostlere, 1967b; Moore, 1969; Poore & Carney, 1973; Mercuri, 1979; Malamed, 1980; Malamed & Trieger, 1983)
- intranasal procedures
  - septal reconstructions
  - polypectomy
  - arterial ligations (MacIntosh & Ostlere, 1967b; Poore & Carney, 1973)
- fracture reduction (Seldin, 1942b; Rankow, 1943; Poore & Carney, 1973; Sweet & Powell, 1983)
- segmental osteotomy (Malamed, 1980b; Malamed & Trieger, 1983)
- excision of large neoplasms (Seldin, 1942b; Rankow, 1943)
- soft tissue surgery (Moore, 1969; Poore & Carney, 1973; Mercuri, 1979)
- incision and drainage of abscesses (Seldin, 1942b; Dickson & Coates, 1945; Corbett & Helmore, 1948; Stebbins & Burch, 1961; Malamed & Trieger, 1983)
- an alternative to other techniques in the
presence of infection or pathology
(Gillam, 1937; Kemp, 1940; Seldin, 1942b;
Corbett & Helmore 1948; Szerlip, 1948;
Stebbins & Burch, 1961; Mercuri, 1979;
Malamed, 1980b; Malamed & Trieger, 1983)
- trismus/false ankylosis (Seldin, 1942)
- poor risk general anaesthetic patients
(Rankow, 1943; Dickson & Coates, 1945;
Szerlip, 1948; Poore & Carney, 1973)
- general anaesthesia not available (Dickson & Coates, 1945; Szerlip, 1948)
- a useful adjunct to awake nasal intubation
(Baddour et al, 1979)
- to treat epistaxis (in conjunction with vasoconstrictor) (Baddour et al, 1979).

(b) Therapeutic Indications
- pain relief, especially with intractable pain
(Silverman, 1923; Stebbins & Burch, 1961;
Moore, 1969)

(c) Diagnostic Indications
- differentiation of neuralgias (Labat, 1928;
Stebbins & Burch, 1961; Moore, 1969; Mercuri,
1979; Malamed, 1980b; Malamed & Trieger, 1983)
- oral and maxillofacial pain syndromes (Mercuri,
1979).
(B) Symptoms of Maxillary Nerve Anaesthesia

Maxillary nerve anaesthesia presents the following symptoms:

(a) ipsilateral numbness of
   - upper lip
   - side of nose
   - lower eyelid
   - infraorbital region extending towards the zygomatic and temporal regions
   - hard and soft palates
   - maxillary teeth and their supporting structures.

(Kemp, 1940c; Seldin, 1942b; Rankow, 1943; Malamed, 1980b).

(b) lumpy feeling in the throat on swallowing (Seldin, 1942b).

(c) dryness of the nasal mucous membrane (Seldin, 1942b; Rankow, 1943).

(d) tendency to gag (Seldin, 1942b; Rankow, 1943).

Symptoms (b)-(d) are due to nasal and palatal anaesthesia. The area of cutaneous anaesthesia from maxillary nerve block is shown in Fig. 3.1.
Fig. 3.1 The stippled area indicates the area of skin anaesthetized.

From a clinical point of view, partial anaesthesia may only be obtained in the anterior region and this may be attributed to overlap from the contralateral branches of the anterior superior alveolar and, in some cases, the nasopalatine nerves.

Peckham (1938), Kemp (1940c) and Seldin (1942b) state that anaesthesia is secured up to the cuspid region, however, Dickson & Coates (1945) found the area to be variable anywhere from the first premolar to the lateral incisor. Corbett and Helmore (1948) found reliable buccal anaesthesia only to the first or sometimes the second premolar. This may be the result of solution being deposited away from the main nerve trunk.

For procedures in the anterior region, if anaesthesia is inadequate, supplementary injections are necessary. Infraorbital block or incisor infiltration on the same or opposite side is recommended by Seldin (1942b) and Rankow (1943). Corbett and Helmore (1948) also found infiltration of the nasopalatine branch at the incisive foramen necessary, in addition to buccal infiltration.

(C) Techniques of Anaesthesia

Maxillary nerve block is performed by depositing local anaesthetic solution in the pterygopalatine fossa where the maxillary nerve emerges from the foramen
rotundum. The deposition site may be approached by the intraoral or extraoral route. The techniques are classified according to these broad categories and discussed in Chapters Four and Five respectively.
CHAPTER FOUR

INTRAORAL MAXILLARY NERVE BLOCK TECHNIQUES

Two intraoral techniques are commonly used for maxillary nerve block within the pterygopalatine fossa. These are the buccal, tuberosity or posterior infraorbital approach and the approach via the greater palatine foramen and the pterygopalatine canal. General advantages of the intraoral approaches are: high success rate, minimal number of needle penetrations (Malamed, 1980; Rankow, 1943; Szerlip, 1948; Corbett & Helmore, 1948), and minimal total volume of local anaesthetic injected. The main advantage of the tuberosity approach is less trauma (Malamed, 1980). The stated advantages of the approach via the pterygopalatine canal include less damage to vessels and subsequent haematoma formation (Szerlip, 1948; Corbett & Helmore, 1948), reliable access to the target area (Corbett & Helmore, 1948), shortest route to the target area (Szerlip, 1948), and certainty of landmarks (Szerlip, 1948).

Disadvantages of the tuberosity approach include haematoma formation (Malamed, 1980b; Cook, 1950) and the absence of bony landmarks (Malamed, 1980b). Pain and potential trauma to canal contents (Malamed, 1980b; Roberts & Sowray, 1979d), needle breakage within the pterygopalatine canal (Corbett & Helmore, 1948), variations in the location of the greater palatine
foramen (Malamed, 1980b), nausea and faintness due to spread to the soft palate (Labat, 1928) are disadvantages of the palatal approach.

With both techniques, the risk of carrying infection into the pterygopalatine fossa is potentially serious (Cook, 1950; Roberts & Sowray, 1979b).

Other possible contra-indications to intraoral techniques are paediatric patients, unco-operative patients, traumatized and infected tissues at the injection site (Malamed, 1980b; Mercuri, 1979; Szerlip, 1948), trismus (Szerlip, 1948), and inexperienced operators (Malamed, 1980). Specific contra-indications include haemorrhage risk especially in haemophiliacs using the tuberosity approach and difficulty of access to the pterygopalatine canal, as in 5-15% of cases obstruction has been reported (Malamed, 1980b).

EQUIPMENT ADAPTATION FOR USE IN INTRAORAL MAXILLARY NERVE BLOCK

The early oral local anaesthetists soon realized and appreciated the difficulties in accessibility of the pterygopalatine fossa whether approached from the buccal or palatal aspect. In Labat's comprehensive text of 1928, the use of special outfits with needle and extension nozzle modifications for intraoral access was
discussed. In Labat's words: "different shapes and lengths facilitate the approach of the nerves by the oral route and permit of more refined technic and greater precision".

Modifications were not only designed for dental and oral surgery but also for ophthalmological and otorhinolaryngological procedures.

The Labat dental outfit (No. 3) used a standard 5ml Luer syringe, five extension nozzles, two 80/8 stainless steel needles and eight needles on a sterilizing tray enclosed in a nickel case. (Fig. 4.1)

Extension nozzles were as follows (Fig. 4.2):

No. 1 Short straight
No. 2 Long straight
No. 3 Angled 135°
No. 4 Angled 120°
No. 5 Angled 90°.

Needles were various lengths (Fig. 4.3):

No. 1 1 cm
No. 2 2 cm
No. 3 3 cm
No. 4 4 cm.

Each needle was made of stainless steel with a diameter ranging from 0.3-0.5 millimetres. Attachment to
Fig. 4.1 Labat outfit No. 3.


Fig. 4.2 Extension nozzles and socket wrench.

Fig. 4.3 Labat needles for dental outfit No. 3.

the extension nozzle was by a screw connection. The needles were interchangeable.

Labat's recommendations for use of the various needles and nozzles are detailed in Table 4.1. The long needles in the dental outfit were used for extraoral block techniques of the maxillary and mandibular nerves.

Other authors have also advocated the use of angular attachments, in particular Seldin (1942b) who stated that: "although some experience is required to manipulate the needle attached to the syringe at an angle, this technique is somewhat more certain in its results" (in relation to the buccal approach to the maxillary nerve).

Details of the preferences of authors for the use of angled attachments and various needle lengths is contained in the text relating to the specific techniques.
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<tr>
<th>TECHNIQUE</th>
<th>EXTENSION NOZZLE</th>
<th>NEEDLE</th>
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<tr>
<td>Infraorbital block</td>
<td>No. 1</td>
<td>No. 4</td>
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<tr>
<td>Inferior alveolar block</td>
<td>No. 2</td>
<td>No. 4</td>
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<td>No. 3</td>
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<td>Palatal infiltrations</td>
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<td>- Nasopalatine</td>
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<td>- Greater palatine</td>
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Labat's extension nozzle/needle combinations (1928).
MAXILLARY NERVE BLOCK VIA THE PTERYGOPALATINE CANAL:
The Palatal Approach

Maxillary nerve block via the pterygopalatine canal was apparently first described by Mendel Nevin in 1917. He stated that the method was "not successful and fraught with danger" (quoted by Corbett & Helmore, 1948). However, Silverman reported favourably on the technique in 1923 but later acknowledged that Dr. Juan Waldo Carrea of Buenos Aires had anticipated him in most of the methods described in work published in South America in 1921 (Szerlip, 1948).

The technique or modifications thereof have been published in journals and textbooks on anaesthesia since that date. This approach has not enjoyed the same degree of popularity as the orthodox buccal (tuberosity) approach. Exponents of the pterygopalatine approach list the following advantages over the buccal approach:

- shortest route (Szerlip, 1948);
- certainty of landmarks (Szerlip, 1948; Corbett & Helmore, 1948);
- less chance of haematoma formation (Szerlip, 1948; Corbett & Helmore, 1948);
- passes through fixed tissue and does not involve muscle (Corbett & Helmore, 1948; Gillam, 1937);
- route of choice if infection present in the region of the buccal puncture point (Gillam,
Disadvantages of the pterygopalatine approach include:

- difficulty in access due to bony obstruction (Dickson & Coates, 1945; Corbett & Helmore, 1948; Szerlip, 1948);
- possible injury to nerves and blood vessels in the pterygopalatine canal (Szerlip, 1948);
- possibility of needle fracture (Seldin, 1942b) although this is less than the tuberosity approach (Corbett & Helmore, 1948).

The aim of the technique is to deposit local anaesthetic solution in the vicinity of the maxillary nerve trunk within the pterygopalatine fossa by advancing a needle along the pterygopalatine canal.

The pterygopalatine canal extends from the greater palatine foramen, upward through the palatine bone to the pterygopalatine fossa. It contains the greater palatine nerves and blood vessels. In a study involving measurements from 200 skulls, Cook (1950) made the following observations on the pterygopalatine canal:

1. Average length: 25.4 mm.
2. Diameter: 1.5–4.0 mm.
4. Lateral inclination in some skulls.
Palatal soft tissue overlying the greater palatine foramen varies in depth. The range is between two and seven millimetres. The depths observed in seven published reports are summarized in Table 4.2. Thus, any assessment of the depth of penetration of the needle should take palatal soft tissue depth into consideration.

**PUNCTURE POINT**

The puncture point is determined by the position of the greater palatine foramen, which lies between the horizontal plate of the palatine bone and the alveolar process of the maxilla. When locating the position for the puncture point, the position of the greater palatine foramen should first be sought. Various methods are useful. A ball burnisher or other blunt instrument such as a cotton wool pledget can be used to probe the soft tissue in the palatal reflection. In the region of the foramen, a depression should be felt (Stovin, 1931; Corbett & Helmore, 1948; Szerlip, 1948; Cook, 1950; Jorgensen & Hayden, 1972; Mercuri, 1979; Roberts & Sowray, 1979d; Malamed & Trieger, 1983). Stovin (1931) recommends the palpation of the area to locate the more prominent posterior ridge of the foramen.

Position of the puncture point from the median line of the palate is variable. Some authors advocate bisecting the distance between midline and palatal gingival margin (Gillam, 1937; Seldin, 1942b; Dickson &
### Table 4.2

<table>
<thead>
<tr>
<th>Author</th>
<th>Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gillam</td>
<td>(1937) 2</td>
</tr>
<tr>
<td>Dickson &amp; Coates</td>
<td>(1945) 3 - 4</td>
</tr>
<tr>
<td>Corbett &amp; Helmore</td>
<td>(1948) 4</td>
</tr>
<tr>
<td>Cook</td>
<td>(1950) 4 - 7</td>
</tr>
<tr>
<td>Canter et al</td>
<td>(1964) 2 - 7</td>
</tr>
<tr>
<td>Viegas &amp; Hemphill</td>
<td>(1966) 2.00 - child</td>
</tr>
<tr>
<td></td>
<td>5.00 - adult</td>
</tr>
<tr>
<td></td>
<td>3.00 - adult (aged)</td>
</tr>
<tr>
<td>Malamed &amp; Trieger</td>
<td>(1983) 3 - 4</td>
</tr>
</tbody>
</table>

Depth of soft tissue overlying the greater palatine foramen showing a range of 2 - 7 mm.
Coates, 1945; Corbett & Helmore, 1948). Labat (1928) and Adriani (1967) bisect the distance between midline and buccal gingival margin in the second molar area, thus placing the puncture point somewhat more laterally than the previous position.

Peckham (1938) and Rankow (1943), estimate the position to be just short of midway between the alveolar crest and the midline. Silverman (1923) and Szerlip (1948) state that the foramen lies fifteen millimetres lateral to the median line whilst Dogliotti (1939) placed the position one centimetre medial to the second molar. Table 4.3 summarizes the position of the puncture point as described by the various authors.

Amongst all the confusion over the position of the greater palatine foramen and the puncture point for the injection, an attempt was made to describe reliable intraoral anatomical landmarks by Malamed and Trieger (1983). In a study of 204 skulls of mixed racial background, the following results emerged which may enable the clinician to locate the greater palatine foramen in a consistent manner.

(a) Location

Medio-laterally: at the junction of the horizontally placed hard palate and the vertical maxillary alveolar process.
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silverman</td>
<td>(1923) 5 mm anterior to tuberosity in edentulous cases</td>
</tr>
<tr>
<td>Labat</td>
<td>(1928) Area of second molar</td>
</tr>
<tr>
<td>Stovin</td>
<td>(1931) Level with interproximal space of second and third molar teeth</td>
</tr>
<tr>
<td>Gillam</td>
<td>(1937) Middle of second molar</td>
</tr>
<tr>
<td>Peckham</td>
<td>(1938) Middle of second molar</td>
</tr>
<tr>
<td>Lundy</td>
<td>(1942) Opposite third molar</td>
</tr>
<tr>
<td>Seldin</td>
<td>(1942b) Level with third molar (if erupted) or Level with second molar</td>
</tr>
<tr>
<td>Dickson &amp; Coates</td>
<td>(1945) Level with second molar (if third molar unerupted)</td>
</tr>
<tr>
<td>Rankow</td>
<td>(1943) Opposite palatal root of third molar</td>
</tr>
<tr>
<td>Corbett &amp; Helmore</td>
<td>(1948) Level with third molar</td>
</tr>
<tr>
<td>Szerlip</td>
<td>(1948) 3-6 mm anterior to junction of hard and soft palate</td>
</tr>
<tr>
<td>Cook</td>
<td>(1950) Adjacent to the lingual root of third molar</td>
</tr>
<tr>
<td>Jorgensen &amp; Hayden</td>
<td>(1972) In the same sagittal plane and anterior to pterygoid hamulus</td>
</tr>
</tbody>
</table>

Antero-posterior position of puncture point for maxillary block via the pterygopalatine canal.
Sagittally: 50.63% anterior half of third molar
39.87% posterior half of second molar
9.49% posterior half of third molar.

(b) Patency

Using a 25 gauge spinal needle, a patency rate of 97.55% was found.

(c) Relationship of greater palatine foramen to the posterior aspect of the hard palate

Considerable variation existed.

<table>
<thead>
<tr>
<th>Range</th>
<th>3.0 - 12.0 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>6.97 mm</td>
</tr>
<tr>
<td>6.5 - 8 mm</td>
<td>48%</td>
</tr>
<tr>
<td>&lt; 6.5 mm</td>
<td>27%</td>
</tr>
<tr>
<td>&gt; 8 mm</td>
<td>24%</td>
</tr>
</tbody>
</table>

(d) Relationship of the greater palatine foramen to the hamular process of the pterygoid

The hamular process bears a constant relationship to the greater palatine foramen in the sagittal plane.

<table>
<thead>
<tr>
<th>Range</th>
<th>3.0 - 20 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>12.0 mm</td>
</tr>
</tbody>
</table>
In seventy-two percent of skulls, the greater palatine foramen was between 9.0 and 14.5 millimetres from the hamular process of the pterygoid.

DEPTH OF PENETRATION

The depth of penetration of the needle has also been a source of variation between authors, ranging from 30 to 40 millimetres. Individual depths are documented in Table 4.4.

Jorgensen (1948) felt that the reason the technique of maxillary nerve block had fallen into disfavour stemmed from the inability of the operator to determine the depth of injection essential for optimum anaesthesia. This prompted him to study experimentally the anatomic distances involved on 200 skulls. He found that the height of the maxilla or "facial measurement" i.e. the vertical distance from the infraorbital margin to the gingival margin (alveolar crest) of the second premolar approximated the distance from needle tip to gingival margin (alveolar crest) of the second molar with the needle in position in the pterygopalatine fossa. This length is measured with a Boley gauge then marked on the needle using a sterile, movable rubber stop. The needle is inserted until the stop is opposite the gingival margin of the second molar, thus placing the needle within the pterygopalatine fossa. This technique may be used for both buccal and palatal approaches.
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>DEPTH (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silverman (1923)</td>
<td>50</td>
</tr>
<tr>
<td>Labat (1928)</td>
<td>35 - 40</td>
</tr>
<tr>
<td>Stovin (1931)</td>
<td>35</td>
</tr>
<tr>
<td>Gillam (1937)</td>
<td>36 - 46</td>
</tr>
<tr>
<td>Peckham (1938)</td>
<td>40</td>
</tr>
<tr>
<td>Dogliotti (1939)</td>
<td>38</td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td>30</td>
</tr>
<tr>
<td>Seldin (1942b)</td>
<td>38</td>
</tr>
<tr>
<td>Rankow (1943)</td>
<td>38</td>
</tr>
<tr>
<td>Dickson &amp; Coates (1945)</td>
<td>39</td>
</tr>
<tr>
<td>Corbett &amp; Helmore (1948)</td>
<td>39 - 40</td>
</tr>
<tr>
<td>Jorgensen (1948)</td>
<td>Equivalent to height of maxilla *</td>
</tr>
<tr>
<td>Szerlip (1948)</td>
<td>32</td>
</tr>
<tr>
<td>Cook (1950)</td>
<td>39 - 42</td>
</tr>
<tr>
<td>Canter et al (1964)</td>
<td>33 + soft tissue depth (35-40)</td>
</tr>
<tr>
<td>Baddour et al (1979)</td>
<td>38</td>
</tr>
<tr>
<td>Mercuri (1979)</td>
<td>39 - 40</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td>30</td>
</tr>
<tr>
<td>Malamed (1980b)</td>
<td>32</td>
</tr>
<tr>
<td>Malamed &amp; Trieger (1983)</td>
<td>32</td>
</tr>
<tr>
<td>Range</td>
<td>30 - 50</td>
</tr>
</tbody>
</table>

* Measured from infraorbital margin to gingival margin of premolars.

Depth of needle penetration for maxillary block via the pterygopalatine canal.
Malamed and Trieger (1983) used the same measurement in their study of 204 skulls of mixed racial origin following the work of Mercuri (1979) and obtained these results:

<table>
<thead>
<tr>
<th>Range</th>
<th>24 - 41 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>32.15 mm</td>
</tr>
<tr>
<td>30-35 mm</td>
<td>65%</td>
</tr>
<tr>
<td>&lt; 30 mm</td>
<td>18%</td>
</tr>
<tr>
<td>&gt; 35 mm</td>
<td>17%</td>
</tr>
</tbody>
</table>

Thus in the typical adult, on insertion of the needle to 32 millimetres, the needle tip should be within 2-3 millimetres of the pterygopalatine fossa. The measurement of 32 millimetres does not take into consideration the 3-4 millimetres of palatal soft tissue overlying the foramen nor the 1-2 millimetres of gingival soft tissue overlying the alveolar crest.

