

5-1-1939

Trigeminal neuralgia

Oscar Carp
University of Nebraska Medical Center

This manuscript is historical in nature and may not reflect current medical research and practice. Search [PubMed](#) for current research.

Follow this and additional works at: <https://digitalcommons.unmc.edu/mdtheses>



Part of the [Medical Education Commons](#)

Recommended Citation

Carp, Oscar, "Trigeminal neuralgia" (1939). *MD Theses*. 732.
<https://digitalcommons.unmc.edu/mdtheses/732>

This Thesis is brought to you for free and open access by the Special Collections at DigitalCommons@UNMC. It has been accepted for inclusion in MD Theses by an authorized administrator of DigitalCommons@UNMC. For more information, please contact digitalcommons@unmc.edu.

TRIGEMINAL NEURALGIA

BY

OSCAR CARP

SENIOR THESIS PRESENTED TO

THE COLLEGE OF MEDECINE,

UNIVERSITY OF NEBRASKA,

OMAHA, 1939

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I. Preface	2
II. Definition and History	3
III. Anatomy	9
IV. Etiology and Pathology	19
V. Symptoms and Diagnosis	26
VI. Treatment	
A. Medical	34
B. Injection	41
C. Surgical	58
VII. Summary	76
VIII. Supplement	77
IX. References Cited	79

PREFACE

It was the author's intention earlier in the course of his reading and planning to cover only the treatment of Trigeminal Neuralgia. However, the other phases of the disease because of their general interest prompted the author to change his plans. This paper will be a discussion of Trigeminal Neuralgia in general with emphasis on the evolution of the treatment of the disease. Because of the fact that the present day literature on this disease entity has become so voluminous and repetitious, the author of this paper considered it impractical to attempt to review the literature in its entirety. As is so often the case in most scientific advances, the major additions to our understanding and treatment of this malady have been developed by a few enterprising pioneers in Neuro-Surgery. Again, as is so often true in medical science, the most exciting and spectacular developments have occurred in the field of therapy, especially surgery. By far the greatest share of the work done on Trigeminal Neuralgia, has been planned and executed by neuro-surgeons in the United States and England. It is the author's plan in so far as is possible, to trace the steps which have changed this condition from one of hopeless despair to one in which cure is practically one hundred per cent and mortality nil.

DEFINITION AND HISTORY

A Neuralgia has been defined by Anstie(I), as a disease of nervous system manifesting itself by pains which in the great majority of cases, are unilateral, and which appear to follow accurately, the course of the particular nerves, and ramify sometimes into a few, and sometimes into all the terminal branches of these nerves. These pains are usually sudden in their onset, and of a darting, stabbing, boring, burning, character; they are at first unattended with any local change or any general febrile excitement. They are markedly intermittent, at any rate at first, the intermissions are sometimes regular, and sometimes irregular, the attacks commonly go on increasing in severity on each successive occasion. The intermissions are distinguished by complete freedom from suffering, and in recent cases, the patient appears to be quite well at these times, except for some short time after the attack, the parts thru which the painful nerves ramify remain sore and tender to the touch. In old standing cases, however, persistent tenderness and other signs of local mischief are apt to be developed in the tissues around the peripheral twigs. Severe neuralgias are apt to be complicated with secondary affections of other nerves which are intimately connected with those that are the original seat of pain, and in this way, congestions of blood vessels, hypersecretion of glands,

inflammation and ulceration of tissue are brought about.

The neuralgia of the fifth cranial nerve is typical of Anstie's general classification and description. It is the author's intention to present a complete and descriptive picture of Trigeminal Neuralgia further on in this paper. For the present therefore, we shall be more concerned with the history of this condition than with a development of our primary definition.

The ancients made few contributions to the knowledge of neuralgic diseases in general and facial pains in particular. Most medical historians feel that Hippocrates description was too vague to give any proof of his recognition of the disease. Trigeminal Neuralgia was not described by Aëratus, Galen, or Leon, although Aëratus describes a form of headache as occurring in paroxysmal attacks, separated by pain free intervals accompanied by facial spasm and followed by fainting spells. Neither the Arabic school nor the Greek or the Romans presented any evidence that they recognized this condition. (2)

There is considerable controversy regarding the first authentic description of Trigeminal Neuralgia. Some writers believe that Avicenna 1000 A. D. presented an accurate description of this disease. (3) (4). Harris (5) believes that the disease was recognized by the monks of the Wells Cathedral during the middle part of the thirteenth century.

He notes especially the carved capitals on the pillars of the cathedral of Wells in Somerset, three of which at least are illustrations of persons suffering violent facial pain. He also notes that Bishop Button of Wells had the reputation of curing this condition.

Lewy (2) combed the literature and thinks that the first authentic case history of this disease dates from 1671. This case history of Johannes Bausch was presented before the Imperial Leopoldian Academy of Natural Sciences in 1677. From that time the literature became flooded with additional case histories.

After the furor regarding the recognition of the disease had subsided, the next great step in the advancement of knowledge concerning the disease was made in 1756 by André, a Frenchman, who described facial neuralgia as being due to a definite involvement of specific nerves, and it was he who first used the term "Tic Douloureux". About twenty years later, Thouret, another Frenchman, described this neuralgia with considerable minuteness. A few years previous to Thouret's paper, Ludwig and Hoffman also published well marked cases, the former under the title of, "De Dolore Superciliari Acerbissimo"; the latter heading his communication, "De Cephalalgia Rebelli".

These various descriptions published nearly at the same time, by physicians in different parts of Europe,

might at first seem to favor the opinion, that the disease originated about the middle of the eighteenth century. It will be observed, however, that some of these cases were communicated thru the means of medical journals , which then first began to appear, affording a facility of disseminating information which was previously unknown.

The next important steps in recording the advances made in the recognition of this disease were made in England. In 1829 a manuscript of the celebrated John Locke was presented to the College of Physicians by the late Lord King in which is detailed the case of the Countess of Northumberland, ambassadress at Paris in 1677 to whose embassy Locke appears to have been attached as Physician. In this curious document, not only are the symptom of facial neuralgia accurately given, but the true seat of the disease is distinctly referred to. (6)

Most modern authors disregard the previously mentioned students of Major Trigeminal Neuralgia, and assign the merit of originality in describing this species of neuralgia to John Fothergill whose account of,"A Painful Affection Of The Face,"was published in 1776. This excellent communication was no doubt the means of introducing the disease to the knowledge of the practitioners of England and of some parts of the continent, for it was described by many writers of that period as "Dolor Faciei Fothergillii".(6)

In his monograph John Fothergill wrote of Major Trigeminal Neuralgia:

" This affection seems to be peculiar to person's advancing in years and to women more than to men. I never met with it in anyone much under forty, but after this period no age is exempt from it.