**PATENCY OF THE GREATER PALATINE FORAMEN AND THE PTERYGOPALATINE CANAL**

To enable the deposition of anaesthetic solution in the pterygopalatine fossa, advancement of the needle (usually 25 gauge) through the pterygopalatine canal should be unhindered. Jorgensen and Hayden (1972) noted bony obstructions in 15% of more than 200 skulls using a
25 gauge needle but did not state if these obstructions were absolute. Malamed and Trieger (1983) passed a three inch, 25 gauge probe through the greater palatine foramen without difficulty into the pterygo-palatine fossa in 191 of the 204 skulls evaluated, a patency rate of 97.55%, somewhat higher than Jorgensen and Hayden's results. In some cases, the foramen exists as several fine openings and not a single large one, thus making penetration of the canal impossible. In their series of eighty cases, Dickson & Coates (1945) noted a failure rate of 2.5%. Failure to penetrate the canal occurred in 6 out of 92 clinical cases in Corbett and Helmore's study (1948), a failure rate of 6.5% which illustrates the difference between clinical experience and using dry skulls.

Minor or partial obstruction to advancement of the needle may be overcome by moving the needle slowly backwards and forwards at different angles, rotating it to allow the bevel to guide it (Seldin, 1942b; Dickson & Coates, 1945; Corbett & Helmore, 1948). Rankow (1943) advocates slight withdrawal then "stepping" the needle back up again through the canal to overcome minor resistance. Malamed and Trieger (1983) recommend withdrawal by one millimetre, change of angle and re-advancement without force.

Incorrect needle angulation, usually more perpendicular insertion, is often the cause of difficulty in advancement of the needle (Peckham, 1938;
Rankow, 1943). In such cases the tip of the needle engages the anterior wall of the pterygopalatine canal or may be inserted into one or two very narrow smaller palatine foramina (Peckham, 1938).

Another common anatomic obstruction to the needle is the anterior or lateral border of the lateral pterygoid plate. Canter et al (1964) noted this obstruction in 40 to 53 percent of adult skulls depending on age, race and sex. When the angle of the pterygopalatine canal with the Frankfort horizontal was extremely obtuse, there was a greater tendency to encounter the lateral pterygoid plate due to lateral flare of the canal. (Fig. 4.4.)

**Angulation of the Hub or Needle**

Because of the difficulties in access and the posterior, superior course of the pterygopalatine canal, angulation of the hub or needle has been advocated to help compensate for these factors. Opinion is almost equally divided – ten authors using straight needles, eight authors using angled hubs or needles and one author (Stovin, 1931) using either.

Angulation of the hub or needle is most commonly an angle of 45° (5 authors). Mercuri (1979) advocates a 30° angle and Dogliotti (1939) an angle of 90°. Two authors (Jorgensen, 1948; Roberts & Sowray, 1979a) use an angled extension nozzle but do not state the angle.
Fig. 4.4 Deflection of needle.

A needle correctly positioned in pterygo-palatine fossa.

B needle deflected and lying lateral to pterygoid plate.
Table 4.5 summarizes these findings.

The use of an angled extension nozzle as advocated by Labat (1928) may make it extremely difficult to apply pressure along the axis of the needle and may increase the difficulty of needle penetration along the pterygo-palatine canal.

Details of Technique: Palatal approach

(a) Patient position.

Patient position is referred to by only four authors. Peckham (1938) states that the patient's head should be tipped back, but does not state the angle. Szerlip (1948), Mercuri (1979) and Malamed and Trierger (1983) recommend the semi-reclining position. Mercuri (1979) amplifies this by advocating that the palate should be at sixty degrees to the horizontal. Malamed and Trierger (1983) enlist the aid of a mouthprop to maintain oral opening, a useful practical suggestion.

(b) Needle length and gauge

Considerable variation exists, however, the most common combination is 25 gauge stainless steel, 42 millimetres in length. These combinations are
<table>
<thead>
<tr>
<th>STRAIGHT</th>
<th>ANGLED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extension Nozzle/Hub</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Silverman (1923)</td>
<td>Labat (1928)</td>
</tr>
<tr>
<td>*Stovin (1931)</td>
<td>Dickson &amp; Coates (1945)</td>
</tr>
<tr>
<td>Gillam (1937)</td>
<td>Jorgensen &amp; Hayden (1972)</td>
</tr>
<tr>
<td>Peckham (1938)</td>
<td>Roberts &amp; Sowray (1979d)</td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td></td>
</tr>
<tr>
<td>Seldin (1942b)</td>
<td></td>
</tr>
<tr>
<td>Rankow (1943)</td>
<td></td>
</tr>
<tr>
<td>Corbett &amp; Helmore (1948)</td>
<td>Subtotal</td>
</tr>
<tr>
<td>Szerlip (1948)</td>
<td></td>
</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>Subtotal</td>
</tr>
<tr>
<td>Malamed &amp; Trieger (1983)</td>
<td>Subtotal</td>
</tr>
</tbody>
</table>

*uses either straight or angled

Angulation of needle and extension nozzle/hub for maxillary block via the pterygopalatine canal.
summarized in Table 4.6.

(c) Depth markers

Only five authors recommend the use of depth markers (Jorgensen, 1948; Szerlip, 1948; Cook, 1950; Mercuri, 1979; Malamed & Trieger, 1983). Markers may be either sterile rubber endodontic stoppers, sterile rubber dam or Penrose drain material.

(d) Solution type and volume

Early studies used one or two percent procaine with or without adrenalin. Lignocaine was first released in Sweden in 1948 (Roberts & Sowray, 1979b). Therefore later studies used two percent lignocaine with adrenaline 1:100,000 when this combination superseded procaine. Current thought (Malamed and Trieger, 1983), recommends the use of any approved solution. The usual volume injected varies between one and four ml. The most common volume used is two ml.

(e) Induction time

Time of onset of anaesthesia is variable and depends on concentration of anaesthetic, pH of solution and the site of deposition (Roberts & Sowray, 1979a).
### Table 4.6

<table>
<thead>
<tr>
<th>Author</th>
<th>Length (mm)</th>
<th>Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silverman</td>
<td>(1923) 60</td>
<td>22</td>
</tr>
<tr>
<td>Labat</td>
<td>(1928) 40</td>
<td>24</td>
</tr>
<tr>
<td>Stovin</td>
<td>(1931) 40-60</td>
<td>22</td>
</tr>
<tr>
<td>Gillam</td>
<td>(1937) 42-50</td>
<td>25</td>
</tr>
<tr>
<td>Peckham</td>
<td>(1938) 47</td>
<td>25</td>
</tr>
<tr>
<td>Dogliotti</td>
<td>(1939) -</td>
<td>-</td>
</tr>
<tr>
<td>Lundy</td>
<td>(1942) 42</td>
<td>25</td>
</tr>
<tr>
<td>Selden</td>
<td>(1942b) 50</td>
<td>25</td>
</tr>
<tr>
<td>Rankow</td>
<td>(1943) 42/47</td>
<td>23</td>
</tr>
<tr>
<td>Dickson &amp; Coates</td>
<td>(1945) 42</td>
<td>16</td>
</tr>
<tr>
<td>Corbett &amp; Helmore</td>
<td>(1948) 42</td>
<td>26</td>
</tr>
<tr>
<td>Jorgensen</td>
<td>(1948) -</td>
<td>25</td>
</tr>
<tr>
<td>Szerlip</td>
<td>(1948) 38</td>
<td>25</td>
</tr>
<tr>
<td>Cook</td>
<td>(1950) 45</td>
<td>27</td>
</tr>
<tr>
<td>Canter et al</td>
<td>(1964) 42</td>
<td>18</td>
</tr>
<tr>
<td>Baddour et al</td>
<td>(1979) 38</td>
<td>27</td>
</tr>
<tr>
<td>Mercuri</td>
<td>(1979) 42</td>
<td>25</td>
</tr>
<tr>
<td>Roberts &amp; Sowray</td>
<td>(1979d) 47</td>
<td>25</td>
</tr>
<tr>
<td>Malamed</td>
<td>(1980b) 32</td>
<td>25</td>
</tr>
<tr>
<td>Malamed &amp; Trieger</td>
<td>(1983) 32</td>
<td>25</td>
</tr>
</tbody>
</table>

**Range**

32-60 16-27

*Needle length and gauge for maxillary block via the pterygopalatine canal.*
Induction times quoted in the literature reviewed are summarized in Table 4.7.

(f) Duration of anaesthesia

Duration of anaesthesia depends on the type and volume of solution and the use of vasoconstrictors. The range varies from twenty minutes to three and a half hours in the papers reviewed.

MAXILLARY NERVE BLOCK VIA THE BUCCAL APPROACH

The buccal or so-called tuberosity approach to the maxillary nerve has been historically more popular than the palatal approach. First described by Smith in 1920, Labat followed with variations of the technique in 1923. Since then, numerous authors have presented their modifications of the original techniques (Kemp, 1940; Seldin, 1942b; Lundy, 1942; Stebbins & Burch, 1961; Jorgensen & Hayden, 1972; Roberts & Sowray, 1979d; Malamed, 1980b).

The stated advantages of the buccal approach are the high success rate and atraumatic technique (Malamed, 1980). Possible disadvantages are:

(a) haematoma formation due to involvement of the pterygoid plexus of veins (Dickson & Coates, 1945) or more likely puncture of the bucco-gingival branch
### TABLE 4.7

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>INDUCTION TIME (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gillam (1937)</td>
<td>5</td>
</tr>
<tr>
<td>Peckham (1938)</td>
<td>5</td>
</tr>
<tr>
<td>Rankow (1943)</td>
<td>6 – 8</td>
</tr>
<tr>
<td>Dickson &amp; Coates  (1945)</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Baddour et al (1979)</td>
<td>10</td>
</tr>
<tr>
<td>Mercuri (1979)</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Malamed &amp; Trieger (1983)</td>
<td>5 – 7</td>
</tr>
<tr>
<td><strong>RANGE</strong></td>
<td><strong>5 – 20</strong></td>
</tr>
</tbody>
</table>

Induction time for maxillary block via the pterygopalatine canal.
of the posterior superior alveolar artery (Carter, 1983; Malamed, 1980b).

(b) uncertainty of landmarks (Dickson & Coates, 1945; Malamed, 1980b).

(c) loss of needle in soft tissues if breakage occurs (Dickson & Coates, 1945).

The absolute indications for the use of the buccal approach are the presence of palatal infection precluding the use of the palatal approach (Stebbins & Burch, 1961) and inability to negotiate the pterygopalatine canal.

The aim of the buccal approach is to deposit local anaesthetic solution in the vicinity of the trunk of the maxillary nerve within the pterygopalatine fossa i.e. anterior to foramen rotundum and posterior to the entrance of the infraorbital canal. To achieve this the needle must be passed close to the posterior aspect of the maxillary tuberosity, through the pterygo-maxillary fissure to enter the pterygopalatine fossa.

The maxillary nerve may be approached from the buccal aspect by two techniques:
(a) Posterior infraorbital.
(b) Pterygomaxillary.

In the posterior infraorbital approach, the most
common technique, the puncture point lies buccal to the second or third molar tooth or maxillary tuberosity and the needle advanced upwards, backwards and inwards (Fig. 4.5) to a depth of between 30 millimetres and 45 millimetres (Smith, 1920; Labat, 1928). Details of puncture point location and depth of injection will be elaborated subsequently (Tables 4.8, 4.10).

In the pterygomaxillary approach, the needle is introduced behind the last molar tooth and tuberosity and directed upward and somewhat inward almost perpendicular to the occlusal surface of the teeth, passing laterally in the angle formed by the tuberosity of the maxilla and the pterygoid process to reach the pterygopalatine fossa at a depth of 35 to 40 millimetres (Labat, 1928). (Fig. 4.6).

Modifications of Smith's and Labat's original techniques have been advocated to eliminate the gagging and discomfort occasioned by anaesthesia of the sphenopalatine ganglion and subsequent uvular and pharyngeal anaesthesia (Seldin, 1942b). To do this, solution must be deposited anterior to the ganglion which is suspended from the main trunk of the nerve, posterior to the beginning of the infraorbital canal. However, this distance is only approximately one centimetre and it is impossible to believe in selective diffusion in such a small anatomical area as the pterygopalatine fossa.
Fig. 4.5 Maxillary nerve block via the posterior infraorbital approach.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)

Fig. 4.6 Maxillary nerve block via the pterygomaxillary approach.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)
In the modified Smith technique (Seldin, 1942b), a straight needle is used to deposit solution at the entrance to the pterygopalatine fossa i.e. in the region of the pterygomaxillary fissure, at a depth of approximately three centimetres (Seldin, 1942b).

In the modified Labat technique (Seldin, 1942b), an angled attachment is used to deposit solution on the posterior surface of the maxilla, above the point where the maxillary nerve enters the infraorbital canal.

The puncture point

The puncture point for the buccal approach depends on the technique being used. As a general rule, the puncture point lies in the mucobuccal fold in the molar region. The original and modified techniques of Smith (Smith, 1920; Seldin, 1942b) and the technique of Kemp (1940) puncture mucosa in the third molar region. Labat's original tuberosity/buccal technique (1928) and the modified Labat technique of Seldin (1942b) puncture mucosa in the first molar region. The techniques of Stebbins and Burch (1961), Roberts & Sowray (1979d) and Malamed (1980b) puncture mucosa in the second molar region. Jorgensen and Hayden (1972) puncture mucosa opposite the last molar tooth, which, in view of their use of the Smith technique, must mean the third molar. Obviously, the puncture point must be sufficiently laterally placed to avoid engaging the postero-superior
wall of the maxilla, or the zygomatico-alveolar crest particularly when using a more anteriorly placed puncture point.

When using Labat's pterygomaxillary approach (1928), the puncture point lies behind the last molar tooth in the sulcus between the tuberosity and pterygoid plate.

Table 4.8 summarizes the position of the puncture points for maxillary block via the buccal approach.

**Needle direction**

The line of direct access to the site of deposition of solution is the direction in which the needle should be advanced once mucosa has been punctured. For the tuberosity approach of Smith, the direction is upward, inward and slightly backward (Smith, 1920; Lundy, 1942; Stebbins & Burch, 1961). The techniques advocated by Labat (1928), Seldin/Modified Labat (1942b), Roberts & Sowray (1979d) and Malamed (1980) use the same general directions but specify angulations in relation to the sagittal plane, occlusal plane and the vertical plane/long axis of the second molar tooth. Kemp (1940) uses upward and medial angulation but unlike the other techniques, angles the needle towards the glabella. The various modifications of needle direction are summarized in Table 4.9.
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>PUNCTURE POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith</td>
<td>(1920) buccal fold opposite third molar</td>
</tr>
<tr>
<td>Labat</td>
<td>(1928) a. Posterior Infraorbital mucous reflection above first molar b. Pterygomaxillary behind last upper molar</td>
</tr>
<tr>
<td>Kemp</td>
<td>(1940) reflection of mucobuccal fold over apices of upper third molar or on buccal side of tuberosity if third molar not present</td>
</tr>
<tr>
<td>Modified</td>
<td>(1942b) 3/4&quot; (15mm) lateral to apex of distal root of upper first molar</td>
</tr>
<tr>
<td>Modified</td>
<td>(1942b) opposite apices of third molar</td>
</tr>
<tr>
<td>Modified</td>
<td>(1942b) highest point in mucous fold opposite upper third molar; lateral enough not to engage the posterior surface of maxilla</td>
</tr>
<tr>
<td>Stebbins</td>
<td>(1962) mucobuccal fold slightly posterior to second molar</td>
</tr>
<tr>
<td>Burch</td>
<td>(1972) height of vestibule opposite last molar &amp; some distance from alveolar mucosa</td>
</tr>
<tr>
<td>Jorgensen</td>
<td>(1972) over apices of second molar laterally; to clear zygomatic process</td>
</tr>
<tr>
<td>Hayden</td>
<td>(1980b) height of mucobuccal fold above distal aspect of second molar</td>
</tr>
</tbody>
</table>

Puncture point position for maxillary block via the buccal approach.
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>NEEDLE DIRECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith (1920)</td>
<td>upward\n                            inward\n                            slightly backward</td>
</tr>
<tr>
<td>Labat (1928)</td>
<td>a. Posterior Infraorbital\n                           upward, backward, inward at 40° to sagittal plane of the head\n        b. Pterygomaxillary\n                           upward, slightly inward, perpendicular to occlusal surface of teeth</td>
</tr>
<tr>
<td>Kemp (1940)</td>
<td>syringe barrel parallel to maxillary occlusal plane, needle moved in direction of glabella</td>
</tr>
<tr>
<td>Modified Labat</td>
<td>45° inward and backward\n                                      60° upward from maxillary occlusal plane</td>
</tr>
<tr>
<td>(Seldin) (1942b)</td>
<td></td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td>upward\n                            medially\n                            slightly posteriorly</td>
</tr>
<tr>
<td>Modified Smith</td>
<td>upward \n                almost perpendicular \n                inward at 45° to the vertical</td>
</tr>
<tr>
<td>(Seldin) (1942b)</td>
<td></td>
</tr>
<tr>
<td>Stebbins &amp; Burch</td>
<td>superiorly\n                            medially\n                            posteriorly</td>
</tr>
<tr>
<td>Jorgensen &amp;</td>
<td>as per Smith 1920\n                                    upward, inward, slightly backward</td>
</tr>
<tr>
<td>Hayden (1972)</td>
<td></td>
</tr>
<tr>
<td>Roberts &amp; Sowray</td>
<td>upward and inward at 30° to vertical\n                                    or sagittal plane\n                           backwards at 30° to occlusal surfaces of upper teeth</td>
</tr>
<tr>
<td>Malamed (1980b)</td>
<td>upward and backward at 45° to occlusal plane\n                                    inward at 45° to long axis of second molar</td>
</tr>
</tbody>
</table>

Direction of needle advancement for maxillary block via the buccal approach.
Depth of Needle Penetration

Depth of needle penetration depends on the site of deposition of solution. To deposit solution within the pterygopalatine fossa requires greater penetration than for deposition at its entrance, i.e. the pterygomaxillary fissure as in the modified Smith technique (Seldin, 1942b). Depths of penetration recommended by the various authors are summarized in Table 4.10.

The most reliable method of determining the depth of penetration follows the work of Jorgensen (1948), already quoted in the section on the palatal approach to the maxillary nerve. The facial measurement, the distance from the infraorbital margin to the gingiva of the maxillary premolars, is the same as the posterior height of the maxilla. A needle inserted, according to the technique of Smith (1920), to the depth of the facial measurement would deposit solution at or near the maxillary nerve as it courses across the pterygopalatine fossa (Jorgensen & Hayden, 1972). The maxillary height is measured using a Boley gauge and the length marked on a needle using a piece of sterile rubber.

Details of technique: Buccal approach

(a) Patient position

The patient must be placed in a comfortable position
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>DEPTH (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith (1920)</td>
<td>30</td>
</tr>
<tr>
<td>Labat (1928)</td>
<td>a. Posterior Infraorbital 35 – 40</td>
</tr>
<tr>
<td></td>
<td>b. Pterygomaxillary 35 – 40</td>
</tr>
<tr>
<td>Kemp (1940)</td>
<td>35 – 40</td>
</tr>
<tr>
<td>Modified Labat (Seldin) (1942b)</td>
<td>41</td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td>30</td>
</tr>
<tr>
<td>Modified Smith (Seldin) (1942b)</td>
<td>30</td>
</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>Measure maxillary height from infraorbital margin to gingival margin of premolars</td>
</tr>
<tr>
<td>Jorgensen &amp; Hayden (1972)</td>
<td>Measure maxillary height from infraorbital margin to gingival margin of premolars</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979a)</td>
<td>30</td>
</tr>
<tr>
<td>Malamed (1980b)</td>
<td>32</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>30 – 41</td>
</tr>
</tbody>
</table>

Depth of needle penetration for maxillary block via the buccal approach.
to allow the operator ease of access. Malamed (1980b) is the only author to recommend a desired position: supine or semi-supine.

(b) Needle Length and Gauge

Table 4.11 summarizes these details. The most common combination is a 25 gauge, 42 millimetre needle.

(c) Angulation of the Needle and Hub

The use of an angled hub or needle for the buccal approach to the pterygopalatine fossa makes the technique easier, more precise (Labat, 1928) and achieves more certain results (Seldin, 1942b). The use of an extension nozzle, as pioneered by Labat, is more popular than bending the needle to the desired angulation, although this is possible with modern single use needles. Jorgensen and Hayden (1972) are the only authors to recommend angulation of the body of the needle. Needle breakage is the reason for avoidance of needle bending and this was common with the use of needles which had been re-sterilised many times or needles which had been bent and then straightened (Roberts & Sowray, 1979e). Modern needles are flexible, strong and disposable so that fracture is rare as bending and re-straightening with resultant work-hardening is not
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>LENGTH (mm)</th>
<th>GAUGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith (1920)</td>
<td>Not stated</td>
<td>Not stated</td>
</tr>
<tr>
<td>Labat (1928)* a</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>b</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Kemp (1940)</td>
<td>42</td>
<td>24/25</td>
</tr>
<tr>
<td>Modified Labat (Seldin) (1942)</td>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td>40</td>
<td>Not stated</td>
</tr>
<tr>
<td>Modified Smith (Seldin) (1942)</td>
<td>42</td>
<td>21</td>
</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>Not stated</td>
<td>25</td>
</tr>
<tr>
<td>Jorgensen &amp; Hayden (1972)</td>
<td>Not stated</td>
<td>25</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>Malamed (1980b)</td>
<td>42</td>
<td>25</td>
</tr>
</tbody>
</table>

* a = Posterior Infraorbital
  b = Pterygomaxillary

Needle Length and Gauge: Buccal approach.
necessary. For these reasons, I believe it is possible to use a bent needle instead of an angled attachment with the precaution that the needle is never inserted to the hub or past the bend thus allowing retrieval should fracture occur. A straight needle may be used although this makes access more difficult. Labat (1928) believes that the standard buccal approach may be performed with either a straight or angled attachment, however an angled attachment is essential for the pterygomaxillary approach. The most commonly used angle is 135°, however in Kemp's study in 1940, an angle of 110° is recommended (Fig. 4.7). This is based on his observations that if the barrel of the syringe is held parallel to the occlusal plane of the maxillary teeth, an angle of 110° will allow the needle to be directed smoothly towards the foramen rotundum using a puncture point in the reflection of the muco-buccal fold over the apices of the upper third molar or buccal side of the tuberosity.

Connolly (1927) favoured a curved needle for the intraoral maxillary block, however, Smith (1920) believes: "a curved needle is contra-indicated for blocking any deep nerve branch for the reason that it is impossible to know the exact location of the point when it is concealed from view in the tissues". (Quoted by Kemp, 1940b).
Fig. 4.7  The Kemp technique for maxillary block using an angled attachment of 110°.

(Illustration by courtesy of Dr. H.R. Kemp.)
Table 4.12 summarizes the hub and needle angulations for the buccal approach to the maxillary nerve block.

(d) Use of depth markers

In the light of Jorgensen's work in 1948, depth markers are essential to avoid overpenetration and its sequelae. Sterile rubber markers, which can be placed on the shaft of the needle at the desired length are used (Stebbins & Burch, 1961; Jorgensen & Hayden, 1972; Roberts & Sowray, 1979d; Malamed, 1980b).

(e) Aspiration

Because of the location of the injection site and the extremely vascular areas along the route of injection, aspiration is essential although it is not mentioned by the earlier authors (Smith, 1920; Labat, 1928; Seldin, 1942b). Malamed (1980b) claims a positive aspiration rate of less than one percent of cases of high tuberosity block.

(f) Onset and duration of anaesthesia

This depends, as stated in a previous section, on the type of anaesthetic agent, the use of a vasoconstrictor and the proximity of the needle to the
<table>
<thead>
<tr>
<th>STRAIGHT</th>
<th>ANGLED</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HUB/EXTENSION NOZZLE</td>
<td>NEEDLE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labat * (a)</td>
<td>Smith (1920)</td>
<td>135°</td>
<td>Jorgensen &amp; Hayden (1972)</td>
<td>135°</td>
</tr>
<tr>
<td>Modified</td>
<td>Modified Smith (1942)</td>
<td>135°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smith</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lundy</td>
<td>Labat* (a) (1928)</td>
<td>135°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labat* (b) (1928)</td>
<td>135°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malamed (1980b)</td>
<td>Kemp (1940)</td>
<td>110°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stebbins &amp; Burch (1961)</td>
<td>Not stated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jorgensen &amp; Hayden (1972)</td>
<td>135°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roberts &amp; Sowray (1979)</td>
<td>Curved or contra-angled</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                  | 4                           | 8                | 1                |

* (a) = Posterior Infraorbital  
(b) = Pterygomaxillary

Angulation of needle and extension nozzle/hub for maxillary block via the buccal approach.
nerve. Onset of anaesthesia is usually between five and twenty minutes, similar to the approach via the pterygopalatine canal (Table 4.7). Duration of anaesthesia is variable but may last hours with modern long-acting anaesthetic agents such as bupivicaine.

(g) Solution type and volume

Procaine was used in the studies prior to the introduction of lignocaine in 1948 (Roberts & Sowray, 1979b). The volume of solution used should be in the range 1.8 - 4.0 ml.
CHAPTER FIVE

EXTRAORAL MAXILLARY NERVE BLOCK TECHNIQUES

Extraoral techniques are more commonly used by our medical colleagues perhaps because of their lack of familiarity with the oral cavity. Numerous advantages have been given for the use of extraoral maxillary nerve blocks. Seldin (1942c) claims the extraoral technique is more direct; there is less chance of needle fracture; the field of injection is readily visible; asepsis is more easily secured on skin than oral mucous membrane and the technique is no more dangerous than the intraoral route.

Poore and Carney (1973) believe that the extraoral approach is easier and that there is less bleeding and less pain than the intraoral approach.

Apart from the general indications for maxillary nerve block injections, specific indications for the extraoral approach include acute inflammation and malignant growths over the injection site, trismus, anatomic deviation of nerves (Topazian and Simon, 1962) and infection (Seldin, 1942c).

Contra-indications to extraoral techniques as cited by Poore and Carney (1973) are pediatric patients, uncooperative patients, traumatized tissues and infection in the area of injection. Such contra-indications are not
specific to extraoral techniques, but are also apposite to intraoral techniques.

The disadvantages of extraoral maxillary nerve blocks are the same as apply to the various intraoral approaches, namely (after Roberts & Sowray, 1979d):

(1) The passage of the needle into areas of high vascularity with the attendant risk of haemorrhage into the inaccessible deeper tissues.

(2) Uncertainty as to the site of deposition of the solution due to the depth of insertion necessary to reach the target zone.

(3) The possibility of serious consequences should infection result.

(4) The techniques are relatively painful.

(5) The complexity of the techniques may preclude their use where a simpler nerve block would suffice (for example an infraorbital block).

There are four techniques available to block the maxillary nerve from an extraoral approach:
(A) Lateral.
(B) Anterior.
(C) Orbital.
(D) Intranasal.

Because of the diversity of approach, each technique warrants separate discussion.

(A) LATERAL APPROACH

The lateral approach to the maxillary nerve is the most commonly reported extraoral technique. It is the easiest, quickest, safest, of most practical value and the first choice when considering an extraoral approach (Adriani, 1967; Murphy, 1980). It is known by various other names: zygomatic route No. 1 (Labat, 1928), post coronoid route (Seldin, 1942c), the extraoral technique via the sigmoid notch (Poore & Carney, 1973), coronoid notch and infratemporal fossa (Murphy, 1980).

Should the operator wish to achieve concomitant third division trigeminal anaesthesia, the lateral approach permits this via a single puncture point (MacIntosh & Ostlere, 1967c; Labat, 1928). (Fig. 5.1)

The puncture point lies on the skin above the sigmoid notch and below the zygomatic arch. The needle must be advanced medially to strike the lateral pterygoid plate, then reangled to "step off" the plate and enter
Fig. 5.1 Maxillary block.

Direction of the needle in relation to the skeleton. 1 makes contact with pterygoid process; 2 aims at the foramen rotundum; 3 aims at the foramen ovale and illustrates the possibility of injecting both maxillary and mandibular nerves from a single point of entrance.

(From: Labat, G., Regional Anesthesia, Philadelphia, W.B. Saunders, 1928.)
the pterygopalatine fossa. Solution is deposited at a predetermined depth.

A full description of puncture point location, needle re-angulation and depth of penetration follows.

Location of Puncture Point

In Labat's text of 1928, the technique of determining the middle point/bisector of the zygomatic arch is discussed. The puncture point should lie just below the bisector. The bisector is located as follows: "With the patient lying on his back and the operator standing on the side to be injected, the tip of the index-finger of the left hand is placed in front of the tragus and the patient asked to open and close his mouth; the condyle of the ascending ramus is felt moving downward and forward, then backward and upward, with each movement of the lower jaw. The finger is then displaced anteriorly to the condyle, the nail pointing toward the zygomatic arch and the axis of the finger brought at right angles to the arch. The patient being again asked to open and close his mouth, a depression is felt in which the ball of the finger lies. It is the sigmoid notch, with the condyle back of the finger and the coronoid process in front of it. The extremity of the finger touches the zygomatic arch and the prolongation of the axis of the finger bisects the arch. The middle point of the zygomatic arch is the middle point of the
bisector of the arch". (Fig. 5.2).

Seldin's technique (1942c) for location of the puncture point is as follows: "With the left index finger, palpate the depression on the skin above the mandibular notch and below the lower border of the zygomatic arch. Mouth opening and closing aids this procedure. With a small ball-burnisher dipped in tincture of iodine, outline the horizontal line of the inferior border of the zygomatic arch, the deepest point on the curve of the mandibular notch, and the angles formed by the junction of the coronoid process with the zygomatic arch and the condyloid process with the zygomatic arch. By connecting the last three points, the exact confines of the space just superior to the mandibular notch is recorded upon the skin of the patient. Place a dot in the centre of the dish-shaped outline".

Moore's technique (1969) is similar to the Seldin technique (1942c), however, the puncture point lies in the posterior inferior aspect of the mandibular notch.

Stebbins and Burch (1961) locate the mandibular notch and site the puncture point in the centre of the notch and slightly anterior to its centre. Topazian and Simon (1962) locate the puncture point by using Adriani's technique (1956): the skin is marked one centimetre below the pre-articular fossa, a depression in the
Fig. 5.2 Labat's technique for determining the midpoint of the zygomatic arch.

(From: Labat, G., Regional Anesthesia, Philadelphia, W.B. Saunders, 1928.)

Fig. 5.3 Puncture point positions within the "puncture zone": Lateral extraoral approach.
zygomatic arch just anterior to the articular eminence. MacIntosh and Ostellere (1967c) site the puncture point in a different fashion. The patient opens the mouth and the condylar head is palpated anterior to the articular eminence. The skin is marked at this point and when the mouth is closed again, the mark lies over the mandibular notch, somewhere near the middle of the dish-shaped outline.

Roberts & Sowray (1979d) palpate the midpoint of the depression on the lower border of the zygomatic process and mark the skin in this position for the puncture point.

Murphy (1980) uses palpation on wide opening followed by closing to determine a point on the skin below the midpoint of the zygomatic arch.

Sweet and Powell (1983) locate the midpoint of the zygomatic arch and site the puncture point one quarter of an inch (6mm) below this point.

As can be seen from the foregoing discussion, the puncture point for the lateral approach to the maxillary nerve is variable and may be better described as a "puncture zone". All authors claim success with their techniques so the following conclusion can be made: the puncture zone is most commonly sited between the midpoint of the zygomatic arch and the mandibular notch. Other
positions for the puncture point are low and anterior, low and posterior, and middle/high posterior (Fig. 5.3). The lateral pole of the condyle in the maximally open position approximates the middle of the zygomatic arch - sigmoid notch space. Once the needle has punctured skin, angulation will be the arbiter of successful deposition of local anaesthetic solution.

**Needle Insertion**

Three basic needle movements are required to enable deposition of local anaesthetic solution in the pterygo-palatine fossa via a lateral extra-oral approach:

1. The needle is advanced medially to strike the lateral pterygoid plate having punctured the skin as discussed in the previous section. (Fig. 5.1)

2. On encountering the lateral pterygoid plate, the depth marker is set. A depth marker is a piece of sterile rubber which is placed along the shaft of the needle to indicate the depth to which the needle must be inserted. The sterile rubber may take the form of a small piece of rubber dam, Penrose drain or a circular endodontic stopper. The needle is then withdrawn partially or almost completely.

3. The needle is re-angled in a forward and upward direction depending on operator preference to the
predetermined depth (vide infra). (Fig. 5.1)

Modifications of the three basic movements relate to three main considerations:

(a) Angulation through skin.
(b) Re-angulation of needle.
(c) Depth of insertion.

(a) Angulation through skin

Six variations have been recorded.

(i) At right angles to the median plane/sagittal plane (Labat, 1928; Seldin, 1942c; Sweet and Powell, 1983).
(ii) At right angles to skin surface (Roberts & Sowray, 1979c; Topazian & Simon, 1962).
(iii) Medial direction—no angle given (Murphy, 1980).
(iv) Horizontally and anteriorly at $30^\circ$ (MacIntosh & Ostlere, 1967c).
(v) $30^\circ$ anterior with $5^\circ$ vertical angulation (Stebbins & Burch, 1961).
(vi) $45^\circ$ to skin (Moore, 1955).

In an attempt to illustrate and analyse the above recommendations, values allocated to skin angulation variations have been superimposed on a diagram.
illustrating the six common puncture point sites. (Fig. 5.3) From this superimposition it becomes obvious that if the puncture point is situated on the line joining the middle of the zygomatic arch and the most inferior point of the sigmoid notch, angulation at right angles to the median or sagittal plane is most common (3 authors). This is followed by angulation at right angles to skin surface (1 author) and medial direction (1 author). Puncture points sited slightly anterior/posterior and inferior to the midline need anterior components of angulation (30° and 45° respectively). Position No. 5, slightly posterior and inferior to the midpoint of the dish-shaped outline uses an angulation at right angles to the skin surface.

MacIntosh and Osthle's puncture point (1967c) in the middle of the outline requires horizontal insertion with a 30° anterior component. When bone is struck, usually the posterior aspect of the maxilla or the anterior surface of the lateral pterygoid plate at a depth of approximately 5 centimetres, solution is deposited. The operator must rely on diffusion medially to obtain maxillary nerve anaesthesia. This technique is less reliable than deposition within the pterygopalatine fossa and has no advantages over other methods.
(b) Direction of re-angulation of needle

Re-angulation of the needle is necessary to enable solution deposition in the pterygopalatine fossa. As discussed, MacIntosh and Ostlere's technique is the only technique not requiring re-angulation. Opinion is equally divided between slightly forward and slightly forward/upward re-angulation (Table 5.1). In Murphy's technique (1980), the needle is not withdrawn for re-angulation, but "walked" anteriorly along the lateral pterygoid plate until it is felt to enter the pterygopalatine fossa.

Re-direction angles are quantified by two authors. Seldin (1942c) re-angles the needle approximately 20° forward and upward. Roberts and Sowray (1979d) re-angle the needle approximately 10° upward and 15° forward.

To enable re-angulation, withdrawal of the needle is necessary. Labat (1928), Seldin (1942c), Roberts and Sowray (1979d), and Sweet and Powell (1983) largely withdraw the needle to lie just under the skin in the subcutaneous tissues. Moore (1969) and Topazian and Simon (1962) recommend only slight withdrawal before re-angulation, the distance withdrawn not being stated.

The most accurate method for needle insertion and
TABLE 5.1

<table>
<thead>
<tr>
<th>Author</th>
<th>Slightly Forward</th>
<th>Slightly Forward &amp; Upwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labat (1928)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Seldin (1942c)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Moore (1969)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Topazian &amp; Simon (1962)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>MacIntosh &amp; Ostlere (1967c)</td>
<td></td>
<td>No re-angulation necessary</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Murphy (1980)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Sweet &amp; Powell (1983)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Needle re-angulation: lateral approach.
re-angulation is to hold the needle in a pen grip, without the syringe attached. (Fig. 5.4) This allows the fine tactile sensation of the finger tips to determine the first bony contact. Bony contact should be light, as heavy contact may cause patient distress. The pen grip also allows judgement of the position of "stepping-off" the lateral pterygoid plate. Such fine movements are difficult to judge if the needle is attached to a syringe and held in the conventional "three finger" grip.

(c) Depth of insertion

The average depth of insertion using the lateral extraoral technique is approximately five centimetres (Table 5.2). The greatest depth of insertion is in the range of 56 to 63 millimetres (Moore, 1969). The most likely explanation for this increased depth is that the puncture point in Moore's technique is in the most posterior and inferior position.

The minimum depth of penetration is 45 millimetres (Stebbins & Burch, 1961; Topazian & Simon, 1962; Sweet & Powell, 1983). There seems little explanation for this as the puncture points of the authors involved are low anterior, mid posterior and centre of the dish-shaped outline respectively (Fig. 5.2).
Fig. 5.4 Pen-grip for accurate needle insertion and re-angulation.

(From: Labat, G., Regional Anesthesia, Philadelphia, W.B. Saunders, 1928.)

Fig. 5.5 Position of needle in relation to the skull for maxillary nerve block via the lateral extraoral approach.
**TABLE 5.2**

<table>
<thead>
<tr>
<th>AUTHOR</th>
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<tbody>
<tr>
<td>Labat (1928)</td>
<td>50</td>
</tr>
<tr>
<td>Selidin (1942c)</td>
<td>50</td>
</tr>
<tr>
<td>Stebbins and Burch (1961)</td>
<td>45 - 55</td>
</tr>
<tr>
<td>Topazian and Simon (1962)</td>
<td>45 - 55</td>
</tr>
<tr>
<td>MacIntosh and Ostlere (1967c)</td>
<td>50</td>
</tr>
<tr>
<td>Moore (1969)</td>
<td>56 - 63</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td>50</td>
</tr>
<tr>
<td>Murphy (1980)</td>
<td>56</td>
</tr>
<tr>
<td>Sweet and Powell (1983)</td>
<td>45</td>
</tr>
</tbody>
</table>

**RANGE** 45 - 63

Depth of insertion: Lateral approach.
The important landmark for gauging depth of injection is the lateral pterygoid plate. Three techniques (Labat, 1928; Seldin, 1942c; Topazian & Simon, 1962) rely on the striking of the lateral pterygoid plate for setting the sterile rubber depth marker. In these cases, it is set approximately 10 millimetres from the skin surface. The depth of the lateral pterygoid plate from the skin surface according to the various authors is detailed in Table 5.3, the depth ranging from 38 millimetres to not greater than 50 millimetres.

An alternative method is to set the depth marker at a constant setting from the tip. Roberts and Sowray (1979d) recommend 50 millimetres while Sweet and Powell (1983) favour 45 millimetres.

Once the lateral pterygoid plate is encountered, the needle is reangled according to the particular author's technique and solution deposited when the depth marker is reached.

A depth marker is not necessary with the technique MacIntosh and Ostlere (1967c) as solution is deposited at the point of bony contact. Moore (1969) states: "Depth markers are not necessary and need not be employed if the anaesthetist is constantly cognizant of the depth to which the needle has been inserted. It is seldom necessary to
<table>
<thead>
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<tr>
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<td>Seldin (1942c)</td>
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</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>38 - 50</td>
</tr>
<tr>
<td>Topazian &amp; Simon (1962)</td>
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<tr>
<td>MacIntosh &amp; Ostlere (1967c)</td>
<td>50</td>
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<tr>
<td>Moore (1969)</td>
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<td>Roberts &amp; Sowray (1979d)</td>
<td>50</td>
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<td>Murphy (1980)</td>
<td>50</td>
</tr>
<tr>
<td>Sweet &amp; Powell (1983)</td>
<td>45</td>
</tr>
<tr>
<td>RANGE</td>
<td>38 - 50</td>
</tr>
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</table>

Depth of lateral pterygoid plate from skin.
insert deeper than 2.25 inches (50 mm), even in a heavy patient. If the needle is inserted past this depth, it may enter the orbit through the inferior orbital fissure."

Fig. 5.5 demonstrates needle position in relation to the skull for maxillary nerve block via the lateral approach.

TECHNICAL ASPECTS: Lateral approach

Table 5.4 summarizes the technical aspects for the lateral extraoral approach to the maxillary nerve block.

Basic requirements include:

1. Patient and operator to be comfortably positioned.
2. Mouth closed.
3. Needle of adequate length and gauge: 75 mm, 22/23 Gauge.