"From imperceptible beginnings, a pain attacks some part or the other of the face, or the side of the head, sometimes the ossa molarium, sometimes the temporal bones are parts complained of. The pain comes suddenly and is excruciating, it lasts but a short time, perhaps a quarter or a half a minute and goes off, it returns at irregular intervals sometimes in a half an hour, sometimes, there are two or three repetitions in a few minutes.

"The kind of pain is described differently by different persons, as may reasonably be expected; but one sees enough to excite one's compassion, if present during the paroxysm.

"Eating will bring it on in some persons. Talking, or the least motion of the muscles of the face, affect others, the gentlest touch of a hand or a handkerchief will sometimes bring on the pain, whilst a strong pressure on the part has no effect. It differs from the toothache in many respects. It affects some, who from age have few or no teeth remaining.

"In cases of singular difficulty or obstinacy, it

is natural for us to be inquisitive into their causes and their nature. Unsuccessful experiments sometimes lead the way to instruction and we ought never to cease investigating the most abstruse recesses of nature, nor at the same time forget the narrow limits of our capacity and the danger of presumption." (7)

Fothergill's description of this maladie did much to interest the European physicians in the treatment and etiology of this neuralgia in particular. Few if any, present day writers have improved on Fothergill's description. The history of the disease after 1776 is bound up with the splendid research done on the anatomy and physiology of the fifth cranial nerve. These studies later lead to improvements in the technic of treating this condition. Since it will be simpler to outline the historical advances in the treatment of of this condition in that section of the paper dealing with treatment, we will postpone further historical discussion till then.

A proper understanding of Major Trigeminal Neuralgia is naturally dependent on a thorough clear familiarity with the anatomy of the Trigeminal nerve. So, with that object in mind the author of this paper includes a short anatomical description of the fifth cranial nerve.

ANATOMY

It would be impossible to fully comprehend any of the factors involved in the symptomatology, etiology, diagnosis, or treatment, without some conception of the anatomical features of the fifth cranial nerve, It is for that reason that this section on the anatomy of the fifth nerve is included. This section will be used, therefore, as a basis upon which we shall draw from time to time in order to explain the premises which prompted the different types of operations used in the progress of the understanding and treatment of the neuralgia of the Trigeminal nerve.

Since the Gasserian ganglion has been the focal point around which the majority of the contemporary surgery has progressed, we shall start from there. (5) The Gasserian ganglion is a small mass of unipolar nerve cells, about the size of a small bean, lying on the middle fossa, in a depression near the tip of the petrous bone, just above and internal to the foramen ovale, and adherent on its inner side to the outer wall of the cavernous sinus. Beneath the ganglion runs the motor root of the fifth nerve and the great superficial petrosal nerve. On account of its shape, this ganglion is sometimes called the semi-lunar ganglion, its convexity being forward, and it is contained within a special sheath of dura mater known as the cave of Meckel and is surrounded by cerebro-spinal fluid, To the concave

back of the ganglion is attached the large sensory root of the fifth nerve which after leaving the pons passes thru a special channel in the dura mater above the ridge of the petrous bone, to enter the cave of Meckel. Tracing the sensory root of the fifth nerve backward from the Gasserian, it enters the side of the pons on its upper surface, rather above the middle where it passes inward to reach the upper sensory nucleus of the fifth nerve, a hemispheroid mass of grey matter known as the convolutio trigemini, situated outside and ventral to the motor nucleus. Before reaching this nucleus, the fibres of the sensory root bifurcate and those fibers which carry tactile and pressure sensations terminate in the nerve cells of this nucleus.

New fibres carrying these sensations upward to the thalamus pass inwards from the nucleus as the raphé bundle, and decussate in the middle line to form the trigemino-thalamic tract, or trigeminal fillet, which keeps separate from the remainder of the fillet fibres and ends in the lateral nucleus of the thalamus.

After the bifurcated fibres of the sensory root have given off the small branch which runs dorsally to end in the main sensory nucleus, the principal branch turns downward at a right angle, the bundle sweeping thru the Pons and the Medulla in a tract or nerve bundle known as the spinal or descending root of the fifth nerve. These nerve

fibers end in nerve cells of the substantia gelatinosa of Rolando, adjacent to this tract which can be traced downwards as far as the second cervical segment of the cord. New fibers from this mass of grey matter, which may be called the nucleus of the spinal root of the fifth nerve carry the pain and temperature sensations upwards by decussating in the middle line and joining the opposite fillet.

The Gasserian ganglion gives off three main branches, each of which has a small ganglion in connection with it. The ophthalmic and maxillary branches are entirely sensory in function, the motor root of the fifth nerve being distributed with the mandibular nerve or third division only.

The first or ophthalmic branch, lies closely attached to the outer wall of the cavernous sinus, and passes forwards to leave the skull by the sphenoidal fissure, where it divides into frontal, nasal and lacrimal branches. It supplies the eyeball with sensation thru the ciliary branches of the nasal nerve, the skin and mucous membrane of the upper eyelid, and the cornea and the rest of the conjunctiva, with the exception of that lining the lower lid. It is said that the corneal supply contains no tactile fibers but only those serving the sensation of pain. It is still debated whether there is any special trophic function in the nerve supply to the cornea.

The cutaneous branches of the first division supply the skin of the eyebrow and forehead as far back as the

vertex, thru the supraorbital and supratrochlear nerves, and the upper side of the nose from the inner canthus down to the tip. Branches from the frontal division of the ophthalmic nerve also supply the mucous membrane lining the frontal sinus, the ethmoidal, and sphenoidal sinuses receiving branches from the nasal branch.

The ciliary ganglion is connected with the nasal nerve, having also a sympathetic root and a motor root from the branch of the third nerve to the inferior oblique muscle.

The second division or maxillary nerve leaves the Gasserian ganglion to pass forwards nearly half an inch to the foramen rotundum, a circular foramen in the sphenoid bone situated about a quarter of an inch below the rim of the sphenoidal fissure. Before entering the foramen, the nerve gives off two fine recurrent meningeal branches, which communicate with similar meningeal branches from the third division and supply the dura mater of the anterior half of the head. The first or ophthalmic division also gives a recurrent meningeal branch which supplies the tentorium.

After emerging from the foramen rotundum into the sphenoid-maxillary fossa behind the orbit, the maxillary nerve gives off the temporo-malar branch which supplies the skin over the malar bones and also the temple and side of the forehead. These are two very common areas for referred pain in neuralgias affecting the second division, but destruction

of the maxillary nerve produces no anaesthesia of the temple beyond the outer canthus of the eye, owing to the overlapping supply by the auriculo-temporal and supraorbital nerves. In the sphenomaxillary fossa the second division also gives two sensory branches to the sphenopalatine or Meckel's ganglion, which lies close to the sphenopalatine foramen.

The main sensory branches of this ganglion are the palatine nerves, the two largest of which are described as direct from the maxillary nerve, merely passing thru Meckel's ganglion to supply the gums and the mucous membrane of the hard and soft palate. They descend from Meckel's ganglion thru the posterior palatine canal, which opens at the posterior and outer angle of the hard palate, opposite the last molar tooth. With the mouth wide open, it is possible to pass a needle up this canal and thus to inject Meckel's ganglion directly with alcohol, though it is not a treatment worth practicing.

The nasal branches of the ganglion enter the nasal fossae by the sphenopalatine foramen and supply with sensation the mucous membrane of the nasal fossae and septum. Meckel's ganglion is also connected by the vidian nerve and great superficial petrosal nerve to the geniculate ganglion of the facial nerve, but the function of this communication is doubtful.

The maxillary nerve next gives off the posterior and middle dental branches to supply the three molar teeth.

and the bicuspid and then enters the infraorbital foramen, the anterior dental branch is given off to supply the canine and incisors.

The infraorbital nerve issues a quarter of an inch below the rim of the orbit, and one inch from the middle line; the three foramina, supraorbital, infraorbital, and mental, being almost in the same vertical line. The cutaneous supply of the nerve is distributed to the cheek and the tip of the nose. The anaesthesia produced by destruction of the infraorbital nerve is bounded externally by a line adjoining the external canthus to the angle of the mouth, and internally at the inner canthus of the eye.

The third and largest of the three divisions of the fifth nerve plunges downward at once from the ganglion into the foramen ovale, an oval opening in the great wing of the sphenoid, which looks downward and slightly outwards and forwards. The small motor root emerging from beneath the ganglion passes thru the foramen ovale with the third division, its fibres forming a partial network with the sensory fibres, known as the plexus of Santorini. As soon as the third division has passed thru the foramen ovale, it gives off a recurrent meningeal branch which re-enters the skull with the meningeal artery thru the foramen spinosum. The foramen ovale is the point of exit thru which the third division of the fifth nerve leaves the skull, and is

an oval opening in the great wing of the sphenoid bone immediately outside and below the edge of the end of the Gasserian ganglion. Close behind it is the foramen spinosum, thru which the middle meningeal artery enters the skull, after passing between the two branches of the third division which join to form the auricle-temporal nerve. From this nerve is given the sensory branch to the otic ganglion, which communicates with the geniculate ganglion on the seventh nerve by means of the small superficial petrosal nerve. Probably, no muscular motor nerve fibers pass thru the otic ganglion. The auriculo-temporal nerve supplies a racquet shaped area of skin on the temple and side of the head above the level of the incisura notch, communicating in front with the supraorbital nerve and the tempora-malar branch of the second division. The auriculo-temporal also supplies the anterior portion of the pinna and the anterior wall of the tympanum in part. In addition to the auriculo-temporal nerve, the third division gives two other main branches, the inferior dental and lingual nerves, and also the buccal branches to the side of the cheek. The inferior dental nerve is the largest of the three main branches and passes forwards and downwards to enter the mandible by the inferior dental foramen, which is guarded on its inner side by the spine of Spix. Supplying the teeth of the lower jaw, the nerve

emerges at the mental foramen opposite the second bicuspid tooth to supply cutaneous sensibility to the chin and lower lip.

The lingual nerve supplies one half of the anterior two thirds of the tongue with ordinary sensation, being joined by the chorda tympani after the latter has left the facial nerve in the middle ear. The lingual nerve is generally believed to carry no taste fibers, which reach it by the chorda tympani, and consequently section of the lingual nerve behind this point, abolishes sensibility on the front of the tongue to tactile and painful impressions, but may leave taste unimpaired. Pressure pain upon the tongue is thought by some to be supplied by nerve fibers running with the chorda tympani or in the hypoglossal nerve, which is the motor nerve to the tongue, just as it is argued that pressure pain sensation on the face is supplied by the sensory branches of the facial nerve and not by the Trigeminal. Harris is somewhat skeptical of this theory that pressure pain is a function of nerve fibers accompanying the motor nerve to the part, such as the Facial or Hypoglossal. (5) Maloney and Kennedy (8) in their work on gasserectomies found that ordinary pressure touch is carried by the fifth nerve and that pressure pain persists in the eye. According to these authors, the facial nerve contains

no pressure sense fibers distal to the fallopian canal. On the other hand, Davis (9) investigating cases following Gasserian operations, concludes that deep pressure pain persists over the face, the fibers running in the facial nerve and in the nerve of Wrisberg.

The motor root after leaving the skull by the foramen ovale supplies the motor fibers to all the muscles of mastication, the temporal, masseter, internal and external pterygoids and the anterior belly of the digastric, It was formerly said also to supply the tensor tympani, but this is probably not true, nor does it supply any motor fibers to the palate. The buccinator muscle receives its motor supply from the seventh nerve. The motor root arises from a group of nerve cells in the pons, situated above and internal to the principal sensory nucleus of the fifth nerve. Occasionally, there is a communication between the motor nucleus and the third nucleus, especially between that portions supplying the depressors of the lower jaw with the nerve to the levator palpebrae. The effect of this is to produce the phenomenon described first by Gunn. known as "jaw winking". In this condition the action of the external pterygoid upon opening the mouth wide causes a retraction of the upper eyelid on the same side.

Joining the motor root on its way thru the pons is a small band of fibers originating from scattered nerve cells

above the motor root on its way thru the pons is a small band of fibres originating from scattered nerve cells above the motor nucleus. This is known as the mesencephalic root, and according to May and Horsely (10) contains both efferent and afferent fibres. It has been stated to be motor in function and to supply the depressors of the mandible. The cells of origin of this mesencephalic root lie much nearer the third nucleus than does the principle motor nucleus of the fifth nerve and "jaw winking" is easier to understand if these fibers supply the depressors of the lower jaw. (5)

As stated in the introductory sentence to this section, the presentation of a description of the anatomy in these few pages was intended to be basic in character. The differences of opinion concerning the anatomical physiology of the fifth cranial and some of its ganglia will be presented in the section on the treatment, as some of these fundamental beliefs form the basis of the various forms of treatment offered to the sufferer from Major Trigeminal Neuralgia.

ETIOLOGY AND PATHOLOGY

The cause of Trigeminal Neuralgia is unknown. The many studies undertaken to determine the cause of this neuralgia have been fruitless. However, these various studies have proven informative, if not enlightening. The vast amount of work done on the neuralgia have at least provided a scientific background for the numerous theories which have arisen concerning this maladie. It will be our purpose, therefore, to acquaint the reader with some of the facts and theories concerning this disease. Since most of the theories about the causes of Trigeminal Neuralgia are supported by some pathological studies, these pathological findings will be correlated with the theories which have been manufactured from these findings. Independent Pathological findings concerning the associated findings in these cases will also be discussed in the section.

The subject matter of this section of this paper will be discussed in the following order:

- I. Incidence
- II. Exciting Causes
- III. Theories
- IV. Associated Pathological Findings

Sufficient studies have been made on large series of cases of Trigeminal Neuralgia to give adequate data concerning the trends of certain predisposing factors

associated with this disease.