Solution used obviously depends on the solutions available at the time of writing the paper. It is surprising that some authors do not state the solution routinely used (Topazian & Simon, 1962; MacIntosh & Ostlere, 1967; Murphy, 1980; Sweet & Powell, 1983). In
<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>PATIENT POSITION</th>
<th>NEEDLE LENGTH (mm)</th>
<th>NEEDLE GAUGE</th>
<th>ASPIRATION</th>
<th>SOLUTION</th>
<th>VOL (ml)</th>
<th>INDUCTION TIME (mins)</th>
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<tbody>
<tr>
<td>Labat (1923)</td>
<td>Supine</td>
<td>80</td>
<td>22</td>
<td>Yes</td>
<td>2% Procaine</td>
<td>2</td>
<td>Not stated</td>
</tr>
<tr>
<td>Seldin (1942c)</td>
<td>Maxillary occlusal plane horizontal</td>
<td>80</td>
<td>20</td>
<td>Yes</td>
<td>2% Procaine</td>
<td>3</td>
<td>10 - 20</td>
</tr>
<tr>
<td>Stebbins &amp; Burch (1961)</td>
<td>Patient comfortable</td>
<td>75</td>
<td>23</td>
<td>No</td>
<td>2% Lignocaine 1:100,000 Adrenalin</td>
<td>3</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Topazian &amp; Simon (1962)</td>
<td>Not stated</td>
<td>90 - 100</td>
<td>20</td>
<td>Yes</td>
<td>Not stated</td>
<td>2 - 3</td>
<td>Not stated</td>
</tr>
<tr>
<td>MacIntosh &amp; Ostlere (1967c)</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Yes</td>
<td>Not stated</td>
<td>7</td>
<td>Not stated</td>
</tr>
<tr>
<td>Moore (1969)</td>
<td>Dorsal recumbent; sagittal section through nose at right angles to table</td>
<td>75</td>
<td>23</td>
<td>No</td>
<td>1% / 1.5% Lignocaine</td>
<td>5 - 10</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td>Not stated</td>
<td>75</td>
<td>Heavy</td>
<td>Yes</td>
<td>Lignocaine</td>
<td>2</td>
<td>Not stated</td>
</tr>
<tr>
<td>Murphy (1980)</td>
<td>Mouth closed</td>
<td>80</td>
<td>22</td>
<td>No</td>
<td>Not stated</td>
<td>5</td>
<td>Not stated</td>
</tr>
<tr>
<td>Sweet &amp; Powell (1983)</td>
<td>Not stated</td>
<td>Spinal needle</td>
<td>Not stated</td>
<td>Yes</td>
<td>Not stated</td>
<td>2 - 3</td>
<td>Not stated</td>
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</table>

Technical Aspects: Lateral extraoral approach.
these cases the most likely choice is lignocaine as the papers were written after 1948, the year lignocaine was introduced.

Other technical considerations include:

(a) The raising of a skin weal.

Preliminary superficial anaesthesia is desirable before proceeding with a nerve block penetrating skin. This may take the form of raising a skin weal centred on the desired puncture point (Labat, 1928; Seldin, 1942c; Stebbins & Burch, 1961; Topazian & Simon, 1962; Moore, 1969; Sweet & Powell, 1983) or by infiltrating subcutaneously as part of a direct approach to engage the lateral pterygoid plate (MacIntosh & Ostlere, 1967c; Roberts & Sowray, 1979d; Murphy, 1980). Seldin (1942c) and Moore (1969) recommend the use of a separate shorter (15-20 mm), 25 gauge needle for the raising of the skin weal.

Because of the close relationship of the branches of the facial nerve to the site of infiltration, it is wise to avoid extensive subcutaneous infiltration which may result in some temporary weakness of the orbicularis oculi muscles (Murphy, 1980). A few drops of local anaesthetic solution are all that is needed.
(b) The elicitation of paraesthesiae.

The elicitation of paraesthesiae is only recommended by Labat (1928) and Moore (1969). Paraesthesiae in the upper jaw or teeth indicate that the maxillary nerve has been encountered. In such cases, anaesthesia is almost immediate (Labat, 1928). Paraesthesiae are characterized by sharp, spraying, electric shock sensations and may radiate to the ala of the nose, upper lip, cheek, lower eyelid and teeth. In Moore's technique (1969), paraesthesiae are actively sought and the patient cautioned to say "Now" and not move when they are felt. Paraesthesiae are thus used to determine the injection site and their elicitation is essential if therapeutic nerve blocking with alcohol or other neurolytic agents is to be used, especially as it is easy for the depth of injections to be overextended and solution deposited intraorbitally or intracranially.

Paraesthesiae may be simulated by periosteal stimulation overlying the lateral pterygoid plate, however, in this instance the pain does not radiate. Moore (1969) believes paraesthesiae to be essential in minimizing failure and quotes the dictum, "No paresthesias, no anesthesia".
Radiographic localization with the needle in place may be useful if paraesthesiae are unable to be elicited in cases requiring therapeutic block. This is hardly a practical procedure for routine local anaesthesia.

(B) ANTERIOR APPROACH

The anterior approach to the maxillary nerve is the second most commonly reported extraoral technique. It is useful when infection is present in the region of the lateral technique puncture point or when there are anatomic distortions due to pathosis (Labat, 1928) and is the favoured extraoral approach of MacIntosh and Ostlere (1967b). The term "anterior" was first used by Poore and Carney in 1973. Other names for the technique are: zygomatic route No. 2 (Labat, 1928), route of Schlösser (Labat, 1928), precoronoid (Seidin, 1942c), anterior route via the infratemporal fossa (Murphy, 1980).

Poore and Carney (1973) claim that the anterior approach is easier because of the relatively short distance between the point of entry of the needle and the pterygomaxillary fissure, the relative ease of identification of the various bony landmarks and the favourable angle between the pterygomaxillary fissure and the coronoid process. Murphy (1980) states that the technique is less safe than the lateral approach because if the needle is advanced too deeply, it can proceed
unchecked into the optic nerve and, by way of its foramen, into the cranial cavity. The anterior angulation necessary for the lateral approach will only result in impingement on the posterior surface of the maxillary or palatine bones and thereby prevent damage to deeper structures.

Location of the Puncture Point

There are two basic methods for locating the puncture point. The simplest method is that of MacIntosh and Ostlere (1967b). A vertical line is extended from the lateral orbital margin to join a horizontal line through the middle of the upper lip. The point of intersection is the puncture point which lies over the anterior border of the masseter, one centimetre below the inferior margin of the zygoma. (Fig. 5.6) This is confirmed by palpation.

The other method and its modifications have been described by Labat (1928), Seldin (1942c), Poore & Carney (1973) and Murphy (1980). The angle formed by the anterior border of the coronoid process with the lower margin of the zygomatic bone is palpated. These landmarks may be outlined with a small ball burnisher dipped in iodine as described by Seldin. (Fig. 5.7) In Labat's technique the needle is introduced in the angle thus formed, no particular site being otherwise specified. Seldin (1942c) bisects the angle and the
Fig. 5.6 Method of location of puncture point and needle angulation.

(From: MacIntosh, R. & Ostlere, M., Local Analgesia: Head and Neck, Baltimore, Williams & Wilkins, 1967.)

Fig. 5.7 Method of location of puncture point for the anterior extraoral approach.
(after Seldin, 1942)
puncture point is located one centimetre along the bisecting line, from the vertex/apex. (Fig. 5.7) In the technique of Poore and Carney (1973), the apex of the angle is palpated with the third finger of the left hand as the patient opens and closes his mouth. The finger is retracted two millimetres (with the mouth closed) to tense the skin and the point at the tip of the finger should then overlie the apex of the angle/puncture point.

The puncture point in Murphy's technique (1980) is located anterior to the coronoid process at a point below the anterior aspect of the zygomatic arch.

**Needle Insertion**

The basic needle direction required to deposit local anaesthetic solution in the pterygopalatine fossa via an anterior extraoral approach is upward, inward and backward (superiorly, medially, posteriorly). The following five techniques reviewed here vary sufficiently in their detail as to warrant individual discussion.

In Labat's technique (1928), the needle is introduced transversely and directed slightly upwards towards the maxillary tuberosity. On contact with the tuber, the needle is withdrawn sufficiently to allow a change of direction and re-introduction with more posterior inclination to allow entry into the pterygopalatine fossa, immediately after losing contact
with the maxilla. The general direction is upward, backward and toward the apex of the orbit. The maximum depth is between fifty and sixty millimetres.

In the technique of Seldin (1942c), the needle is advanced inward, upward and backward at an angle of 45°. Contact with the postero-lateral curvature of the maxilla above the tuberosity is essential, as is the avoidance of engaging periosteum. With correct angulation and "grazing" of the maxilla, the needle is further inserted to a depth of not greater than fifty-five millimetres.

In the technique of MacIntosh and Ostlere (1967b), the puncture point is somewhat more anterior than the techniques of Labat and Seldin. The needle is introduced (with the patient supine) with a backward deviation of about 30° from the horizontal, upward and inward so that when viewed from the front the shaft of the needle lies in a line which passes through the pupil. (Fig. 5.8) The needle passes very close to the postero-lateral surface of the maxilla. The posterior superior alveolar nerves may be stimulated causing molar toothache if periosteum is engaged. If the posterior maxilla does not protrude, the needle should pass through the pterygomaxillary fissure into the pterygopalatine fossa, without bony contact. In cases where the posterior maxilla protrudes, the needle is deflected or directed to a point on the upper part of the lateral pterygoid plate posterior to the pterygomaxillary fissure at a depth of
Fig. 5.8 Needle angulation and direction for the anterior extraoral approach of MacIntosh and Ostlere.

(From: MacIntosh, R. & Ostlere, M., Local Analgesia: Head and Neck, Baltimore, Williams and Wilkins, 1969.)

Fig. 5.9 Position of needle in relation to the skull for maxillary nerve block via the anterior extraoral approach.
approximately forty millimetres. The maximum depth reached is between forty and fifty millimetres.

In the technique of Poore and Carney (1973), the needle is inserted at right angles to the plane tangential to the cheek and directed at an angulation of 20° superiority and 40° posteriorly. It is then advanced until the lateral pterygoid plate is engaged. The needle is then withdrawn about ten millimetres and reinserted one or two millimetres more anteriorly, without alteration of the superior angulation. This procedure is repeated until the needle is felt to "step off" the anterior margin of the lateral pterygoid plate through the pterygomaxillary fissure. Insertion within the pterygopalatine fossa should be no further than two millimetres after passing through the fissure.

Although the depth of injection is not given, Poore and Carney (1973) perform "test injections" to determine needle position. To check for intracranial penetration, 0.5 ml of anaesthetic solution is injected after negative aspiration. The patient's level of consciousness is monitored for two minutes. Deposition of solution into the subarachnoid space of the middle cranial fossa causes unconsciousness of dose dependent duration and respiratory arrest. If no change is noted in the patient's level of consciousness, a second "test injection" is performed to check for intraorbital penetration. One ml of local anaesthetic solution is
injected rapidly. The operator should observe the patient for any transient proptosis.

If both test injections are negative, maxillary block may proceed. Should unconsciousness occur, the injection is ceased and controlled ventilation commenced until spontaneous respiration returns.

Should transient proptosis occur, the needle is withdrawn to the subcutaneous level and reinserted. It is essential to establish a deep landmark for each patient. This is the lateral pterygoid plate.

In the technique of Murphy (1980), the needle is directed medially towards the pupil of the eye to pass posterior to the posterior surface of the maxilla directly into the pterygopalatine fossa. No contact is made with the posterior maxillary wall or the pterygoid plates as with other techniques. The needle should not be inserted to a depth greater than five centimetres as the needle may proceed unchecked into the optic foramen. Murphy believes, as stated earlier, that this approach is less safe than the lateral approach where impingement of the posterior surface of the maxillary or palatine bone prevents damage to deeper structures. However, it is apparent that only slight modification of Murphy's technique would be necessary to enable bony contact with the posterior maxilla, or the lateral pterygoid plate, as a guide to the needle position.
To summarize, bony contact is used as a guide to needle position by Labat and Seldin (tuberosity), and Poore and Carney (lateral pterygoid plate). No bony contact is achieved in Murphy's technique and only in MacIntosh and Ostlere's technique if the posterior maxilla protrudes. In these cases, depth marking is essential. Table 5.5 summarizes depth of injection and the use of depth markers. Fig. 5.9 demonstrates needle position in relation to the skull for maxillary nerve block via the anterior approach.

Technical Aspects

Technical aspects of the anterior extraoral approach are summarized in Table 5.6. The supine and "armchair" positions seem to be most suitable. A needle length of eighty millimetres and gauge finer than twenty is the most common combination. Aspiration should be routinely performed. Solution type, volume and induction times are similar to those recommended for the lateral extraoral approach. Other aspects include:

(a) the raising of skin weals: As discussed previously, most authors infiltrate the subcutaneous tissues in the region of the puncture point with local anaesthetic solution prior to the deeper nerve block injection. This usually requires a shorter, finer gauge needle (less than twenty millimetres and 24 or 25 gauge). The local anaesthetic solution
### TABLE 5.5

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<th>AUTHOR</th>
<th>DEPTH (mm)</th>
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<td>Seldin (1942c)</td>
<td>55</td>
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</tr>
<tr>
<td>MacIntosh &amp; Ostlere (1967b)</td>
<td>40 - 50</td>
<td></td>
</tr>
<tr>
<td>Poore &amp; Carney (1973)</td>
<td>Not stated. Must contact lateral pterygoid plate. Not necessary</td>
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</tr>
<tr>
<td>Murphy (1980)</td>
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RANGE 40 - 60

Depth of injection and use of depth markers: anterior extraoral approach.
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<th>AUTHOR</th>
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<th>NEEDLE</th>
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<th>SOLUTION</th>
<th>VOLUME (ml)</th>
<th>INDUCTION TIME (mins)</th>
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<td>2% Procaine</td>
</tr>
<tr>
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<td>Maxillary occlusal plane horizontal</td>
<td>80</td>
<td>20</td>
<td>Yes</td>
<td>2</td>
<td>2% Procaine</td>
</tr>
<tr>
<td>MacIntosh &amp; Ostrere (1967b)</td>
<td>Horizontal</td>
<td>≥ 50</td>
<td>Not stated</td>
<td>Yes</td>
<td>Not stated</td>
<td>8</td>
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<tr>
<td>Poore &amp; Carney (1973)</td>
<td>&quot;Armchair&quot; position</td>
<td>75</td>
<td>22</td>
<td>Yes</td>
<td>2-6</td>
<td>2% Lignocaine with Adrenalin</td>
</tr>
<tr>
<td>Murphy (1980)</td>
<td>Not stated</td>
<td>80</td>
<td>22</td>
<td>Not stated</td>
<td>Not stated</td>
<td>5</td>
</tr>
</tbody>
</table>

Technical Aspects: Anterior approach.
used for this may not contain vasoconstrictor and may be weaker (Poore & Carney, 1973). As surface anaesthesia is only required for a short duration, the use of a weaker solution without vasoconstrictor will have little effect on the quality of the anaesthesia and the amount of solution necessary.

(b) the elicitation of paraesthesiae: Paraesthesiae are not routinely sought in this technique except for alcohol injections for therapeutic nerve block. A more detailed discussion on this aspect has been covered in the section on the lateral extraoral approach.

(C) ORBITAL ROUTE

An alternative method to the lateral and anterior approaches involves traversing the infero-lateral borders of the orbit and depositing the local anaesthetic solution supero-laterally in the pterygopalatine fossa (Murphy, 1980). The technique was originally proposed by Matas (Labat, 1928). The needle is introduced on the lateral part of the lower orbital margin, close to its inferior lateral angle, and is directed vertically downward to meet the orbital floor. On reaching the orbital floor, the needle is swung downward to the horizontal plane (Fig. 5.10) then advanced slowly and gently in the direction of the orbital apex, maintaining close contact with the orbital floor until passing
Fig. 5.10 Maxillary block via the orbital route. The needle in the vertical position makes contact with the floor of the orbit before being shifted to the horizontal in the direction of the arrow.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)
through the inferior orbital fissure thus gaining access to the pterygopalatine fossa (Fig. 5.11). At an average depth of forty-five to fifty millimetres, the foramen rotundum is encountered. Two millilitres of solution are then deposited. In the technique described by Murphy (1980), the needle is only advanced forty millimetres to deposit solution within the pterygopalatine fossa. No attempt is made to deposit solution at the foramen rotundum. A 60 or 80 mm, 22G needle with a depth marker is suitable for the procedure. Haematoma formation is frequent with this technique. Intraorbital spread of local anaesthetic solution may cause temporary blindness or paralysis of the extraocular muscles.

Although not recommended as a first choice for second division trigeminal block, the orbital route is an alternative when local conditions may preclude the conventional approach via the infratemporal fossa.

(D) INTRANASAL ROUTE

This particular route is used specifically for sphenopalatine (Meckel's) ganglion block in the treatment of Sluder's neuralgia using alcohol injection. However, it may be used to deliver local anaesthetic solution into the pterygopalatine fossa, in a somewhat deeper position than the normal maxillary block. The technique, described by Labat (1928), is difficult and involves
Fig. 5.11 Maxillary block via the orbital route. Direction of the needle in relation to the skeleton.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)

Fig. 5.12 Intranasal route for sphenopalatine ganglion block.

(From: Labat, G., Regional Anesthesia. Philadelphia, W.B. Saunders, 1928.)
first cocainizing the posterior extremity of the middle turbinate and the lateral nasal wall. Using a 100 mm, 22G straight needle, the posterior end of the middle turbinate is transfixed while the needle is directed upward, backward and outward until bony contact is made. With some pressure, depending on the thickness of the bone, this bony wall is pierced and the needle passed into the pterygopalatine fossa. (Fig. 5.12) If the ganglion has been reached, the patient will immediately complain of excruciating pain radiating from the eye, to the ear, to the mastoid area, over the occiput and down into the shoulder. Injection of local anaesthetic solution is made once the pterygopalatine fossa has been entered. Failure to obtain anaesthesia by this route may be due to anatomic distortions such as a deviated/deflected septum or a septal spur which obstructs the site of the puncture. Absence of the middle turbinate, which is the chief landmark, makes the procedure a blind one. Excessive thickness of the bone separating the nasal cavity from the ganglion may make entering the pterygopalatine fossa difficult or impossible. The most frequent complication is profuse bleeding at the time of puncture of the middle turbinate.

Because the lateral and anterior extraoral approaches are so simple, there is little reason to prefer the intranasal route. The technique is best summed up in the words of Labat (1928) and Adriani (1967) who state: "The intranasal route is best left to
rhinologists. The extraoral and palatine routes are safer and should be the procedures of choice...".
CHAPTER SIX

COMPLICATIONS OF MAXILLARY NERVE BLOCK ANAESTHESIA

The complications of maxillary nerve block anaesthesia can be divided into three categories based on the route of injection.

(A) Complications common to intraoral and extraoral approaches.

(B) Specific complications of the intraoral approaches

(B1) Palatal

(B2) Buccal.

(C) Specific complications of the extraoral approach.

(A) COMPLICATIONS COMMON TO INTRAORAL AND EXTRAORAL APPROACHES

These may be classified as:

(1) Vascular

(2) Visual

(3) Neural

(4) Intracranial penetration

(5) Nasal penetration

(6) Anaesthetic problems

(7) Pain during and after injection

(8) Injection of excessive volumes of solution

(9) Broken needles

(10) Risk of infection.

Because of their implications, each of the above
complications warrants separate discussion.

(1) VASCULAR COMPLICATIONS

The site of deposition and route of injection for the maxillary nerve block lie in extremely vascular areas. Within the infratemporal fossa lie the maxillary artery, two of its branches and the pterygoid venous plexus. The pterygopalatine fossa contains the terminal or third part of the maxillary artery, its five branches and accompanying veins.

Vascular complications will be discussed under the following headings (after Roberts & Sowray, 1979e):
(a) Arterial irritation
(b) Intravascular injection
(c) Haemorrhage into the tissues
(d) Other: Nasal bleeding (Epistaxis).

(a) Arterial Irritation

A needle may graze an artery without penetrating the lumen because of the elastic nature of the vessel wall. This may cause transient discomfort and be accompanied by blanching of the skin or mucous membrane. This vasoconstriction is due to spasm occurring in the tunica media (muscular layer) of the blood vessel and is caused by direct stimulation of the muscle fibres or irritation of the
sympathetic nerve plexus which surrounds the vessel (Roberts & Sowray, 1979e). The terms reflex vasospasm or angiospasm are also used to describe the phenomenon. The areas affected are the regions of the face supplied by terminal branches of the maxillary artery. These follow the distribution of the terminal branches of the maxillary nerve (Mercuri, 1979). Kemp (1940c,d) noted blanching in the infraorbital, zygomatic and palatal regions in eleven of his three hundred and fifty cases of maxillary block via the tuberosity approach.

Blanching may also be caused by intravascular injection and the local effects of the anaesthetic solution, particularly when raising a skin weal prior to performing an extraoral maxillary block.

The effects of blanching are transient and there are no sequelae (Mercuri, 1979).

(b) Intravascular Injection

The consequences of intravascular injection include tachycardia, syncope, failure to produce analgesia and blanching of tissues (Roberts & Sowray, 1979e; Mercuri, 1979). Intravascular injections most frequently occur when the maxillary nerve is approached from the buccal or tuberosity approach.
It has been reported that toxicity following intravascular injections can be two hundred times as high as when the anaesthetic is properly administered (Roberts & Sowray, 1979e). Routine aspiration on advancement and prior to injection is essential to avoid this complication. Should a positive aspiration occur, the needle should be re-positioned and aspiration again performed prior to injection (Mercuri, 1979).