Most authors agree as to the age incidence of this disease. The average age of the individual suffering from this disease is fifty. Studies by Grant(II) on one hundred eighty-five cases, by Frazier(I2) on two hundred seventy-five cases, and by Horrax and Poppen(I3) on four hundred sixty-eight cases compare as follows;

Ages---	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Grant	0%	1%	3.5%	19%	35%	29%	6%	2.7%	1%
Frazier	0	3%	8%	25%	26%	25%	14%	-----	
H. & P.	.02%	2%	6%	9%	24%	33%	17%	2%	.02%

Harris(I) in a series of two hundred cases confirms these figures. His youngest case was twelve and his oldest was eighty-seven. Flynn, reporting on one hundred fifty cases had an average age of fifty-four.(I4) Adson in a review of eight hundred thirty-nine cases found that the average age was fifty-three, and that youngest case was seventeen and the oldest was eighty-eight.(I5) These studies definitely establish the disease as one of middle life and beginning senility.

Women are more susceptible to the disease than are men in the ratio of three to two.(I6) This statement must be accepted with some reservation. Grant(II) found in his series of one hundred eighty-five cases that there were

ninety-eight females to eighty-seven males. However, in another group of cases collected by the same writer, the ratio of women to men was three to two. (17) Although the majority of series of cases of this maladie show a predominance in the female, Harris (19) and Adson (15) have both published series in which the disease has been more frequently found in the male than the female.

Trigeminal Neuralgia affects the right side of the face more commonly than it does the left side. Most men agree with Adson (15) (18) and Harris (1) (19) whose figures show a right sided predominance of two to one over the left side of the face. Studies by these same men and others have shown that the neuralgia rarely attacks the ophthalmic branch alone. The divisions of the Trigeminal nerve were usually involved according to frequency as follows:

Divisions--	I	2	3	I&2	2&3	I&2&3
Horrax and Poppen (13)	2.9%	24%	42.1%	4%	21.9%	5%
Adson (15)	1%	16%	20%	11%	35%	15%

Although these figures show variation with respect to the involvement of the first division of the fifth cranial nerve, they emphasize the predominance with which the neuralgia involves the mandibular branch. The figures also show the frequency with which the divisions are involved in combination with each other.

Three exciting causes in particular may awaken a latent potential neuralgia: 1. Emotion, 2. A chill to the face, 3. Trauma. (5) There has been no worthwhile explanations of these exciting causes and their mechanism. Horsely (20) feels that the fact these attacks occur in persons of middle life, and people who have been subject to mental worry and anxiety, that they have a lower threshold to stimuli which unbalance them. He feels that the greater majority of sufferers are neurotics before they ever have an attack. He further assumes that a neuralgia is an exaggeration of an neuritis, and as such that cold should be a frequent cause of Trigeminal Neuralgia, since then the mischief begins in the peripheral branches of the nerve, and that cold is in general a frequent cause of neuritis. Horsely feels that trauma operates under two circumstances: a) Local injury to the nerve trunks as they pass thru bones; in which case he feels hemorrhage occurs in the sheaths of the nerves and leads to intense pain ultimately becoming persistent and so setting up a neuralgia; b) Local injury to the branches of the nerves at their periphral ends.

Because he could find no other plausible explanation for this disease, Fothergill described the condition as one due to a cancerous growth. (I) Thouret imagined that this affection arose from pressure of the nerves, in

consequence of disease of the bony canals thru which they pass, but he had no facts to support this theory.(6) Since that time the theories which have been advanced in explanation of this disease have been numerous and unproven.

That the disease is hereditary has never been accepted by anyone. The fact that the disease may be associated with some form of organic disease has never been proven. Theories that the disease may be due to anemia, malnutrition, (I) or tumors or alcohol have been advanced but never accepted.(2I) In view of the fact that the pathological findings in Trigeminal Neuralgia have been nil to date, authorities have never accepted an arteriosclerotic explanation. Again, since no chronic degenerative changes in the Gasserian ganglion have ever been shown, this theory has never been accepted. There have been attempts to prove that the neuralgia is a septic neuritis, and that it usually follows a severe dental operation or a history of bad teeth for years. Harris(5) believes that it is a septic neuritis of the dental nerve filaments in the jawbone which acts as the neuralgic focus from which the painful stimuli spread. These branches of the fifth nerve are the only nerve filaments in the body which are so constantly exposed to septic infection and these nerves are, almost without exception, the only nerves which suffer from chronic paroxysmal neuralgia. He feels that this theory will explain why it is that the

second and third divisions of the fifth nerve and not its first division, are commonly involved in the neuralgia. In this respect Keegan(22) and Melchior(23) concur with Harris..

Gross(24) states unequivocally his conclusions that diseased teeth may be directly or indirectly responsible for a greater number of Trifacial Neuralgias than all other causes combined. The regions from which these teeth have extracted may retain pathological tissue or the alveolus may have been injured to such an extent as to have caused a jagged condition thereof, over which the mucoperiosteum has healed. These condition then act as local irritants to the already hyper stimulated peripheral nerve endings.

Harris(25) has suggested lately that the neuralgia may be due to the association of the fifth cranial nerve with the sympathetic nerve fibers from the cervical sympathetic system. Along this same line of reasoning Frazier (26) suggested that the disease was similar to Raynaud's Disease in symptoms and so was probably due to the same cause. He also suggested that the Tabetic crisis was also so similar to Trigeminal Neuralgia, especially in its lightning like paroxysmal character, that the diseases could be related except for the fact that an associated lesion of the nervous tract has never been found. The whole Trigeminal tract, the ganglion and its three divisions

are supplied by sympathetic fibers thru the Otic, Meckels, and Ciliary ganglion. Whether by the induction of anemia, thru its vasomotor control the Sympathetic system may play an indirect role in the etiology of these paroxysmal neuralgias is an interesting problem for discussion in the future.

Ellis(27) attempts to make a case for a toxic theory as a cause of Trigeminal Neuralgia. His case reports are too few for any such conclusion at present. Whether the disease is terminal in origin, or central in origin is debateable at present. Harris(5) has accumulated evidence pointing to a peripheral origin, while Alajouanine and Thourel(28) subscribe to a theory embracing a more central origin of the pain. Ball(29) places Trigeminal Neuralgia in the category of functional nervous conditions.

Most workers agree with Hutchinson (30) who reports that there are no pathological changes in the nerves, their structures, in their sheaths, or their vessels, that can be made out in the most inveterate cases of Trigeminal Neuralgia. Horsely(20) has been unable to find any more degeneration in the nerves or the ganglia than did Hutchinson. Spiller(31) has been about the only worker to consistently report pathological changes in the Gasserian ganglion.