(c) Haemorrhage into the Tissues

Puncturing or tearing of a vessel wall during insertion or withdrawal of the needle will cause bleeding into the tissues. Needle tips, bent or barbed by bony contact, cause gross tissue damage on removal. The facial tissues are particularly vulnerable to vessel damage because the pliable, easily stretched skin offers no obstruction to the spread of blood. A large haematoma may form in the eyelids or cheek within a few seconds and the ensuing dramatic facial swelling often distresses the patient. If external pressure is not applied then bleeding will continue into the tissues until the vessel seals itself or blood fills the tissue space and pressure outside the vessel equals the pressure from within (Moore, 1955).
(i) Haematoma formation within the cheek.

This is the most common complication of intra-oral maxillary nerve block via the buccal approach. The blood vessels implicated are either:

(1) The pterygoid venous plexus (Kemp, 1940b; Seldin, 1942b; Dickson & Coates, 1945; Corbett & Helmore, 1948; Killey & Kay, 1977; Roberts & Sowray, 1979e; Malamed, 1980b), or

(2) Branches of the maxillary artery (Seldin, 1942b; Jorgensen & Hayden, 1972; Malamed, 1980b) in particular the bucco-gingival branch of the posterior superior alveolar artery. (Sicher & DuBrul, 1975e; Carter, 1983).

The pterygoid venous plexus lies posterior to the maxilla and lateral to and closely applied and embedded within the fibres of the lateral pterygoid muscle (Carter, 1983). Needles directed too far posteriorly (Malamed, 1980b) or laterally (Roberts & Sowray, 1979e) are likely to encounter the venous plexus and the lateral pterygoid muscle. Hence the needle should be kept close to the zygomatic and infratemporal surfaces of the maxilla. The
modified Labat technique of Seldin (1942b) was proposed to avoid pterygoid venous plexus involvement. In Kemp's series of three hundred and fifty injections (1940d) using his modified buccal technique, five cases of haematoma were observed. Corbett and Helmore (1948), believe haematoma formation can occur in up to 25 percent of maxillary blocks via the buccal approach.

The maxillary artery lies about one centimetre behind the route of the needle during the buccal approach (Seldin, 1942b) and it is unlikely to be involved unless the needle is misdirected. However, the bucco-gingival branch of the posterior superior alveolar artery (a branch of the third part of the maxillary artery), when present, courses along the maxillary alveolar process from the distal aspect of the tuberosity towards the premolar region. It is bound firmly to peristeum by a thin sheet of fascia which prevents the artery from rolling away from the path of the advancing needle.

Most haematomata forming in the cheek present as rapidly developing swellings during or immediately after injection. (Fig. 6.1) Such rapid development can only result from arterial
Fig. 6.1 Large cheek haematoma following administration of a left maxillary block via the buccal approach.
pressure due to injury to the posterior superior alveolar artery or its gingival branch, a theory subscribed to by the renowned oral anatomist, Sicher (Sicher & DuBrul, 1975e). Needles kept too close to the posterior aspect of the maxilla may encounter these vessels which should be borne in mind when approaching the maxillary nerve by the buccal route.

Haematoma of the cheek is also a complication of extraoral maxillary nerve block. Both lateral (Moore, 1969) and anterior (Labat, 1928) approaches have been implicated. However, such haematomata do not occur when using the palatal approach (Gillam, 1937; Malamed, 1980b).

Treatment for a cheek haematoma can best be divided into two phases:

(1) Immediately after formation
   - well directed pressure over the cheek to decrease the soft tissue space into which blood may flow;
   - application of ice packs to decrease bleeding.

(2) In an established haematoma
   - application of warm moist compresses to
hasten resolution and lessen pain (Moore, 1969)

- antibiotic therapy: to prevent infection in a stagnant collection of blood (Killey & Kay, 1977);

- reassurance that the rapid developing swelling will resolve, that permanent disfigurement will not result (Malamed, 1980b) and that facial discoloration will subside (Killey & Kay, 1977);

- aspiration is desirable if the haematoma is extensive.

(ii) Intraorbital and periorbital haematoma formation.

Bleeding from damaged blood vessels in the vascular pterygopalatine fossa may spread to the orbit. Bleeding into the orbit usually presents as a swelling or apparent swelling of the eyelids and a marked exophthalmos. As tension mounts, eye pain and diplopia result. Should bleeding continue, loss of vision may follow within five minutes or so from pressure on the optic nerve and/or ophthalmic blood vessels (Moore, 1955).

The serious effects and treatment of retrobulbar haemorrhage are described in the section on visual disturbances. (pp.194-195)
Bleeding may spread into the lax circumorbital tissues and eyelids to produce a profound "black eye" (Moore, 1955; Murphy, 1980; Sweet & Powell, 1983). An orbital haematoma may result from both extraoral and intraoral approaches to the maxillary nerve. The extraoral approach via the orbit results in haematoma formation more frequently than the other techniques (Labat, 1928; Murphy, 1980).

Orbital swelling and haemorrhage should be treated in the following manner:

(1) Loss of vision is an emergency as permanent blindness may occur. Drainage of a haematoma may be necessary to avoid this catastrophe.

(2) Application of pressure and cold packs to reduce swelling and avoid haematoma formation (Moore, 1969).

(3) Once bleeding has stopped, warm moist dressings may hasten resolution and also lessen the pain (Moore, 1969).

(4) Obtain an ophthalmological opinion (Moore, 1955; 1969).

(5) Resassurance regarding the prognosis of any ecchymosis.

(6) Antibiotic therapy is essential for large static collections of blood.
(d) Nasal Bleeding (Epistaxis)

Nasal bleeding may result from inadvertent nasal penetration when performing maxillary nerve blocks via the lateral extraoral (Labat, 1928) and palatal approaches however, it is a rare complication.

Overinsertion of the needle from the lateral extraoral approach may result in the needle passing through the sphenopalatine foramen into the nose. Puncture of the vascular nasal mucosa will result in epistaxis. Depth control of needles will avoid this complication.

When performing maxillary nerve block via the palatal approach, care should be taken not to direct the needle too far medially. The medial wall of the canal may be paper thin or in some cases, non-existent (Fig. 6.2) and may be easily penetrated by an incorrectly angled needle (Cook, 1950). The vascular nasal mucosa lies medial to the pterygopalatine canal and may be easily traumatized with resultant epistaxis. Attention to correct needle angulation and advancement will avoid this complication (Malamed, 1980b).

Profuse nasal bleeding often accompanies the intranasal approach to the sphenopalatine ganglion (and maxillary nerve) at the time of puncture of the
Fig. 6.2 Partial absence of the medial wall of the pterygopalatine canal with the needle appearing in the nasal cavity.
posterior end of the middle turbinate. Secondary haemorrhage is a more frequent complication of the intranasal approach after alcohol injection for therapeutic nerve block (Labat, 1928).

(2) VISUAL COMPLICATIONS

Visual complications of maxillary nerve blocks are rarely reported and difficult to explain (Roberts & Sowray, 1979e). Any visual disturbance is distressing for the patient and should only last as long as the associated maxillary anaesthesia. Diffusion of anaesthetic solution or needle penetration of the orbit or the inferior orbital fissure are the most likely causes. Vascular involvement, e.g. I.V. injection or arterial spasm, is sometimes implicated. Whatever the cause, it is essential to reassure the patient as to the transient nature of the problem and to cover the affected eye with an eyepad to prevent corneal ulceration. An ophthalmological opinion is essential if symptoms persist after local anaesthesia has worn off or blindness has been noted at any stage.

Visual complications referred to in the literature are:

(a) Diplopia
(b) Blindness (i) Transient
   (ii) Permanent
(c) Squint
(d) Ptosis
(e) Exophthalmos/Proptosis
(f) Ophthalmoplegia
(g) Dilated pupil (Retrobulbar block)
(h) Retrobulbar haemorrhage.

These may occur when either extraoral or intraoral approaches are used.

Each of the above will be discussed separately because of the possible serious nature of visual complications.

(a) Diplopia

Diplopia or double vision is the most common sequel to intraorbital penetration or diffusion of local anaesthetic solution (Mercuri, 1979). Overpenetration is usually due to an overlong needle and lack of depth control. (Fig. 6.3)

Diplopia is a not uncommon occurrence as can be seen in Table No. 6.1. It is interesting to note that most instances of diplopia have been reported when using the palatal approach. Because the palatal approach provides a direct route to the pterygo-palatine fossa via a bony canal, there has been increasing interest in the technique. Critical
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Comparison of the incidence of diplopia. Five studies using various approaches to the maxillary nerve.
review of the techniques has become more common with increased clinical usage. The incidence of diplopia in Kemp's 300 cases (1940d) of maxillary block via the buccal approach is lower than two of the studies for the palatal approach but not as low as Malamed's study (1980b). Malamed uses strict depth control based on the work of Jorgensen (1948) to avoid overinsertion of the needle. The high incidence of diplopia in the studies of Dickson and Coates (1945) and Corbett and Helmore (1948) are probably due to lack of depth control.

Diplopia is one of the sequelae of ophthalmoplegia (vide infra). Paralysis of the intrinsic ocular muscles as a result of anaesthesia of the orbital nerves is the cause. The "motor" nerves to the orbital muscles carry sensory (proprioceptive) fibres which give an indication of tension in the muscle fibres supplied by the nerve. Local anaesthetic solution blocks the proprioceptive fibres resulting in lack of co-ordination of eye movement (Dickson & Coates, 1945). (Fig. 6.4) Diplopia may be accompanied by squint and ptosis. Dickson and Coates (1945) believe that diplopia can be avoided when using the palatal approach by directing the needle slightly laterally to avoid entering the inferior orbital fissure which lies vertically above the greater palatine foramen. If, however, solution is injected too far laterally or
Fig. 6.3 Overinsertion of needle via the palatal approach with orbital penetration.

Fig. 6.4 Lack of co-ordination of eye movement resulting in diplopia.
the canal angles laterally, not only will diplopia be avoided but also maxillary nerve block anaesthesia is unlikely to be obtained as solution may not be deposited in the pterygopalatine fossa. In this instance, the patient will exhibit molar anaesthesia only due to blocking of the posterior superior alveolar nerve.

Diplopia is transient and disappears as the effects of the local anaesthetic wear off. To avoid this complication:

(i) Use depth control measures and avoid the use of an overlong needle.
(ii) Avoid the injection of excessive volumes of solution (2-3 ml being usually sufficient).
(iii) Aspirate and inject slowly to reduce forceful diffusion of solution into the orbit.

(b) Blindness.

Temporary or permanent blindness (amaurosis) is a distressing sequel to local anaesthetic injection. It is more commonly reported following mandibular block injections, probably because of the greater use of this type of injection. The following have been postulated as causes:

(a) intra-arterial injection
(b) reflex angiospasm
(c) direct contact between optic nerve and local anaesthetic solution.

Due to the high vascularity of the area of injection for the maxillary nerve block and the proximity of the orbit, clinicians should always be aware of the possibility of this complication.

(i) Transient Blindness

Involvement of the optic or second cranial nerve by the spread of local anaesthetic solution from the pterygopalatine fossa or by direct injection into the nerve due to over-insertion of the needle is one of the less common causes of transient blindness or amaurosis fugax. Common causes of the condition include migraine, carotid insufficiency, cortical blindness, temporal arteritis, retinal artery spasm, central angio-spastic retinopathy, papilloedema and optic neuritis (Rose, 1969).

Accidental direct injection of the optic nerve is most likely to happen when the anterior extraoral approach, as described by Murphy (1980), is used. Over-insertion permits unimpeded progress of the needle via the inferior orbital fissure to the optic nerve and
via the optic foramen to the cranial cavity. (Fig. 6.5) The foramen rotundum and the optic foramen lie approximately one centimetre apart, hence diffusion of solution over this distance may occur. Excessively forceful injection of solution could easily force solution over this distance.

Accidental intra-arterial injection of local anaesthetic solution has been blamed for some cases of transient blindness. Because of the vascularity of the route of injection, the maxillary artery, a branch of the external carotid, may be penetrated on injection. Solution would reach the middle meningeal artery, the orbital branch of which forms a fairly constant anastomosis with the lacrimal branch of the ophthalmic artery, a branch of the internal carotid (Hyams, 1976). The central artery of the retina is also a branch of the ophthalmic artery and could thus be involved by spread of anaesthetic solution via the rich anastomosis between the internal and external carotid arteries (Walsh and King, 1942). However, this explanation must be treated with caution since blood from the maxillary artery is unlikely to reach the retina in a patient with a normal vascular pattern since reversal of the blood flow in the
Fig. 6.5 Overinsertion of needle via the anterior extraoral approach with orbital and cranial penetration.
ophthalmic artery would be necessary (Blaxter & Britten, 1967).

Temporary sympathetic reflex angiospasm causing central retinal artery occlusion is another possible explanation of transient blindness (Blaxter & Britten, 1967). Skin blanching also occurs as a result of this mechanism.

Sudden monocular blindness often passes unnoticed by the patient (Rose, 1969) thus, this form of visual disturbance may occur more commonly than is reported. It is a potential hazard for patients driving immediately after their appointments and indeed, Blaxter and Britten (1967) quote the case of an anaesthetist who was involved in a collision with a car which had approached unseen from the defective side. His transient blindness was only discovered after the accident.

To minimize the risk of patients developing transient blindness the following precautions should be observed routinely:

1. Proper depth control of needle.
2. Routine aspiration prior to injection.
3. Slow rate of injection.
(ii) Permanent Blindness

The risk of permanent damage to the optic nerve is more likely to occur when therapeutic nerve blocks using neurolytic agents are performed. Alcohol and phenol not only destroy the fibres of the maxillary nerve but unless caution is used, solutions may spread to the orbit via the inferior orbital fissure and involve the oculomotor and optic nerves (Adriani, 1967). It is essential in the therapeutic nerve block techniques to make direct contact with the nerve: paraesthesiae must be elicited.

Needles should be depth controlled and the total amount of neurolytic agent injected should not exceed one millilitre; injection should be slow and gentle, thus minimising the risk of unwanted diffusion.

Permanent blindness was once reported as a result of failure to remove the chemical disinfectant, usually alcohol, from the surface of a needle prior to injection (Killey & Kay, 1977). Another cause of permanent blindness has been attributed to fat embolism from the intra-arterial injection of oily procaine hydrochloride (Walsh, 1957).

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(c) Squint

Squint or strabismus may result from the diffusion of local anaesthetic solution into the orbit via the superior orbital fissure. The extrinsic ocular muscles, as discussed in the section on diplopia, are involved due to anaesthesia of the third, fourth or sixth cranial nerves (Killey & Kay, 1978). Binocular single vision is no longer maintained. One eye fixes on the fixation object and the other eye deviates (Duguid & Berry, 1978b).

(d) Ptosis

Ptosis refers to drooping of the upper eyelid (Duguid & Berry, 1978a). Weakness of the superior rectus muscle supplied by the oculomotor nerve is the cause and is the result of spread of local anaesthetic solution into the orbit (Killey & Kay, 1977; Duguid & Berry, 1978a). (Fig. 6.6)

(e) Exophthalmos/Proptosis

Exophthalmos or proptosis is the condition in which the eyeball protrudes from its bony socket. Over-insertion of the needle when performing a maxillary block can result in intraorbital injection which may cause volume displacement of the orbital structures and the appearance of exophthalmos. Periorbital
Fig. 6.6 Ptosis of right upper eyelid and constriction of right pupil following right maxillary nerve block via the palatal approach.
swelling may also occur (Malamed, 1980b; Poore and Carney, 1973; Moore, 1969).

Excessive volumes of local anaesthetic should not be injected as this may lead to orbital spread and possible exophthalmos (Labat, 1928). Visual disturbance may accompany exophthalmos.

(f) Ophthalmoplegia

Ophthalmoplegia is paralysis of the muscles of the eye. It may be internal, affecting the iris and the ciliary muscle or external, affecting the extrinsic ocular muscles. The patient will present with disturbances in pupil size, accommodation and ability to move the eye. (Fig. 6.6)

Internal and external ophthalmoplegia occur in retrobulbar block (vide infra). Paralysis of the extrinsic ocular muscles may occur in any approach to the maxillary nerve but is probably more common in the rarely used orbital approach. The effects of local anaesthetic-induced ophthalmoplegia should be transient.

(g) Retrobulbar Block

Injection or diffusion of local anaesthetic solution into the retrobulbar region will produce the classic
signs of retrobulbar block – dilated pupil, corneal anaesthesia and motionless eye (Malamed, 1980).

Pupillary dilatation has been noted as a complication of the greater palatine approach (Dickson & Coates, 1945; Corbett & Helmore, 1948; Malamed, 1980b) and the buccal approach (Kemp, 1940c; Malamed, 1980b).

(h) Retrobulbar Haemorrhage

Retrobulbar haemorrhage is an extremely rare complication following maxillary nerve block. Although mentioned by Poore and Carney (1973) they never encountered it in 2,900 maxillary blocks. The effects of retrobulbar haemorrhage are potentially serious leading to irreversible ischaemia of the retinal cells and permanent blindness. The diagnosis of retrobulbar haemorrhage is made clinically by the presence of pain, proptosis, a tense hard eye with dilating pupil, ophthalmoplegia, decreasing visual acuity and a pale optic disc. As blindness ensues the direct pupillary light reflex and contra-lateral consensual light reflex will be lost (Ord, 1981).

Early management is essential as blindness at this stage is reversible. In the presence of increasing proptosis and decreasing visual acuity or blindness,
active treatment in the form of orbital decompression in general and intra-conal space decompression in particular is essential (Rowe & Williams, 1985). A more detailed account of treatment is contained in Rowe and Williams' text (1985).

(3) NEURAL COMPLICATIONS

(a) Injury to neural tissue

Injury to neural tissue is most likely to occur when approaching the maxillary nerve via the palatal route, thus the greater palatine nerve may be traumatized by the advancing needle (Seldin, 1942b; Corbett & Helmore, 1948; Szerlip, 1948, Roberts & Sowray, 1979e). Seldin (1942b) reports the occurrence of paraesthesia or post-injection neuralgia of the greater palatine nerve, however, any such damage should be reversible (Szerlip, 1948; Roberts & Sowray, 1979e).

Needle damage to a nerve may occur with the other maxillary block techniques but is rarely reported. The elicitation of paraesthesiae, as advocated by Labat (1928) and Moore (1969), results in minor trauma to the maxillary nerve. As elicitation of paraesthesiae is essential prior to performing therapeutic nerve block, any damage induced is minor.
compared with the effects of the neurolytic substance injected. Occasionally nerve branches are encountered unintentionally as the needle is advanced. Direct contact not only produces very rapid analgesia but also causes intense pain and a profound numbness which may persist for a few days to several weeks. This type of injury is usually a nerve bruising or neuropraxia. More severe trauma may cause an axonotmesis and the duration of paraesthesia or anaesthesia may be months and occasionally more than one year (Killey & Kay, 1977).

Post-injection anaesthesia or paraesthesia is sometimes attributed to pressure from haemorrhage within the neural sheath or to contamination of the needle point with a chemical disinfectant (Killey & Kay, 1977).

(b) Facial nerve paralysis

Facial nerve paralysis is only reported following extraoral approaches and will be considered in the section on specific complications of the extraoral approach.

(4) INTRA-CRANIAL PENETRATION

Over-penetration of the needle may lead to
deposition of local anaesthetic solution into the subarachnoid space of the middle cranial fossa. The middle cranial fossa may be entered:

(a) via the optic foramen using the anterior extraoral approach (Murphy, 1980);

(b) via the superior orbital fissure using the palatal approach (Canter et al, 1964);

(c) via the supero-medial end of the inferior orbital fissure to enter the orbit then the contiguous infero-medial end of the superior orbital fissure using the anterior extraoral (Poore & Carney, 1973) and rarely the lateral extraoral approaches (Moore, 1969; Nique & Bennett, 1981; Sweet & Powell, 1983).

The anterior extraoral approach gives virtually unimpeded access to the middle cranial fossa and optic foramen and is the technique most often implicated in intra-cranial penetration. The lateral extraoral approach relies on bony landmarks and it is extremely difficult to obtain direct access to the middle cranial fossa without engaging the lateral pterygoid plate or the posterior aspect of the maxilla.

Deposition of solution in the arachnoid space, an intrathecal injection, causes unconsciousness of dose dependant duration, respiratory arrest (apnoea) and
occasionally convulsions (Poore & Carney, 1973). These are similar symptoms to high spinal anaesthesia and the condition is treated as such (Moore, 1969). Respiratory arrest is treated by positive pressure ventilation, continuous monitoring of vital signs (including electrocardiogram) and the establishment of an intravenous route for administration of medications if necessary. Ventilation is continued until spontaneous respiration and the ability to maintain the airway returns, usually up to an hour post-injection. In outpatients, there is always the risk of aspiration of stomach contents. Intubation and ventilation via an endotracheal tube may be necessary (Nique & Bennett, 1981). Meningitis is a potential sequel to intra-cranial penetration and appropriate antibiotics should be administered (Poore & Carney, 1973).