SYMPTOMS AND DIAGNOSIS

Trigeminal Neuralgia is probably one of the most spectacular symptom complexes known in medicine. Harris(5) has published the most complete and descriptive account of these attacks.

"Of the three main divisions of the Trigeminal nerve, it is especially the second and third divisions that are liable to the paroxysmal "Tic". These may be affected in about equal frequency either separately, or both the second and third divisions may be involved at the same time, after one division suffering alone for some years before the neuralgia invades the territory of the other. Only rarely is the first division affected, and then always in association with the second division.

"In a large number of cases the first onset of the pain is not gradual, but sudden and violent, the intensity in the first paroxysm being perhaps more severe than in any subsequent attack. So sudden is the onset of the pain and so violent in character, that most patients lose control of themselves. Such violence and suddenness of the painful paroxysm are characteristic of Trigeminal Neuralgia, and are scarcely met with in any other condition. Intensity of pain is difficult to judge and the same degree of pain that may give rise to an extravagant histrionic demonstration in an individual of unbalanced temperament may be borne

with stoicism and with very slight external evidence of suffering by another person. Often, it is only those in immediate contact with the patient who realize that the neuralgia is something out of the ordinary, and many sufferers from this terrible complaint get little sympathy from their friends, as ordinary neuralgia is common enough.

"After the first onset of the attacks of pain, which may last from a few minutes to a few weeks, there may be complete cessation for a year or more. With succeeding attacks the intervals of freedom from pain tend to become shorter, though some patients have more or less periodic bouts of neuralgic seizures for several weeks or months every year. Some may have scarcely any freedom, but from the very commencement have never a day or even a waking hour free from attacks. Such persons have almost continued hypersensitiveness of the face, being afraid to touch or wash it or to brush the hair on that side.

" The pain is referred to various parts in the upper and lower jaws, in many cases shooting along the side of the tongue, along the lip and the side of the nose and the back of the cheek or front of the temple. In second division neuralgias in addition to the pain affecting the cheek, upper lip and nose, the neuralgia is often described as affecting the eyebrow and lower half of the forehead and spreading up to the temple outside the eye. The character

of the pain is usually sharp and shooting, and may be likened to red hot needles or wires, the pain darting along like electricity and ending like the explosion of a bunch of fireworks in the face. In others the pain is like knives sticking in, and many will deny any sensation of heat. Different sufferers behave differently during the spasms. With some the jaw may be fixed wide open, and salivation may be profuse. In others, lachrymation is seen, especially in neuralgia of the first and second divisions. Some press the hand upon the cheek firmly as a mode of arresting the pain, some dare not touch the face, while yet others rub the face hard with the hands, and from constant friction, the eyebrow and moustache may be practically rubbed away and skin becomes thickened and even show callosities. Some whose pain generally starts at the commencement of a meal can control the pain after a while by forcing themselves to continue eating.

"Very characteristic of Trigeminal Neuralgia is the manner by which the attack may be provoked; in some, a light breath of air upon the cheek or the slightest touch on the lip or the lip or nose will start the paroxysm, though immediately on the cessation of the pain, the cheek and nose can probably be rubbed with impunity, for a minute or so, before it again becomes hypersensitive. Such areas have

been termed 'Trigger Zones', but, in most any movement of the face will start the pain, such as eating, laughing, talking, sneezing, or blowing the nose, Certain spots are described as 'points de Valleix', which were supposed to be especially sensitive and when touched upon were said to start the paroxysms of pain. These spots have been described by Valleix as follows: (I)

- a) First branch- I. Supraorbital Notch 2. Palpebral
in the upper eyelid 3. Nasal 4. Ocular
5. Trochlear-at the inner angle of orbit
- b) Second branch- I. Infraorbital Notch 2. Malar eminence
3. Upper gums 4. Superior labial 5. Palatine point
- c) Third branch I. Auricle-temporal in front of the ear
2. Where Inferior dental comes out 3. Bilingual
point on the side of the tongue 4. Inferior
labial point

"Reflex muscular spasms of the face are naturally the rule during the paroxysms of pain, a facial expression of emotion, but quite apart from these facial movements there is to be seen in a certain number of sufferers from the painful "Tic" definite clonic facial spasm limited to the side of the face afflicted with the neuralgia. The clonic contractions of the facial muscles are more marked during the attacks of pain, but are frequently to be seen between neuralgic attacks.

"The majority of patients are comparatively free from spasms at night, no doubt owing to the quiet and absence of movement, the pain reappearing on washing in the morning or at meal times. In others, however, night brings no relief, and the torture may continue day and night for weeks, until the severity of the attacks dies away, and an interval of freedom from the neuralgia returns. In some cases the intervals of freedom are complete, no sign of neuralgia being present for many weeks or months, but some persons never altogether lose the sensitiveness of the face and slight neuralgia, though the severity of the attacks is in complete abeyance and life is tolerable.

"Year after year the disease tends to become more chronic, the intervals between the bouts of pain being shorter, though the intensity and severity of the paroxysms may be less than formerly. Almost invariably, the pain lasts until death puts an end to the suffering and in former years, suicide often terminated the story before modern methods of relief were known. Though the pain in true Trigeminal Neuralgia never spreads across the middle line, yet the nerves of both sides may be affected, the disease becoming bilateral.

Frazier (26) sums up the symptoms of Trigeminal Neuralgia for diagnostic purposes as follows:

I. The disease usually begins after forty

2. The disease always begins in one division, never in two, and always on one side of the face.
3. The attacks never alternate from side to side.
4. The pain is shooting, lancinating, tearing, darting to points in the terminal distribution. (32)
5. There is complete freedom between attacks.
6. The attacks are incited by contact or movement of muscles
7. The attacks become more frequent
8. Patient exhibits extraordinary tolerance to pain.
9. The patients rarely commit suicide.
10. The patients never crave Opium.

Herrax and Peppen (13) make some very good points concerning differential diagnosis of this disease. First dental cavities must be ruled out because of their liability to infections. Sinusitis is ruled out by local tenderness and Xray. Facial injuries usually have a history of trauma. Post herpetic neuralgia clears up in from weeks to months. Neuralgias of the geniculate ganglion involve the sensory portion of the seventh cranial nerve, causing severe otalgia. The pain of Glossopharyngeal neuralgia involves tonsils, pharynx, and the posterior part of tongue. Sympathetic pains are dull aching, burning, or pressure pains varying in intensity. They seldom follow any anatomical distribution of nerves. The orbit, cheek, and temporal region are usually involved. The pains usually last several hours and may persist

intermittently for months. The intensity usually varies with the nervous stress of the patient. Associated symptoms, such as flushing of the face, increased lacrimation and salivation are common. Tumors involving the Gasserian ganglion produce severe and usually persistent pain, while examination reveals the relative hypesthesia and later a sensory and motor paralysis.