In Poore and Carney's total of 2,900 maxillary nerve blocks via the anterior extraoral route (1973), six cases of subarachnoid block occurred, an incidence of 0.2 percent. The duration of unconsciousness and apnoea ranged from four to sixty five minutes and all patients recovered uneventfully.

Although intra-cranial penetration is a rare complication of maxillary nerve block, its occurrence can be avoided by:

(a) the avoidance of over-penetration and the use of
depth markers;
(b) aspiration prior to injection - if cerebrospinal fluid is aspirated, withdraw and re-aspirate.

(5) NASAL PENETRATION

The nasal cavity may be penetrated when performing maxillary nerve block via
(a) the lateral extraoral approach;
(b) the palatal approach.

If the needle is inserted too far medially using the lateral extraoral approach, the needle will pass through the sphenopalatine foramen into the nasal cavity. Nasal haemorrhage may result (Labat, 1928). (Fig. 6.7)

Penetration of the nasal cavity may also occur during insertion of the needle along the pterygopalatine canal. (Fig. 6.2) Medial deviation of the needle may result in penetration of the paper-thin medial wall to enter the nasal cavity (Jorgensen & Hayden, 1972; Malamed, 1980b). In some instances, the medial wall may have no osseous layer (Cook, 1950). On aspiration, large amounts of air appear in the cartridge. If injection proceeds, the patient will complain of local anaesthetic solution running down the throat. This complication can be prevented by maintaining maximum oral opening and
Fig. 6.7 Nasal penetration resulting from overinsertion of the needle using a lateral extraoral approach.
careful needle advancement in the correct plane (Malamed, 1980).

(6) ANAESTHETIC PROBLEMS

(a) Inability to obtain anaesthesia

This is the problem most often encountered by inexperienced operators using both extraoral and intraoral techniques. In most cases, the solution is not deposited near enough to the nerve (Roberts & Sowray, 1979e). Particular attention is therefore necessary in locating landmarks for the puncture point of the needle. Should re-angulation of the needle be necessary as in some of the extraoral techniques, then care is needed in performing this manoeuvre to enable accurate deposition of solution.

In the case of the palatal approach, inexperienced operators have difficulty in locating the greater palatine foramen (Mercuri, 1979). The work of Malamed & Trieger (1983) should help to locate the foramen with more accuracy. Their recommendation is:

"the greater palatine foramen is most often located between the middle of the second molar and the middle of the third molar, approximately 7mm from the end of the hard palate or 12mm directly anterior to the tip of
the pterygoid hamulus."

Even if the foramen is located, it will be impossible to negotiate the pterygopalatine canal in a small percentage (less than 5 percent) of cases. Incorrect needle angulation within the canal may cause bony impingement (Peckham, 1938) or misplacement of the needle tip with deposition of solution into the maxillary sinus or nasopharynx. If the needle is angled too far laterally, the tip may be deflected on exit from the pterygopalatine canal by the pterygoid plate with subsequent deposition of solution outside the pterygopalatine fossa. (Fig. 4.4)

To avoid this mishap it is essential to review the relevant anatomy in relation to puncture point, route of injection and site of deposition before attempting maxillary block via the extraoral and intraoral routes.

Accidental intravascular injection has been cited as another possible cause for inability to obtain anaesthesia (Roberts & Sowray, 1979e). Due to the vascularity of the route of injection and the site of deposition of solution for the maxillary nerve block, it is essential to aspirate to avoid intravascular injection.
(b) Anaesthesia not profound

Lack of profound anaesthesia may be due to:
(i) inadequate height of injection/needle too short;
(ii) high vascularity of area injected;
(iii) collateral innervation;
(iv) too little anaesthetic injected.

If the solution is not deposited high enough in the pterygopalatine fossa, only the branches below the main trunk of the maxillary nerve will be anaesthetized. This will most likely result in posterior superior alveolar and greater palatine nerve anaesthesia only. Lateral deflection of the needle by the pterygoid plate on exit from the pterygopalatine canal may cause solution to be deposited well below and lateral to the main nerve trunk.

The high vascularity of the site of deposition and the possibility of intravascular injection has been discussed in Section (a) and may possibly cause lack of profound anaesthesia.

Cross innervation from overlapping branches of the nasopalatine and infraorbital nerves has been suggested as a cause for lack of anaesthesia in the anterior maxilla, especially in the region of the
central incisor (Dickson & Coates, 1945; Corbett & Helmore, 1948; Mercuri, 1979). Infiltration in the region of the incisive canal and on the buccal aspect of the ipsilateral central incisor will anaesthetize these overlapping branches (Corbett & Helmore, 1948; Mercuri, 1979). Dickson and Coates (1945) advise palatal and labial infiltration over the contralateral central incisor.

An interesting observation was made by Kemp (1940d) in patients who had received bilateral maxillary nerve blocks via the buccal approach. He noted lack of anaesthesia in the upper central incisor and frenulum labii superioris regions i.e. the premaxilla region. It is believed that this region is supplied by small filaments from the medial internal nasal branches of the anterior ethmoidal nerve (ophthalmic division of trigeminus) and the nervus terminalis. Local infiltration of the unanaesthetised area will provide profound anaesthesia provided there is no acute inflammation.

Malamed & Trieger (1983) believe the onset of palatal anaesthesia to be almost immediate, however, they experienced occasional difficulty in achieving profound anaesthesia of the labial surface of the incisor teeth and their pulpal innervation. An infraorbital nerve block or a supraperiosteal infiltration is used in such cases to provide the
necessary anaesthesia.

Rankow (1943) believes it is necessary to block the decussating fibres from the opposite anterior superior alveolar or infraorbital nerves when procedures are to be performed on the anterior teeth and their investing tissues.

It is worthwhile noting that a successful maxillary block has been defined by Malamed and Trieger (1983) as adequate anaesthesia, not requiring supplemental injection.

Clinical studies of the success of anaesthesia were conducted by various authors with the results summarized in Table No. 6.2.

Successful anaesthesia was obtained in over 80% of cases using either buccal or palatal approaches. The most common cause of partial anaesthesia in these studies was failure to penetrate high enough into the pterygopalatine fossa. Assessment of landmarks and re-evaluation of maxillary height as advocated by Jorgensen (1948) should be performed before resorting to supplemental injection.

Patency of the pterygopalatine canal is a significant factor in determining the success of the palatal approach. Malamed and Trieger (1983) noted
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<tr>
<td>Dickson &amp; Coates (1945)</td>
<td>80</td>
<td>Palatal</td>
<td>80.0%</td>
<td>17.5%</td>
<td>–</td>
<td>2.5%</td>
</tr>
<tr>
<td>Corbett &amp; Helmore (1948)</td>
<td>95</td>
<td>Palatal</td>
<td>78.0%</td>
<td>13.7%</td>
<td>2.0%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Malamed &amp; Trieger (1983)</td>
<td>150</td>
<td>Palatal</td>
<td>90.0%</td>
<td>10.0%</td>
<td>–</td>
<td>2.45% of 204 skulls**</td>
</tr>
</tbody>
</table>

*not applicable

**Although not related to their clinical study, the percentage of blockage in Malamed & Trieger's series of 204 skulls has been included for comparison.

Success of anaesthesia: Intraoral approaches.
blockage on 2.45% of 204 skulls examined. The clinical studies of Dickson and Coates (1945) and Corbett and Helmore (1948) revealed blockage of the pterygopalatine canal in 2.5% and 6.3% respectively. Incomplete penetration of the needle occurred in 2% of Corbett and Helmore's cases (1948). Unsuccessful anaesthesia is thus the result of incomplete penetration of the needle or inability to penetrate the pterygopalatine canal more than a few millimetres from the greater palatine foramen. Should this occur, maxillary nerve block via a buccal or an extraoral approach may prove more successful.

(7) PAIN DURING AND AFTER INJECTION

(a) Due to Chemical irritation.

Local anaesthetic solutions containing catecholamine-vasoconstrictors have a much lower pH than plain solutions. Such solutions are thus more likely to cause pain on injection. Before the introduction of disposable needles, contamination of the needle by chemical antiseptic was a source of painful injections (Roberts & Sowray, 1979e) and post-injection paraesthesia (Killey & Kay, 1977). It was sensible to squirt a little local anaesthetic solution through the needle prior to giving an injection to check the patency of the needle and the
correct assembly of the syringe system as well as to clear any intraluminal antiseptic after re-usable needles were used.

(b) Due to trauma.

The use of blunt or damaged needles increases pain during injections as more force is needed for needle penetration. There is also more post-injection discomfort. Withdrawal of a needle tip bent by contact with bone may cause extensive soft tissue laceration and post-injection discomfort (Killey & Kay, 1977). The use of disposable needles has reduced the incidence of this problem.

Periosteal grazing, as may occur when advancing the needle along the posterior surface of the maxilla, may cause pain similar to the elicitation of posterior superior alveolar nerve paraesthesiae. Post-injection pain may also occur in this manner.

The seeking of paraesthesiae and unintentional contact with the maxillary nerve trunk will cause a "toothache-like" sensation. As nerve block via the palatal approach may be painful (Roberts & Sowray, 1979d; Malamed, 1980), local infiltration in the region of the greater palatine foramen will help reduce this, especially during attempts to locate the opening of the foramen. The raising of a skin
weal has been advocated by many authors to help alleviate some of the discomfort experienced when extraoral maxillary block techniques are used (Labat, 1928; Seldin, 1942c; Stebbins & Burch, 1961; Topazian & Simon, 1962; Moore, 1969; Sweet & Powell, 1983).

An anaesthetised upper lip may easily be bitten by the patient or traumatized by hot food and drink. Patients should be warned about the possibility of self-inflicted trauma.

Excessive force of injection may cause discomfort and tissue trauma, hence slow injection is essential in every case. Attention to details of armamentarium and technique will help to minimize pain experienced during and after injection.

(8) INJECTION OF EXCESSIVE VOLUMES OF SOLUTION

The injection of an excessive volume of solution into the pterygopalatine fossa is likely to be followed by exophthalmos, eyelid oedema, ophthalmic nerve anaesthesia and abducens nerve paralysis (Labat, 1928). This is the result of direct spread into the orbit and has similar effects to intra-orbital deposition of solution.

The amount of solution injected may vary between one
and ten millilitres. In my experience and in the light of recent literature, two to four millilitres of local anaesthetic solution with vasoconstrictor is adequate for routine procedures. Slow injection of this volume of solution should avoid the sequelae mentioned above.

(9) BROKEN NEEDLES

Needle breakage is fortunately a rare occurrence. The causes of such a complication (Killey & Kay, 1977) are:

(i) Sudden movement by an anxious, restless patient. This may involve jerking the head, seizing or striking the operator's hand, sudden mouth closure or lateral force applied to the needle by the tongue or cheek.

(ii) Structural defects in the needle. Modern, single-use dental needles are unlikely to have this problem, however, it was common when needles were re-used or bent then re-straightened, causing weakening. Despite the use of disposable needles, Killey & Kay (1977) report that most of the broken needles they have had to recover have been new.

(iii) Faulty technique. The use of excessive force or the sudden encountering of an obstacle in
the path of the needle may cause needle fracture. As needles usually fracture near the hub it is wise to leave a few millimetres of the shaft protruding from the soft tissues to enable retrieval.

Needle fracture may occur when injecting the maxillary nerve via either the intraoral or extraoral approach. The palatal approach has been criticized because of the possibility of obstruction in the pterygopalatine canal and subsequent risk of needle fracture when attempting to negotiate it (Seldin, 1942b). However, needle loss is a greater danger when using the buccal approach as the course lies within soft tissue (Dickson & Coates, 1945; Corbett & Helmore, 1948; Szerlip, 1948). Recovery of a needle from the soft tissue of the infratemporal fossa is technically a far more difficult and dangerous procedure than recovery from a bony canal. Even so, recovery from the pterygopalatine canal is not without its difficulties.

Needle breakage should be avoidable by taking some simple precautions:

2. Never bury the needle up to the hub (Mercuri, 1979).
3. Use long needles for block injections (Killey & Kay, 1977).
4. Never re-straighten needles bent to allow ease of
access.

5. Any bends should be single, not multiple bends at the same point (Mercuri, 1979).

6. The grip on the syringe should not be altered during the injection (Killey & Kay, 1977).

7. The instrument should be held firmly and not allowed to sway when embedded in the soft tissues (Killey & Kay, 1977).

8. Apply controlled pressure when inserting the needle. If an obstruction is encountered, withdraw slightly and reinsert with a different angulation and rotation of the tip (Killey & Kay, 1977).

9. The soft tissues at the puncture point should be steadied (Killey & Kay, 1977).

10. The patient should be correctly positioned in the chair (Killey & Kay, 1977).

11. The injection site should be well illuminated (Killey & Kay, 1977).

12. The operator should guard against sudden patient movement.

Should needle breakage occur, early recovery from the tissues is essential because: (Roberts & Sowray, 1979e)

(i) the fragment is mobile in soft tissue and may travel to a position where it may be dangerous to the patient;

(ii) the fragment may induce scarring which may lead
to trismus and pain;

(iii) perforation of blood vessels may occur and result in sudden haemorrhage and haematoma formation;

(iv) the patient may suffer considerable psychological distress at the thought of a needle "stuck" in their mouth;

(v) the risk of litigation is increased.

(10) RISK OF INFECTION

The effects of introducing infection into the infratemporal space and pterygopalatine fossa by the use of an unsterile needle or contaminated local anaesthetic solution are potentially fatal (Cook, 1950; Roberts & Sowray, 1979e). The resultant toxaemia causes the patient to feel unwell, become febrile, and marked facial swelling results. Cellulitis may result from spread of infection in the tissue spaces (Roberts & Sowray, 1979e).

Infections of the infratemporal space are always serious due to the proximity of the pterygoid venous plexus which has two important connecting veins. The deep facial vein connects the pterygoid venous plexus to the anterior facial vein and a small vein connects this with the cavernous sinus through the foramen ovale or the foramen of Vesalius, medial to the foramen ovale. This may lead to cavernous sinus thrombosis. Infection can also spread direct through other foramina in the
infratemporal fossa into the middle cranial fossa (Killey, Seward & Kay, 1971). Infection in the pterygopalatine fossa may pass via foramina into the middle cranial fossa, via the inferior orbital fissure into the orbit or pass through the pterygomaxillary fissure into the infratemporal fossa. All these complications are potentially life threatening.

Cavernous sinus thrombosis is a serious sequel to infratemporal and pterygopalatine infection. The signs and symptoms of the condition include: high swinging temperature, rapid pulse, sweats, eyelid oedema, pulsating exophthalmos, ophthalmoplegia, oedematous conjunctiva and papilloedema with multiple retinal haemorrhages. If left untreated, there may be bilateral involvement. The prognosis is poor. High dosages of antibiotics and anti-coagulant therapy are necessary and neurosurgical advice is essential. The elimination of the source of infection and drainage of pus complement antibiotic and anti-coagulant therapy (Killey, Seward & Kay, 1971).

Strict observation of asepsis is essential for any approach to the maxillary nerve, to avoid the catastrophic effects of infection.

(B1) SPECIFIC COMPLICATIONS OF THE PALATAL APPROACH

Specific complications of the palatal approach
relate to the passage of the needle along the pterygopalatine canal and the need for infiltration analgesia prior to location of the greater palatine foramen. Some of these complications have been discussed in previous sections of this chapter.

1. Obstruction of the pterygopalatine canal

The passage of the needle along the pterygopalatine canal may be impeded due to:

(a) curves and constrictions (Corbett & Helmore, 1948);
(b) a tortuous course (Dickson & Coates, 1945; Szerlip, 1948; Mercuri, 1979);
(c) inability to enter the canal due to the presence of multiple fine foramina instead of a single greater palatine foramen (Dickson & Coates, 1945; Corbett & Helmore, 1948; Szerlip, 1948);
(d) the presence of small spines protruding from the canal wall (Gillam, 1937).

If the needle is unable to negotiate the foramen or the canal, failure or incomplete maxillary nerve anaesthesia will result. This has been discussed in the section on anaesthetic difficulties.

The incidence of obstruction varies between authors. In skull studies, Jorgensen and Hayden (1972) noted bony obstructions in 15% of 200 skulls; Malamed & Trieger
(1983) noted obstruction to the passage of a 25 gauge needle in 2.45% of 204 skulls. This large difference in obstruction of the pterygopalatine canal between the two studies may be related to the gauge of the probe or needle used or the small diameter of the pterygopalatine canals in the skulls of the Los Angeles collection (Jorgensen & Hayden, 1972) compared with the skulls from the New York collection (Malamed & Trieger, 1983). As the studies were not conducted on skulls of similar racial type, racial variation cannot be excluded. In a clinical study of 95 maxillary nerve blocks, Corbett & Helmore (1948) were unable to penetrate the foramen in 6.3% and found canal obstruction in 2%, a total of 8.3%.

Mercuri (1979) reported difficulties in negotiating a tortuous canal in 5% or less of patients. He also believes that unless the needle has been bent at the hub to approximately 30° from the horizontal, it is likely to engage on the posterior wall of the canal and will not be able to be advanced — a case of "pseudo" obstruction.

2. Lateral inclination of the pterygopalatine canal

In some skulls, there is lateral inclination of the pterygopalatine canal (Cook, 1950). Unless this is recognized and the path of the needle manipulated accordingly, the needle will lodge on the lateral pterygoid plate, deflecting the needle tip away from the pterygopalatine fossa. (Figs. 6.8, 6.9) As this is a
Fig. 6.8 Needle passing lateral to lateral pterygoid plate due to lateral angulation of the pterygopalatine canal (Skull No. 11).

Fig. 6.9 PA skull radiograph of Skull No. 11 illustrating lateral angulation of the pterygopalatine canal.
common occurrence, Cook (1950) recommended the use of a precise guide to mediolateral needle direction, namely the direction of needle insertion should be toward a line projected directly posterior to the medial side of the iris with the patient looking directly ahead.

3. Posterior inclination of the pterygopalatine canal

The posterior inclination of the pterygopalatine canal varies considerably. In Malamed & Trieger's study (1983) the range was 20° to 70° to the horizontal plane of the hard palate with an average of 45.88°. In over seventy-five percent of skulls the angle was between 37° and 57.5°. This is considerably different to Cook's average (1950) of between 20° and 30° (no reference plane given) and Rankow's angulation (1943) of 60° to the occlusal plane.

These differences in angulation of the canal are difficult to explain as no standard plane of reference is used. The skull collection used by Malamed & Trieger (1983) was of mixed racial origin, however, no racial origin is given for the 200 skulls measured by Cook (1950). Rankow's material (1943), although not stated, appears to be clinically derived. Davies (1986) believes that racial differences are unlikely to account for these variations in angulation of the pterygopalatine canal.

In canals with a higher angulation, the needle may
impinge on the anterior surface of the pterygoid process thus impeding progress into the pterygopalatine fossa. The fine tip of the needle may also be deflected laterally to enter the infratemporal fossa. These types of obstruction to the needle destination occurred in 40% to 53% of 279 skulls examined by Canter et al (1964). The result is, of course, inadequate anaesthesia. A more detailed discussion of the posterior inclination of the pterygopalatine canal is covered in the chapter on radiographic skull measurements.

4. Needle deviation due to operator error

If the needle is not advanced correctly, slight posterior or lateral deviation may cause the needle to slip through the pterygomaxillary fissure into the infratemporal space (Jorgensen & Hayden, 1972; Silverman, 1923). The needle should be advanced in the sagittal plane (Jorgensen & Hayden, 1972) or slightly lateral at about 5° to 8° (Corbett & Helmore, 1948). Needle deviation will result in inadequate anaesthesia.

5. Damage to structures in the pterygopalatine canal

The structures within the pterygopalatine canal are the greater palatine nerve and the descending palatine artery and vein. There is always the risk of damage to these structures but any damage is reversible (Corbett & Helmore, 1948; Szerlip, 1948; Roberts & Sowray, 1979d).
Neural injury has been discussed in the section on neural complications.

Damage to blood vessels can be minimized by the use of a small diameter needle (Gillam, 1937). Roberts & Sowray (1979d) believe that even though the risk of damage is reversible, the palatal route is not to be recommended.

6. Needle breakage within the canal

This complication has been considered in the section on needle breakage and does not require further discussion.