Cushing (33) believes there are five types of facial neuralgia capable of being mistaken for Trigeminal neuralgia: 1. Sluder's phenomena- sphenopalatine involvement, 2. These secondary to Zoster, 3. These secondary to the geniculate ganglion, 4. Those accompanying certain cases of convulsive tic, 5. Involvement of the Trigeminal nerve by tumors. Taylor (34) differentiates Trigeminal neuralgia from Sluder's Neuralgia by noting the relief obtained by cocainization of Meckel's ganglion. This disease is probably often caused by sinus infection. Permanent relief is to be expected from removal of the local foci.

Hutchinson (30) believes that it is important to differentiate between true Trigeminal neuralgia and pseudo Trigeminal Neuralgia.

REAL TRIGEMINAL NEURALGIA	PSEUDO TRIGEMINAL NEURALGIA
I. Beyond middle life	I. Invariably young
II. Strictly unilateral- constant in seat	II. Rarely unilateral variable in seat

III. Pain markedly paroxysmal	III. Pain severe for long periods together
IV. Vasomotor and trophic disturbances common	IV. Vasomotor and trophic disturbances absent
V. Neurasthenic symptoms very moderately marked	V. Neurasthenic condition strongly marked

Oljenick has developed a means of injecting two per cent Procaine Hydrochloride into a suspected Trigeminal branch at its foramen of exit at the of the skull, as a diagnostic measure. Proof of the diagnosis of the Trigeminal Neuralgia is produced by the recurrence of the pain as soon the procaine has worn off. (35) Peppen advocates an alcoholic injection of the nerve trunk as an diagnostic measure. (36) Frazier (37) also advocates an alcoholic injection of the offending nerve as a diagnostic measure. The universal acceptance and use of these new diagnostic aids together with a better understanding of what constitutes True Trigeminal Neuralgia will offer the sufferer a quicker relief from his pain.

TREATMENT

Unless the Trigeminal Neuralgia is treated by one of the excellent modern methods of alleviating the condition, complications of a most severe nature may occur. In a series of cases analyzed by Anstie (I) complications in the untreated form of the disease assumed a variety of changes which hindered the effectiveness of any subsequent treatment. The most common of changes to be noted in chronic cases of the disease are:

- I. Continued Lachrymation
- II. Muscular contractions on the affected side
- III. Dilatation of conjunctival vessels
- IV. Paralysis of the retina on the affected side
- V. Changes in hearing, taste, hair, eyes, vasomotor system, skin, tongue.

Surgical treatment has far outstripped medical treatment as far as effectiveness in alleviating this disease. However, medical treatment has progressed some in general effectiveness. Naturally, most patients demand that medical measures be tried before any surgical procedures are attempted. It has been the general concensus of opinion for some time that analgesics and opiates are not only ineffective but impractical in the treatment of this condition. Practically every drug in the pharmacopeia from the extract of hemlock used by Fothergill, the Cinchona

used by Swieten in 1700, to the use of the coal tar products and opiates, have resulted in reported cures, but has had no universal acceptance till Trichlorethylene began to command attention.

Trichlorethylene, a strong, sweet smelling, white liquid was used in Germany during the world war for removing grease from the metal parts of machinery and was also contained in varnish used to cover the supporting surfaces of airplanes. Plessner (38) in 1915 presented before the Berlin Medical society four workers suffering from the chronic effects of an acute poisoning. These men developed immediately after exposure to this drug developed bilateral anaesthesia of the Trigeminal area without motor involvement. None of these men demonstrated any paralysis of the muscles of mastication which indicated a specificity of the drug for the sensory portion of the Trigeminal tract. Oppenheim who present at this meeting suggested that this drug would be invaluable in the treatment of Trigeminal Neuralgia.

Plessner did all the early experimenting with the drug. He determined the dosage only after a series of trial and error experiments. He finally concluded that from three to sixty drops three times in a day by inhalation, could be used without effects and that twenty to thirty drops thrice daily, would be sufficient to produce complete relief.

In the meantime Joachimoglu investigating the pharmacology of Trichlorethylene clearly proved by animal experimentation that the drug was not irritating to the mucous membrane of the respiratory tract, did not hemolyze the blood, and did not cause fatty degeneration of the liver. Altho this drug belonged to the same group to which chloroform belongs, it did not carry any of the harmful properties of the latter.

Plessner reported a high percentage of cures with this drug. It has been shown conclusively that the results which he obtained were probably due to over enthusiasm on his part. Glaser (38) reporting on one hundred sixty-three cases showed that the total proportion with complete relief was fifteen percent rather than twenty five percent as in Plessner's report. Glaser reports that fifty one per cent had their attacks diminished as to both intensity and frequency.

Glaser's prescribed treatment which is the accepted method of using Trichlorethylene is as follows:

"Twenty to twenty five drops t. i. d. inhaled until the odor has disappeared. This should be carried out over a period of four to six weeks."

The drug may produce vertigo, sleep, drowsiness, and therefore it is well to take the inhalation in a recumbent position. After the pain is relieved, the drug, is then

not needed daily. As a prophylactic measure, it is wise to inhale this drug every two or three months for a period of three consecutive days. The best results have been reported in cases of short duration and those involving the mandibular division. A cure by this means has a greater advantage over a surgical cure in that he is free from pain without resulting anaesthesia.

J. L. Poppen reporting of one hundred cases which were treated exclusively with Trichlorethylene found that: a) Forty-five percent obtained partial to complete relief for six months to six years, b) Twenty per cent obtained only slight relief in that the attacks were less frequent of less intensity, c) Thirty-five per cent obtained no relief whatsoever. He thinks that the reason Trichlorethylene failed was because the patient had not been adequately informed as to how to use the drug. He recommends the use of the drug in all cases as there are no contraindications.

Oljenick (35) used the drug on a number of cases and emphasizes certain conclusions. In a comparatively small number of cases of Trigeminal Neuralgia of irritative neuritis the inhalation of Trichlorethylene continued for some time, appears to give excellent and lasting results. In some cases the period of relief after Trichlorethylene may be interrupted by renewed attacks which as a rule are of a less violent character than before. In most cases it is a useful temporizing

measure which by diminishing the number and vehemence of the attacks, permits the patient's general as well as local condition to improve. As the pain is only rarely uninfluenced by Trichlorethylene, it should be tried in every case. Furthermore, since Trichlorethylene has no effect of facial neuralgias other than those of Trigeminal origin, it may occasionally be of value in differential diagnosis.

Frazier (26) claims that Trichlorethylene has absolutely no value as a therapeutic agent and should never be used as such.

Experimentation is being carried on with new and varied forms of medical treatment. Tyler (39) is using a preparation of Ergotamine Tartrate. He bases his treatment on the logic that Ergotamine has been shown experimentally and clinically to be a powerful depressant of the Sympathetic system. This substance will be of no use unless there will be definite proof that the disease is one of sympathetic origin.