7. Nausea and tendency to gagging

Infiltration anaesthesia in the region of the greater palatine foramen prior to locating the foramen may cause extension of anaesthesia to the soft palate. If excessive amounts of solution are used the combined oedema and anaesthesia may cause the sensation of nausea, which may be mistaken for toxic symptoms due to the drug. The sensation is that of a mass lodged in the nasopharynx which can neither be swallowed nor expelled. Faintness may ensue in nervous individuals (Labat, 1928). Rankow (1943) recommends the cautioning of all patients about the tendency to nausea or "gagging". These effects are most commonly due to excess infiltration and can be
minimized by restricting the amount of solution infiltrated to less than 0.5 ml. This will be sufficient to prevent sensation when probing for the greater palatine foramen.

(B2) SPECIFIC COMPLICATIONS OF THE BUCCAL APPROACH

(a) Trismus

A needle passed lateral or distal to the pterygo-maxillary fissure, as may be done in the buccal approach to the pterygopalatine fossa, may involve the lateral pterygoid muscle. Injection of local anaesthetic solution into the body of the lateral pterygoid muscle or the puncturing of a blood vessel within the muscle may lead to the development of trismus. Although the complication is only mentioned by Kemp (1940c) in relation to the buccal approach, it would seem likely that the lateral pterygoid muscle may also be involved in the extraoral approaches where the lateral pterygoid plate is used as a deep landmark although such an occurrence is not mentioned by any of the authors describing this approach.

(b) Protuberance of the maxillary tuberosity

A protuberance of bone was felt with the tip of the needle at a depth of approximately 10 mm on the
posterior surface of the maxilla in three cases out of Kemp's three hundred and fifty injections (1940b,d). He believed that this protuberance of bone was found around the posterior superior alveolar foramina in a small percentage of cases. This obstruction to injection is not mentioned by any other author. Should obstruction occur, the needle may be manoeuvred around the protuberance or withdrawn and reinserted using a more buccally placed puncture point.

(C) SPECIFIC COMPLICATIONS OF THE EXTRAORAL APPROACH

Facial Muscle Paralysis

Facial muscle paralysis rarely occurs during extraoral maxillary nerve block (Moore, 1969; Sweet & Powell, 1983) and has never been reported when intraoral techniques are used. Occasionally, paralysis is the result of excessive solution used to raise the skin weal and results in difficulties in closing the eyelid, sagging of facial muscles and sometimes an expressionless face, depending on the extent of anaesthesia. (Fig. 6.10)

The effects are usually transient and dissipate as the local anaesthetic wears off however a case of prolonged recovery has been reported by Stoy & Gregg (1951) in which a vascular reflex is thought to have
Fig. 6.10 Facial muscle paralysis following incorrectly administered right inferior alveolar nerve block.
caused ischaemia in the region of the stylomastoid foramen following inferior alveolar nerve block. In this case however, direct trauma to the nerve or chemical irritation could not be excluded. Some authors (Moore, 1969; Poore & Carney, 1973) use anaesthetic solution without vasoconstrictor to raise the skin weal to minimize any prolonged local facial nerve branch involvement. If the injected agent is alcohol, for therapeutic nerve block, the effects may be long lasting.

Should facial nerve palsy develop, it is essential to:

1. protect the cornea using
   (a) sterile paraffin drops (Roberts & Sowray, 1979e)
   (b) an eyeshield or eyepad and bandage (Moore, 1969; Roberts & Sowray, 1979e);

2. warn patient about rubbing the eye or going outside where wind may blow debris into it if unprotected (Roberts & Sowray, 1979e);

3. reassure the patient as to the transient nature of the problem;

4. seek an ophthamological consultation if alcohol has been injected (Moore, 1969).
ORIGINAL RESEARCH
CHAPTER SEVEN

RADIOGRAPHIC SKULL MEASUREMENTS IN RELATION TO MAXILLARY NERVE BLOCK VIA THE PTERYGOPALATINE CANAL

CRANIOMETRY AND RACE IDENTIFICATION

(A) Craniometry

Craniometry is a division of anthropometry and is the term used for measurements made on the skull of a deceased person (Sicher & Du Bruil, 1975b).

Craniometry may be used for (Montague, 1960):
1. the description and analysis of fossil remains
2. the comparative study of primates
3. growth studies of the skull
4. growth studies of dental structures
5. identification of persons
6. studies of skull genetics.

To describe proportions independent of absolute size, indices are used. An index is the ratio of a smaller to a larger linear measurement expressed as a percentage (Sicher & Du Bruil, 1975).

Indices used in Craniometry

A wide range of indices have been devised for use in
craniometry. Useful indices for a general classification are:

(a) Cranial index: the relation of cranial breadth to cranial length. There are three main sub-groups: long or dolichocephalic, short or brachycephalic and a middle type, mesocephalic. A similar index measured on the living, the cephalic index, relates maximum head length and maximum head breadth.

(b) Facial index: characterises the proportions of the face—facial height and zygomatic breadth. The face is then classified as high and narrow or leptoprosopic, low and wide or europrosopic and a middle type, mesoprosopic.

Other indices may be used to describe palatal form, the palatine index; arching of the palate, the palatine height index and the height of the cranial vault in profile and anterior view.

Measurements can be made directly from the skull or from cephalometric radiographs. Where identification is needed, the most useful information can be derived from postero-anterior and lateral cephalometric radiographs (Sassouni, 1963).
(B) Race Identification

Race is difficult to determine from the human skeleton due to lack of both definite racial criteria and precise definitions of what a race is and how it is recognised.

Skulls have been classified into three basic racial groups: Negro, Caucasian and Mongoloid (including American Indians). A brief summary of the traits distinguishing these groups is given by El-Najjar and McWilliams (1978). Skull inspection is essential to note any traits.

It was once believed that the form of the skull remained constant in each race and that different races showed different cranial indices. All one had to do was to measure different cranial skulls, calculate the indices and draw the more or less "obvious conclusions". There are several objections to this naive belief (Montagu, 1960):

(a) the head is now known to be subject to change through environmental influences.
(b) there are great differences in intra-group variability in all measurements and indices among the human ethnic groups
(c) closely related groups and individuals exhibit considerable differences in cranial measurements and
indices, while distantly related groups and individuals exhibit striking likenesses.

(d) the cephalic index will change as the trend towards brachycephalization in man continues.

In cases where an individual is a blend of two or more racial stocks, the problem can be extremely difficult (Gill, 1976 quoted by El-Najjar & McWilliams, 1978), because pure race is now the exception and mixed races the rule, the determination of race is more an art than a science (Sassouni, 1963).

Giles & Elliot (1962) established methods for race and sex determination using a functional discriminant analysis of craniometric measurement. In a further study, Birkby (1966) found that the analysis did not take into account extremes of human variability and that crania may also exhibit a considerable degree of inter-racial overlap.

Howells (1970) also used a statistical analysis but it also had a problem (quoted by El-Najjar & McWilliams, 1978). Thus, it appears that the most we are able to derive from craniometry and other analyses is an accurate description of a skull or group of skulls. (Montagu, 1960). Further evidence as to the race of the skull may be obtained by inspection (El-Najjar & McWilliams, 1978).
ANGULATION OF THE PTERYGOPALATINE CANAL

The angulation of the pterygopalatine canal in the sagittal and coronal planes determines the direction in which the needle must be inserted in order to deposit local anaesthetic solution in the pterygopalatine fossa.

Canal direction also determines the destination of the needle (Canter et al, 1964). Lateral deviation increases the tendency for solution to be deposited outside the pterygopalatine fossa due to the deflection of the needle by the lateral pterygoid plate.

The general direction of the canal is superior and posterior, however, opinion varies regarding angulation and the amount of lateral or medial deviation. Table No. 7.1 summarizes the experience of various clinicians.

In view of the variation of opinion on the angulation of the pterygopalatine canal, it was decided to perform a radiographic study of 22 human skulls. A 40mm, 25 gauge dental cartridge needle was passed along the pterygopalatine canal so that the needle tip was level with foramen rotundum. Cephalometric radiographs were taken in three planes:

- Sagittal : Lateral cephalometric
- Coronal : Postero-anterior skull
- Horizontal : Submento-vertex
<table>
<thead>
<tr>
<th>Author</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogliotti (1939)</td>
<td>directly upward in the sagittal plane</td>
</tr>
<tr>
<td>Lundy (1942)</td>
<td>upward and backward</td>
</tr>
<tr>
<td>Rankow (1943)</td>
<td>direct backward at 60° to occlusal plane</td>
</tr>
<tr>
<td>Dickson &amp; Coates (1945)</td>
<td>upward, backward and slightly laterally at 5°–10° to sagittal plane</td>
</tr>
<tr>
<td>Corbett &amp; Helmore (1948)</td>
<td>upward, backward and slightly laterally at 5°–8° to sagittal plane</td>
</tr>
<tr>
<td>Szerlip (1948)</td>
<td>60° to occlusal plane; parallel to sagittal plane</td>
</tr>
<tr>
<td>Cook (1950)</td>
<td>direct toward a line projected directly posterior to the medial side of the iris; posterior angulation 20°–30° lateral inclination</td>
</tr>
<tr>
<td>Jorgensen &amp; Hayden (1972)</td>
<td>keep needle in sagittal plane</td>
</tr>
<tr>
<td>Mercuri (1979)</td>
<td>30° bend placed in needle compensates for superior and posterior courses</td>
</tr>
<tr>
<td>Roberts &amp; Sowray (1979d)</td>
<td>45° to occlusal plane</td>
</tr>
<tr>
<td>Malamed &amp; Trieger (1983)</td>
<td>45° to long axis of hard palate no lateral or medial deviation</td>
</tr>
</tbody>
</table>

Angulation of pterygopalatine canal.
Angulation of the needle was related to the maxillary occlusal plane, palatal plane, Frankfort Horizontal plane and the mid-sagittal plane.

MATERIALS AND METHODS

Twenty-two human skulls of unknown racial origin were used in this study. Each skull was mounted in the cephalostat of a Siemens Selenix Alfa machine. Ear lugs of the cephalostat were placed in the auditory canals and the nasal bridge approximator placed over the nasal bridge (Figs. 7.1, 7.2) or the internal aspect of the foramen magnum (Fig. 7.3).

Separate lateral cephalometric radiographs were exposed with 25 gauge, 40mm dental needles positioned in the left and right pterygopalatine canals. (Fig. 7.3) Needles were held in place using bite wax. Each skull was re-positioned in the cephalostat to obtain postero-anterior (PA) skull (Fig. 7.2) and submento-vertex projections. (Fig. 7.3) For the PA skull projection, the Frankfort Horizontal plane, the line from the infra-orbital margin to the uppermost point on the external auditory canal, was positioned at right angles to the film. For the submento-vertex projection, the Frankfort Horizontal was positioned parallel to the film. 25 gauge, 40mm dental needles were inserted in the left and right pterygopalatine canals and held in place with bite wax.
Fig. 7.1 Skull positioned in cephalostat for lateral skull projection.

Fig. 7.2 Skull positioned in cephalostat for PA skull projection.
Fig. 7.3 Skull positioned in cephalostat for submento-vertex projection.

Fig. 7.4 Latex rubber glove over exit of central beam.
The film used was Kodak X-Omat RP film, XRP 5. Two types of screened cassettes were used:

(i) a standard screen: Phillips Cawo Universal (Par Speed) type;
(ii) a high speed, rare earth screen: Siemens Special Super High Speed type.

Exposure times for the standard and high speed screens were 0.25 secs and 0.21 secs respectively. To simulate soft tissue overlying the skull and to obtain better bony contrast, a latex rubber glove filled with water to a diameter of approximately four inches (10 cm) was placed over the exit of the beam from the machine. (Fig. 7.4)

Kilovoltage and milliamperage for lateral, PA skull and submento-vertex views were 55/320, 60/320 and 55/320 respectively. Exposure trials determined the optimal combination of kilovoltage, milliamperage and exposure time for standard and rare earth screens.

Exposed films were automatically processed using a Kodak X-Omat M-20 processing unit.

Tracings of the four films taken per skull were made on a standard radiographic viewing box. The tracings showed skull outline, standard cephalometric points and the position of the needle in the left and right pterygopalatine canals. Reference planes were
constructed as follows:

1. Lateral cephalometric projection
   (a) Maxillary occlusal plane. Classically, the maxillary occlusal plane is represented by a line that passes through the occlusion of the mesial cusps of the most anterior permanent molars and halfway between the tips of the upper and lower central incisors (Houston, 1982). However, from a practical point of view, as a reference plane for maxillary nerve block anaesthesia via the pterygopalatine canal, the functional occlusal plane is preferable. This is a line following the occlusion of the molar and pre-molar teeth (Houston, 1982). With teeth not in occlusion, the line joining the cuspal tips of the pre-molar and molar teeth should approximate the functional occlusal plane and was the line used in this study.

   (b) Palatal (Maxillary) plane. This is constructed by a line joining the cephalometric points ANS (anterior nasal spine) and PNS (posterior nasal spine). ANS is the point of the bony nasal spine. It is sometimes difficult to locate in the lateral projection as the tip of the spine may be thin and overlaid by nasal cartilage which is of similar
radiopacity (Houston, 1982). ANS corresponds with the anthropological landmark, acanthion (Rakosi, 1984). The tip of PNS can usually be seen unless obscured by unerupted molars. The outline of the palate gives a good indication of its vertical level and allows the palatal plane to be drawn in. The antero-posterior location of PNS can be located by constructing a line through the most inferior point on the pterygomaxillary fissure, perpendicular to the palatal plane (Houston, 1982). If ANS curves upwards above the level of the nasal floor, the palatal plane is drawn through PNS parallel to the nasal floor.

(c) Frankfort Horizontal. This is a line constructed from Porion (Po) to Orbitale (Or). Porion is the highest point on the bony external acoustic meatus. It is a difficult point to locate reliably and is usually estimated (Houston, 1982; Henderson, 1981). Orbitale is the most anterior point on the margin of the orbit and like Porion, is difficult to locate with accuracy (Houston, 1982). The Frankfort plane is described as being horizontal when the head is in a free postural position. There is considerable individual variation in this plane. As there is also considerable variation in its end
points and the fact that it represents no single coherent anatomical structure, there are serious reservations about its use as a reference plane. This study supported these findings. It would appear that the Frankfort Horizontal plane is of little clinical use as a reference plane for maxillary nerve block anaesthesia.

2. Submento-vertex projection. The mid-sagittal plane (horizontal) was constructed as follows: midpoint of the posterior margin of the horizontal plate of the palatal bone at the suture to the extension of the suture line between the maxillary central incisors.

3. Postero-anterior skull projection. The mid-sagittal plane (vertical) was constructed as follows: a line from crista galli to the mid-point of the maxilla between the central incisors.

RESULTS

The angulations of the needle in the left and right pterygopalatine canals were recorded in relation to the four reference planes: maxillary occlusal plane, palatal plane, Frankfort Horizontal and the mid-sagittal plane on PA skull and submento-vertex projections, there being five recordings per canal. These results are tabulated.
in Table Nos. 1 - 5 (Appendix). For each group of measurements in the left and right pterygopalatine canals, the following statistical calculations were made - mean, standard deviation of the sample (S.D.) and standard error of the mean. Each skull was classified, where possible, according to Cranial and Facial Indices [Table Nos. 6, 7 (Appendix)]. The angulation of the needle was also grouped according to Cranial and Facial Indices [Table Nos. 8, 9 (Appendix)]. Profiles of angulations of the needle to the four planes grouped according to frequency may be found in Figs. 7.5, 7.6, 7.7, 7.8, 7.9. Graphical representation of mean angulation of needle grouped according to Cranial Index may be found in Figs. 7.10, 7.11, 7.12, 7.13, 7.14.

Of twenty-two skulls examined, two skulls (Nos. 15 and 22) had blockages of the pterygopalatine canal (right side and left side respectively) which precluded advancement of a 25 gauge needle. Thus twenty-one observations per side were made on twenty-two skulls.

It was possible to calculate the Cranial Index for all skulls as an intact mandible is not necessary for this index. However, the Facial Index could only be calculated for thirteen skulls as nine mandibles were unavailable.

All data is derived from Table Nos. 1-9 (Appendix) and Figs. 7.5-7.14.
(a) Angulation of Needle to the Plane of Occlusion (Fig. 7.5)

The angle of the needle to the occlusal plane shows mean values of $60.60^\circ$ (left), $60.64^\circ$ (right) with a S.D. of 4.72 and 7.53 respectively. Most angles are in the range $51^\circ-70^\circ$. No significant difference could be found between skulls with a medium or long cranial index. As there was only one skull with a short cranial index, no conclusion could be drawn.

(b) Angulation of Needle to Palatal Plane (Fig. 7.6)

The angulation of the needle to the palatal plane shows mean values of $68.38^\circ$ (left), $68.40^\circ$ (right) with a S.D. of 6.41 and 8.79 respectively. Most angles are in the range $59^\circ-79^\circ$.

(c) Angulation of Needle to the Frankfort Horizontal Plane (Fig. 7.7)

A wide range of angles was noted: $53^\circ-91^\circ$, with means of $69.43^\circ$ (left), $70.86^\circ$ (right) with a S.D. of 5.19 and 7.34 respectively. Most angles fall in the range $61^\circ-76^\circ$.

The Frankfort Horizontal can be a difficult plane to locate reliably on cephalometric radiographs (vide supra). It is even more difficult to locate when using an intra-oral nerve block technique and is not recommended as a reference plane for the maxillary block.
(d) Angulation of the Needle to the Mid-Sagittal Plane on PA Skull Projection (Fig. 7.8)

The angulation of the needle to the mid-sagittal plane on the PA skull projection shows mean values of 6.83° (left), 6.64° (right) with a S.D. of 4.82 and 5.69 respectively. Most angles are in the range 10°-15°. Negative needle angulations indicate that the needle tip is angled medially rather than laterally.

(e) Angulation of Needle to the Mid-Sagittal Plane on Submento-Vertex Projection (Fig. 7.9)

The angulation of the needle to the mid-sagittal plane on the submento-vertex projection shows mean values of 11.71° (left), 14.02° (right) with a S.D. of 12.84 and 16.74 respectively. Most angulations fell in the range 10°-20°. Negative needle angulations indicated that the needle tip was angled medially rather than laterally.

A wide variation of angle was noted. This may reflect the natural variation that exists or may possibly be related to movement of the needle in the canal. Because of foreshortening of the canal on the submento-vertex projection, there were also difficulties in measurement over a short distance. Position of the bevel of the needle may also be critical. If the bevel is positioned laterally, there appears to be less tendency for the needle to slip laterally and be deflected into the infratemporal fossa by the lateral pterygoid plate.
Angulation of needle to plane of occlusion

Fig. 7.5 Profile of angulations grouped according to frequency.
Angulation of needle to the palatal plane

**Fig. 7.6** Profile of angulations grouped according to frequency.
Angulation of needle to the Frankfort Horizontal Plane

Fig. 7.7 Profile of angulations grouped according to frequency.
Angulation of needle to the mid-sagittal plane on the postero-anterior skull projection

![Graph showing angulation of needle](image)

**Fig. 7.8** Profile of angulations grouped according to frequency.
Angulation of needle to the mid-sagittal plane on the submento-vertex projection

Fig. 7.9 Profile of angulations grouped according to frequency
(f) Mean Angulation of Needle to the Various Planes Grouped According to Cranial Index (Figs. 7.10 - 7.14)

The majority of skulls examined showed either a medium \((n = 8)\) or long \((n = 12)\) cranial index. There was only one skull with a short cranial index.

In general mean angulation to the various planes for skulls with medium cranial indices was less on the left than the right. The reverse situation applied to skulls with long cranial indices except in relation to the Frankfort Horizontal plane. As there was only one skull with a short cranial index, it was not possible to establish any trend.

CLINICAL IMPLICATIONS

The most useful planes of reference are the maxillary occlusal plane and the mid-sagittal plane in a postero-anterior projection. To clarify the data clinically, Figs. 7.15, 7.16, 7.17 display the mean, standard deviation and range of needle angulations in relation to the maxillary occlusal plane and mid-sagittal plane on diagrammatic skull projections. In edentulous cases or patients with a mutilated dentition where a plane of occlusion is difficult to establish, the clinical plane of the hard palate from the second premolar posteriorly is a useful alternative plane of reference. This plane, when viewed cephalometrically is parallel to the palatal plane \((\text{ANS-PNS})\).
Mean angulation of needle to plane of occlusion (cranial index)

Fig. 7.10 Mean angulation of needle lying in the pterygopalatine canal grouped according to cranial index
Mean angulation of needle to palatal plane
(cranial index)

Fig. 7.11 Mean angulation of needle lying in
the pterygopalatine canal grouped
according to cranial index
Mean angulation of needle to Frankfort Horizontal plane (cranial index)

Fig. 7.12 Mean angulation of needle lying in the pterygopalatine canal grouped according to cranial index
Mean angulation of needle to the mid-sagittal plane on the postero-anterior skull projection (cranial index)

Fig. 7.13 Mean angulation of needle lying in the pterygopalatine canal grouped according to cranial index
Mean angulation of needle to the mid-sagittal plane on submento-vertex projection (cranial index)

![Graph showing mean angle (degrees) for different cranial index categories.]