Another newer form of medical treatment is that advocated by Inskip. (28) He uses one heaping teaspoonful of Calcium Gluconate in a glass of water, thirty minutes before breakfast each morning. The subsidence of the symptoms was gradual and take from seven to fourteen days to be complete. The main constituent in this form of treatment seems to be the Calcium.

Althaus (40) was the first to use induced current for the treatment of the disease. Horsely (20) has long advocated the use of constant current empirically before any operation is undertaken. Wolf (41) also advocates the use of dathermic treatment for Trigeminal Neuralgia. He places the electrodes at the back of the neck, the base of the skull, and the other over the eye. He uses one thousand milli amperes for thirty minutes to hour. An analysis of his records show some very pertinent facts. Those patients who were sick only for a short time were relieved permanently and quickly. Patients with the genuine "Tic Douloureux" with free intervals reacted well. Old people in whom the disease seems to be due to arteriosclerotic changes in the vasa nervorum seemed to be greatly relieved by the treatment. Trigacial Neuralgias in adults which causes continuous pain with exacerbations, with paresthesias in the mouth and which are evidently due to degenerative changes in the ganglia, seem to be refractory to this treatment.

Ball (29) has sponsored the use of boiled milk for a hyperthermic reaction. His results show either complete relief from or great amelioration of their symptoms.

Barre (42) has developed an ionization method of treating this disease. He ionizes Aconitin Nitrate, and gives from ten to eighty, twenty to forty minute applications every day or second day with a fifteen milli ampere current.

He claims that the nine cases that he treated with this treatment were either cured or improved. Budden (43) has advocated the use of ionized Sodium Salicylate, but has not reported any cases cured by this treatment.

Moramarco (28) indicates that good results may be obtained with ultra-violet, infra-red, and X-ray irradiation. Brunner, Ornstein and Guttman advise the use of cold quartz lamps. The majority of patients treated in this manner were either cured or definitely relieved. Only five per cent of their patients were refractory to this treatment. Haven also reviews the work Eowenstein who reports on ten years experience with the use of Radium radiation in the treatment of this condition. He found that one third of the cases under treatment responded to treatment.

It should be apparent so far in the paper that no medical cure for this condition gives more than an even chance for a cure or relief from the pain of Trigeminal Neuralgia. These forms of treatment should therefore be reserved for those patients who are in such poor condition that any form of treatment would be out of the question. It is our intention to pass now to the other forms of treatment which give sure relief and a better chance of cure, the injection treatment of Trigeminal Neuralgia.

INJECTION TREATMENT

The use of pain deadening and nerve destroying substances in the treatment of Trigeminal Neuralgia has been encouraged and practiced since Fothergill's time. (44) The need for a more drastic and more effective treatment of this condition was probably the objective in the minds of the earlier experimentors with the use of the injection treatment in Trigeminal Neuralgia. The condition had already been attributed to the Trigeminal nerve over a hundred years before Bartholow suggested and carried out the injection of the peripheral branches of the Trigeminal nerve with Chloroform in 1874. His success with this procedure in the treatment of the neuralgia was the stimulus to other men for further experimentation with this mode of treatment.

The use of Osmic acid was advocated by Eulenburg (21) a short time later. The Osmic acid is a tetroxide of Osmium. It is colorless, solid, crystalizable in long, brilliant, prisms, melts at 40 degrees Centigrade. Eulenburg used a one percent solution in distilled water. He found the the injection of the above strength caused no unpleasant symptoms. Eulenburg thought that like the Chloroform, the Osmic acid acted as a narcotic on the nerve. No attempt was made at this time to inject the substance intra-neurally. In 1884 Billroth and Neuber adopted a similar procedure with gratifying results in thirty-six out of thirty-seven

cases. Schapiro in 1885 followed with the use of a one per cent solution of the acid in glycerin and water, recording five successes in eight cases. (44) It was Schapiro who first suggested that most important action of the drug was to cause inflammation of the terminal branches. This suggestion bore fruit in the work of Bennett in 1889. (45) He reported a series of cases in which the nerve trunks were treated with an aqueous solution of a two per cent Osmic acid, after exposing them to direct needle puncture by blunt dissection. There were many supporters of Bennett's procedure, however the use of Osmic acid suffered a bad reputation because of the many cases of bone necroses which accompanied its use.

An new era in the injection treatment of Trigeminal Neuralgia was opened in 1902 by Pitres and Verger when they suggested and carried out an injection of the Trigeminal nerve branches with Alcohol. (46) The work of Pitres and Verger was followed shortly by the work of Schloesser of Munich who advocated alcohol injection of the deep foramina of exit of the main fifth nerve branches from the skull. (47) Although in the earlier years of this treatment, attempts were made to inject the Ophthalmic branch of the Trigeminal nerve, Schloesser early recognized that the problem was one of injecting the second and third branches of the nerve, and he concentrated on this phase of the treatment accordingly.

Schloesser's original method was to reach the foramen ovale and the foramen rotundum from within the mouth, the needle being passed upwards behind the palate thru the pharyngeal roof. Schloesser used eighty per cent alcohol, a substance which in its concentrated form coagulates albumin and therefore destroys locally any nerve trunk into which it is injected. Alcohol when injected into the tissues causes later the development of fibrositis and subsequent injections may be hindered by the toughness of the tissues impeding the facility for manipulation of the needle when searching for the nerve. The effect of the alcohol is to produce neurolysis, a local destruction by coagulation of the nerve fibers themselves at the point of injection followed by degeneration of the nerve elements below this point to the periphery. So long as the nerve fibers above the point of injection and its nerve cell of origin within the ganglion are intact, a new nerve fiber will at once commence to grow downwards from the proximal undamaged end of the nerve in the process of nerve regeneration, and by this means the damaged nerve is renewed and its conducting powers are reestablished after an interval varying from six months to two years.

Kiliani (47) introduced Schloesser's method in the United States in 1906. In the same year Levy and Baudoin introduced their original method of approach to the foramen

retundum and ovale thru the outside of the cheek and according to Patrick who introduced their method the United States, they recommended seventy-five per cent alcohol, containing a little chloroform and a little cocaine. (48) He describes their aim as, attempting to reach the Inferior Maxillary branch of the fifth nerve just after its exit from the foramen ovale, the Superior Maxillary branch, just after its exit from the foramen retundum. The alcohol should be injected into the nerve sheath if possible. He describes the dangers of this procedure as: sepsis, hemorrhage, paralysis of the Facial nerve, and the danger of pushing the fluid into the skull. The real difficulty is the difficulty of accuracy, the difficulty of striking the nerve. Patrick believed that a single injection within the nerve sheath would stop the pain at once. He thought that it was not necessary to make the injection with absolute accuracy into the nerve; that when the alcohol is injected near the the nerve it undoubtedly diffuses sufficiently to reach it. Hecht (44) did much to popularize the Levy-Baudoin method in this country.