**Fig. 7.14** Mean angulation of needle lying in the pterygopalatine canal grouped according to cranial index
Fig. 7.15 Mean, standard deviation and range of needle angulations in the left pterygopalatine canal to the maxillary occlusal plane superimposed on a diagrammatic lateral skull projection.
Fig. 7.16 Mean, standard deviation and range of needle angulations in the right pterygopalatine canal to the maxillary occlusal plane superimposed on a diagrammatic lateral skull projection.
Fig. 7.17 Mean, standard deviation and range of needle angulation in the left and right pterygopalatine canals to the mid-sagittal plane superimposed on a diagrammatic PA skull projection.
Needles should be gently advanced upward, backward and slightly laterally. Too much lateral inclination of the needle or medial inclination of the bevel of the needle may aid lateral deflection with deposition of solution outside the pterygopalatine fossa and consequent inadequate anaesthesia.

PERCENTAGE DIFFERENCE BETWEEN LEFT AND RIGHT PTERYGOPALATINE CANALS FOR EACH INDIVIDUAL SKULL

Table Nos. 7.2 and 7.3 summarize the percentage difference from the average needle angulation in the left and right pterygopalatine canals for each individual skull to the useful clinical planes, occlusal plane and mid-sagittal plane. In the great majority of the twenty skulls examined (excluding those with canal obstruction), there was no significant difference between left and right sides of angulation of the needle to the occlusal plane (Table No. 7.2), however, there was a larger variation between left and right sides of angulation of the needle to the mid-sagittal plane (Table Nos. 7.3). Possible explanations for this larger variation may include:

(a) latitude for lateral movement within the pterygopalatine canal which is dependent on puncture point location and lateral angulation of the needle
(b) deflection of needle by the lateral pterygoid plate if too great a lateral inclination of needle is used
(c) asymmetry between left and right sides found
TABLE NO. 7.2

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Percentage difference from average needle angulation in left and right pterygopalatine canals for each individual skull to the occlusal plane on lateral skull projection.
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Percentage difference from average needle angulation in left and right pterygopalatine canals for each individual skull to the mid-sagittal plane on PA skull projection.
normally in all individuals

d) the smaller angulation involved from the plane of
reference. Any marked difference between left and
right sides especially where needles were angled
laterally in relation to the mid-sagittal plane on
one side and medially on the other would result in a
larger absolute difference and thus a larger
difference between sides.

DEPTH OF NEEDLE INSERTION VIA THE PTERYGOPALATINE CANAL

The work of Jorgensen (1948) established the
maxillary height (infraorbital margin to gingival margin
of the maxillary premolar region) to be a useful guide
for depth of needle insertion when performing maxillary
nerve block via the pterygopalatine canal. Mercuri
(1979) and Malamed and Trieger (1983) utilize this
measurement in their techniques for maxillary nerve
block.

Fourteen skulls were examined. The vertical
distance from the infraorbital margin directly above the
infraorbital foramen to the crestal bone between the
maxillary premolars (the maxillary height) was measured
on the left and right sides of each skull. This length
was then transferred to a 50mm, 25 gauge hypodermic
needle using an endodontic rubber marker. The needle was
inserted along the pterygopalatine canal and advanced to
the pterygopalatine fossa until the tip was adjacent to
the inferior margin of foramen rotundum. The position of
the rubber marker was then adjusted to be flush with the
palatal entrance of the pterygopalatine canal. (Fig.
7.18). This length was measured using a caliper. Table
Nos. 7.4 and 7.5 tabulate this data and also the
difference between the two measurements. In all cases
the maxillary height was greater than the distance from
the foramen rotundum to the palatal entrance of the
pterygopalatine canal. The difference ranged from 1-8mm
on the left side and 1-6 millimetres on the right side.

The distribution of the frequency of the difference
between the maxillary height and the distance from the
palatal opening of the pterygopalatine canal to the
foramen rotundum is shown in Fig. 7.19 for the left side
and Fig. 7.20 for the right side.

Assuming that the depth of soft tissue overlying the
greater palatine foramen and the gingival tissue
overlying the crestal bone between the maxillary
premolars is approximately the same, then measurements
from the skull can be extrapolated to the clinical
situation. These results support the findings of
Jorgensen (1948) and enable the maxillary height to be
used as a useful guide to depth of insertion. By
measuring this height on the patient and subtracting ten
percent (representing the mean difference between
maxillary height and the actual depth of insertion), the
risk of overpenetration should be avoidable. These
Fig. 7.18 Diagrammatic representation of anatomical structures and measurements used in the study of depth of needle insertion via the pterygopalatine canal.
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<th>Difference %</th>
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* = Canal blockage

The relationship between maxillary height and length of pterygopalatine canal.
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Frequency distribution of tooth adjacent to needle at the level of the palatal gingival margin/alveolar bone crest when inserted into the pterygopalatine canal.
Fig. 7.19 Frequency distribution of difference between maxillary height and distance from palatal opening of the pterygopalatine canal to the foramen rotundum - left side.

Fig. 7.20 Frequency distribution of difference between maxillary height and distance from palatal opening of the pterygopalatine canal to the foramen rotundum - right side.
results correlate well with the findings of Malamed and Trieger (1983).

In addition to the above findings, the position of the long axis of the needle in relationship to the palatal aspect of the maxillary molar teeth at the level of the crestal bone was noted. Table No. 7.5 summarizes these results. As expected, the needle most commonly was adjacent to the maxillary second molar tooth and less commonly in the region of the first molar or between the first and second molars. On one side of one skull, the needle was adjacent to the third molar. One side of one skull was edentulous and no conclusion was possible.
CHAPTER EIGHT

THE USE OF RADIOPAQUE MEDIA IN THE STUDY OF
THE SPREAD OF LOCAL ANAESTHETIC SOLUTIONS

Radiopaque media have been mixed with local
anaesthetic solutions to study the spread of local
anaesthetic solution deposited for anaesthesia of the
posterior superior alveolar nerve (Goldberg & Sadove,
1961) and inferior alveolar nerve (Berns & Sadove, 1962;
Galbreath and Eklund, 1970; Petersen, 1971; Gustainis and
Peterson, 1981). There are no documented reports of
injection of radiopaque dye to study the spread of local
anaesthetic solution following maxillary nerve block
anaesthesia.

The purpose of this limited study was therefore to
demonstrate radiographically the spread of radiopaque
local anaesthetic solution deposited in the pterygo-
palatine fossa via the pterygopalatine canal.

MATERIALS AND METHOD

The author volunteered for the injection of
radiopaque media/local anaesthetic solution administered
by a colleague using the technique described by Corbett
and Helmore (1948).
The Injected Mixture

Lignocaine 2% with 1:100,000 adrenaline (1 ml) was mixed with 3 ml of Urografin 76 under sterile conditions immediately prior to injection. Urografin 76 contains meglumine diatrizoate 66% and sodium diatrizoate 10%, equivalent to 37% iodine. Meglumine diatrizoate is an odourless white powder containing 47.1% of iodine and is freely soluble in water. Sodium diatrizoate is an odourless white powder containing 4% to 7% of water. It contains approximately 59.9% of iodine and is soluble one in two of water. Allergy to iodine is a contraindication to the injection of Urografin (Reynolds, 1982).

Injection Technique

The injection mixture was loaded into a sterile 5 ml disposable Luer-Lok syringe with a 38mm, 25 gauge needle attached to the hub. Following antiseptic preparation of the palatal mucosal surface in the region of the greater palatine foramen, 0.5ml of solution was deposited submucosally over the foramen. After one minute, the entrance to the pterygopalatine canal was found and the needle advanced upward, backward and slightly laterally at 5°-8° to the sagittal plane. At a depth of 35mm, 3 ml of the injection mixture were deposited following negative aspiration. Radiographic surveys (PA skull, lateral skull and submento-vertex projections) were
performed immediately post-injection (Figs. 8.1, 8.2, 8.3) and tracings of the important bony landmarks made from these radiographs (Figs. 8.4, 8.5, 8.6).

RESULTS

Examination of films and tracings reveal the following:

(a) There has been lateral flow of the solution through the pterygomaxillary fissure with pooling in the tuberosity region of the maxilla, anterior to the mandibular ramus.

(b) The needle is slightly short of the desired vertical level, foramen rotundum (shaded black) (Fig. 8.4).

(c) The needle runs parallel to the lateral nasal wall, approximately 30° off the vertical when viewed postero-anteriorly (Fig. 8.4).

(d) In a true lateral view, the needle lies at an angle of approximately 55° to the palatine process of the maxilla and 59° to the Frankfort Horizontal (Fig. 8.5).

(e) The needle lies at an angle of approximately 10° to the mid-sagittal plane as seen in a submento-vertex projection (Fig. 8.6).
Fig. 8.1 PA skull projection.

Fig. 8.2 Lateral skull projection.
Fig. 8.3 Submento-vertex projection.

Fig. 8.4 Tracing from PA skull projection showing spread of radiopaque solution (pink).
Fig. 8.5 Tracing from lateral skull projection showing spread of radiopaque solution.

Fig. 8.6 Tracing from submento-vertex projection showing spread of radiopaque solution.
Post injection, there was a marked facial swelling in the tuberosity region anterior to the mandibular ramus.

Over a period of five hours, this swelling decreased in size and moved anteriorly, dissipating into the soft tissues. Incomplete maxillary nerve block anaesthesia was obtained by this injection. The areas supplied by the infraorbital, long sphenopalatine and anterior superior alveolar nerves remained unaffected. Anaesthesia covered the distribution of the posterior superior alveolar and greater palatine nerves. As a result of this injection the following observations may be made:

1. Radiopaque local anaesthetic solution does not diffuse upward as is the case in anaesthesia of the inferior dental nerve in the pterygomandibular space (Berns & Sadove, 1962; Petersen, 1971). The reason why it does not may be that in the case of the inferior dental nerve block, the presence of the medial pterygoid muscle, sphenomandibular ligament and interpterygoid fascia helps prevent lateral and downward spread whereas no such boundary exists to prevent exit of solution through the pterygomaxillary fissure.

2. In this case, the solution diffused laterally
and passed out through the pterygomaxillary fissure, into the infratemporal fossa and continued to diffuse anteriorly.

3. Ideally, the depth of penetration of the needle should be such that its tip approximates the level of the foramen rotundum if profound anaesthesia of the maxillary nerve is to be attained. In this example, deposition of solution at a lower level may have contributed to incomplete maxillary nerve anaesthesia, but it is likely that dilution of the 2% lignocaine with Urografin to a concentration of only 0.5% was the prime factor.
CONCLUSION
CONCLUSION

In the foregoing dissertation I have reviewed extraoral and intraoral techniques for maxillary nerve block. It is readily apparent that the techniques are not a new development. Gaston Labat was one of the pioneers of regional anaesthesia. He wrote detailed textbooks in the 1920's (First Edition, 1923) which included a variety of extraoral and intraoral approaches to the maxillary nerve. Modifications have been made to the techniques since then by various authors, however, the basic principles remain the same.

The use of an extraoral or an intraoral approach depends basically on operator preference. Clinicians with a dental background will most likely favour the intraoral approach whereas clinicians with a medical background will favour the extraoral approach. Compared with the commonly performed intraoral inferior alveolar nerve block, landmarks for the puncture point and depth of injection for maxillary nerve blocks using both approaches are not as definite. This may well explain the reluctance of clinicians to include the maxillary block as part of their practice. It is essential before performing any maxillary nerve block to be well versed in the applied anatomy of maxillary nerve block. The target area is very small when compared with the inferior alveolar nerve block. The lack of a deep bony landmark for deposition of solution also makes depth control an
essential part of the technique. The complications associated with overpenetration of the needle are more serious than those of the inferior alveolar nerve block.

From a dental point of view, I believe the intraoral approach via the pterygopalatine canal provides the most direct approach. The work of Malamed and Trieger (1983) has provided valuable information on the location of landmarks for the puncture point and is recommended reading before attempting the palatal approach to the maxillary nerve. The usefulness of the palatal approach prompted my interest in the technique and provided the impetus for the original component of this treatise. The radiographic skull study illustrated the wide variation between individuals. Therefore, it is not possible to provide a routine approach to the palatal route. Landmarks for the puncture point must be assessed in the individual case. Once the foramen has been located, the needle should be advanced slowly upward, backward and slightly laterally to the individually assessed depth, following the work of Jorgensen (1948). Overpenetration and its sequelae may be avoided by subtracting ten percent from the maxillary height which represents the mean difference between this measurement and the actual depth of insertion. It is essential to "feel your way" along the canal because of the wide variation in canal angulation to the horizontal and mid-sagittal planes. The most reliable plane of orientation is the maxillary occlusal plane. In the edentulous maxilla, the palatal
plane posterior to the premolar region should be used.

The radiographic dye study provided useful information about the spread of solution and first hand experience of the effects of maxillary nerve block via the pterygopalatine canal. Unlike the inferior alveolar nerve block, solution deposited in the pterygopalatine fossa diffuses inferiorly. In the pterygomandibular space, inferior diffusion is limited by the interpterygoid fascia and the medial pterygoid muscle. Solution will then diffuse superiorly within the confines of the pterygomandibular space. The clinician cannot rely on superior diffusion in the pterygopalatine fossa so it is essential for solution to be deposited at or above the level of the maxillary nerve trunk to attain complete anaesthesia. Undoubtedly, inferior diffusion was enhanced by the increased weight of solution containing radiopaque material, however, it was surprising the distance the solution spread anteriorly, coming to rest in the soft tissues anterior to the zygomatic crest in the infraorbital/canine fossa region.

Despite the preference for the palatal approach, I believe the oral and maxillofacial surgeon should develop expertise in the variety of intraoral and extraoral approaches to the maxillary nerve to provide alternate routes of injection for different clinical situations.
Measurements of angulation of needle to occlusal plane on lateral skull projection

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No. of observations 21 21 22 13

Range 51 - 67.5 47.5 - 76

Mean 60.60 60.64

S.D. (Sample) 4.72 7.53

S.E.M. 1.03 1.64

Table 1 (Appendix): Tabulation of measurements and associated cranial (C.I.) and facial (F.I.) indices of skulls.
Measurements of angulation of needle to palatal plane on lateral skull projection

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No. of observations 21 21 22 13

Range 55.5 - 80 52.5 - 88

Mean 68.38 68.40

S.D. (Sample) 6.41 8.79

S.E.M. 1.40 1.92

Table 2 (Appendix) : Tabulation of measurements and associated cranial (C.I.) and facial (F.I.) indices of skulls.
Measurements of angulation of needle to Frankfort Horizontal on lateral skull projection

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No. of observations 21 21 22 13

Range 59 - 81 53 - 90

Mean 69.43 70.86

S.D. (Sample) 5.19 7.34

S.E.M. 1.13 1.60

Table 3 (Appendix): Tabulation of measurements and associated cranial (C.I.) and facial (F.I.) indices of skulls.

281
Measurements of angulation of needle to mid-sagittal plane on postero-anterior projection

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Table 4 (Appendix): Tabulation of measurements and associated cranial (C.I.) and facial (F.I.) indices of skulls.
Measurements of angulation of needle to mid-sagittal plane on submento-vertex projection

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<td>- 2</td>
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<td>L</td>
<td>I</td>
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<td>-</td>
<td>5.5</td>
<td>L</td>
<td>N</td>
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</tbody>
</table>

No. of observations | 21 | 21 | 22 | 13

Range | -17 - 50 | -2 - 76
Mean | 11.71 | 14.02
S.D. (Sample) | 12.84 | 16.74
S.E.M. | 2.80 | 3.65

Table 5 (Appendix): Tabulation of measurements and associated cranial (C.I.) and facial (F.I.) indices of skulls.
## Classification of Skulls according to Cranial Index

<table>
<thead>
<tr>
<th>SKULL NO.</th>
<th>BREADTH (B) (cm)</th>
<th>LENGTH (L) (cm)</th>
<th>CRANIAL INDEX B/L x 100</th>
<th>CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>13.5</td>
<td>18.0</td>
<td>75.0</td>
<td>M</td>
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<td>3</td>
<td>13.1</td>
<td>17.8</td>
<td>73.6</td>
<td>D</td>
</tr>
<tr>
<td>4</td>
<td>12.8</td>
<td>16.4</td>
<td>78.0</td>
<td>M</td>
</tr>
<tr>
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<td>13.5</td>
<td>18.7</td>
<td>72.1</td>
<td>D</td>
</tr>
<tr>
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<td>17.3</td>
<td>78.0</td>
<td>M</td>
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<tr>
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<td>17.2</td>
<td>77.9</td>
<td>M</td>
</tr>
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<td>17.3</td>
<td>78.0</td>
<td>M</td>
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<td>18.2</td>
<td>70.3</td>
<td>D</td>
</tr>
<tr>
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<tr>
<td>12</td>
<td>11.2</td>
<td>16.2</td>
<td>69.1</td>
<td>D</td>
</tr>
<tr>
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<td>13.7</td>
<td>16.2</td>
<td>84.5</td>
<td>B</td>
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<td>17.1</td>
<td>73.1</td>
<td>D</td>
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<td>15</td>
<td>11.8</td>
<td>17.0</td>
<td>69.4</td>
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<tr>
<td>18</td>
<td>13.1</td>
<td>18.6</td>
<td>70.4</td>
<td>D</td>
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<td>19.2</td>
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</table>

Table 6 (Appendix) : Tabulation of data used to calculate Cranial Index.

- **HD** = Hyperdolichocephalic
- **D** = Dolichocephalic
- **M** = Mesocephalic
- **B** = Brachycephalic
Classification of Skulls according to Facial Index

<table>
<thead>
<tr>
<th>SKULL NO.</th>
<th>FACIAL HEIGHT (H) (cm)</th>
<th>ZYGOMATIC BREADTH (B) (cm)</th>
<th>FACIAL INDEX B x 100 L</th>
<th>CLASSIFICATION</th>
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<tbody>
<tr>
<td>3</td>
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<td>81.5</td>
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<td>12.0</td>
<td>100.0</td>
<td>HL</td>
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<td>7</td>
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<td>11.6</td>
<td>94.8</td>
<td>LP</td>
</tr>
<tr>
<td>10</td>
<td>10.0</td>
<td>13.1</td>
<td>76.3</td>
<td>HE</td>
</tr>
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<tr>
<td>13</td>
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<td>11.4</td>
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<td>MP</td>
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<td>17</td>
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<td>12.1</td>
<td>85.9</td>
<td>MP</td>
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<td>12.7</td>
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<td>LP</td>
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</table>

Table 7 (Appendix) : Tabulation of data used to calculate Facial Index.

HE = Hypereuryprosopic
EP = Euryprosopic
MP = Mesoprosopic
LP = Septoprosopic
HL = Hyperleptoprosopic
Angulation of Needle grouped according to Cranial Index

**SHORT  \( N = 1^* \)**

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<td>S.D.</td>
<td>S.E.M.</td>
<td>Mean°</td>
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<tr>
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<td>-</td>
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<td>66.00</td>
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<td>PP</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>74.00</td>
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<td>-</td>
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* No S.D. or S.E.M. Calculable

**MEDIUM  \( N = 8 \)**

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<td>S.E.M.</td>
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<td>68.00</td>
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**LONG  \( N = 13 \)**

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**OP** = Occlusal plane  \( \text{MSP (SMV)} = \text{mid-sagittal plane on submento-vertex projection} \)

**PP** = Palatal plane  \( \text{MSP (PA)} = \text{mid-sagittal plane on postero-anterior skull projection} \)

**FH** = Frankfort Horizontal  

Table 8 (Appendix) : Tabulation of angulation of needle in degrees (°) lying in the pterygopalatine canal to specified planes of reference classified according to Cranial Index.

286
## Angulation of Needle grouped according to Facial Index

### NARROW  \( N = 4 \)

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### INTERMEDIATE  \( N = 5 \)

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### WIDE  \( N = 4 \)

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</tr>
<tr>
<td>MSP (PA)</td>
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<td>3.57</td>
</tr>
</tbody>
</table>

OP = Occlusal plane  
MSP (SMV) = mid-sagittal plane on submento-vertex projection  
PP = Palatal plane  
FH = Frankfort Horizontal  
MSP (PA) = mid-sagittal plane on postero-anterior skull projection

Table 9 (Appendix): Tabulation of angulation of needle in degrees (°) lying in the pterygopalatine canal to specified planes of reference classified according to Facial Index.


pp. 91-102.

(a) pp. 1-48, (b) pp. 149-179.

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(a) pp.316-319, (b) pp.602-603, (c) pp.793-796,
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Dental Nerves in Relation to Growth Changes in the
Upper Jaw.
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