The early reports on the alcohol injection treatment of Trigeminal Neuralgia were very encouraging. Schleesser(44) reporting in 1907 gave it as his opinion based on two hundred nine cases seen during the past five years, that the cures were not permanent, but afforded freedom from pain for about

a year. He felt that repeated injections delay these recurrences more and more so that an almost absolute immunity of pain may be ultimately promised these patients.

Harris (49) began to use the injection method for the treatment of Trigeminal Neuralgia in 1909. He began to use a general anaesthetic, chloroform, as a preliminary measure while inserting the needle.

Most workers found that a complete and thorough injection of the second and third divisions of the fifth nerve causes total anaesthesia to touch, prick, temperature, and pressure over most of the area supplied by these nerves and in addition injection of the third division at the foramen ovale causes complete loss of taste instantly on the anterior two thirds of the tongue on that side in the very large majority of cases. Motor paralysis, too, of the muscles of mastication will also result from this destruction of the third division of the fifth nerve so that the lower jaw will deviate towards the paralyzed side on opening the mouth, owing to the weakness of the external pterygoid muscle and no contraction of the temporal and masseter muscles will be apparent on clenching the teeth. In many cases there is temporary wasting of these muscles so that there is a slight hollowing above and below the zygoma, but very rarely is there any permanency of this condition, even after a total destruction of the

ganglion by injection, though after a Gasserian ganglion operation this motor paralysis is nearly always lasting.

For the alcohol injection to be successful the point of the needle must puncture the nerve trunk so that the spirit penetrate amongst the fibers. In as much as strong spirit is a tissue fixative, its affects are strictly local, and consequently alcohol will not diffuse into the nerve trunk if injected outside the sheath, unless very excessive quantities are used. In this way alcohol behave entirely differently from Novocaine and Cocaine solutions, which are commonly used for infiltration anaesthesia. If two per cent Novocaine solution is injected into a nerve trunk, dense anaesthesia of the distribution of this nerve will be found after half a minute, but infiltration will take about twenty minutes to produce complete anaesthesia. Alcohol injected into a nerve produces anaesthesia almost instantaneously. Such injection is, however, excessively painful, the pain resembling a flame or intense burning sensation over the area supplied by the nerve.

As early as 1908 Harris had begun to experiment with injection of the Gasserian ganglion with alcohol for this condition. In 1912 he published the results of seven cases (50) of alcohol injection of the Gasserian ganglia. This advance in the treatment was probably the result of the great future indicated by the surgical extirpation of the ganglia earlier.

Harris used the same method of approach to reach the ganglion that most operators use to inject the third division. When he reached the third division with the needle, and the patient complained of the pain, he confirmed the site by injecting Novocaine into the nerve, and noted the typical anaesthesia of the third division of the Trigeminal nerve. Without moving the needle, he injected ninety per cent alcohol into the branch. A burning pain spreading up over the cheek and nose even up to the eye and forehead indicated that alcohol is infiltrating thru the root of the third division into the Gasserian ganglion. A complaint of a foreign body in the eye which is due to developing anaesthesia of the cornea and the conjunctiva is a sure sign of the injection reaching the inner portion of the ganglion.

Difficulties with the Gasserian ganglion injection became apparent at once. Peculiarly the first division became anaesthetic before the second and third division, which was unfortunate because in a very large majority of neuralgias, it is the second and third divisions that are involved, and if either division is spared it is the first division that is preferred, in order to avoid keratitis and the visual defect. Injections into the cavernous sinus was another complication. The syndrome for this usually consisted of: coarse nystagmus, deafness, vomiting, vertigo, paralysis of face muscles, and loss of sensation on the face.

A short time after Harris's publication in 1912, Haertel of Bier's clinic in Germany advocated an ascending extra-buccal route to the Gasserian ganglia. Haertel preferred a longer route to the foramen ovale by inserting his needle in front of the coronoid process, by which means a steeper line of approach to the foramen ovale is obtained and a greater certainty of passing the needle thru the foramen is assured, once the foramen is reached. The route of the needle in the Haertel technic is : thru the cheek opposite the alveolar process of second upper molar tooth, between anterior ramus of the lower jaw and the tuberosity of the superior maxilla, between the Buccinator and The Masseter, between the coronoid process of the lower maxilla and the Temporal muscle, into the zygomatic fossa, thru the External Pterygoid muscle, along the great wing of the Sphenoid, and into the foramen ovale. (51) Grinker was the first to introduce Haertel's method to this country. Grinker (52) emphasized that the method was dependent upon good finger touch perception, a correct appreciation of bone sensation, a knowledge of the approximate depth to which the needle must attain before reaching the foramen ovale, and the recognition of the direction which the needle is taking. An interesting complication of Haertel's early cases was a neuroparalytic keratitis in four out of ten cases.

Patrick reporting on an early series of cases in 1912

concludes that the alcohol injection treatment is best for the very old, the very feeble, and those with grave organic disease. The fact that the mastery of the injection treatment is difficult to attain, is shown in his series in which he records twenty-five per cent total misses, and forty-five per cent partial successes. He records no complications.(53)

Cushing writing in 1920 (46) concedes that the use of Alcohol injections has stopped the needless peripheral operations going on at these times. However, he is violently against what he terms a blind procedure of injecting alcohol into the Gasserian ganglion. He says, "Anyone who is familiar with the appearance of the ganglion in the living, bathed as it is with cerebrospinal fluid would be terror stricken at the idea of blindly injecting alcohol into its arachnoid capsule." He believes that in neuralgias limited to one of the two lower divisions which do not extend to other Trigeminal areas, alcohol injection is the treatment of choice. He lists the following complications which has seen as the liabilities which detract from the use of the injection treatment: Paralysis of the Oculomotor nerve, lockjaw, paralysis of the motor fifth, sloughs of the nasal bones, facial paralysis, and labyrinthine trouble.

Adson reporting in 1922 on 1570 alcoholic injections feels that this procedure is a temperizing one, and that once started, it is necessary to keep on reinjecting periodically

In his series of neural injections the average period of relief from pain was about eight months. An average of about four injections per patient was made. He feels that permanent cure will never occur with intra-neural injections, but that it is advisable to use this method as a preliminary to surgery. (18)

Many men objected to this form of treatment because of the lack of control of the needle while it was in the skull. Pollock and Potter (51) began to experiment with Xray as an aid to the visualization of the progress of the needle. Their experiment was founded on the fact that the foramen ovale is directly in front of and above and internal to the Eustachian tube. By inserting a Eustachian catheter with the assistance of a nasopharyngoscope and by inserting thru the catheter a bougie made of fused lead, they could visualize the direction and approximate location of the Eustachian tube. Then knowing that the bone separating the sulcus the tube from the foramen was one to three millimeters they could calculate ways and means of inserting the needle, all the while knowing where that needle was by means of a fluoroscope. They used Haertel's method of injection as the one more appropriate for their use.

Grant (54) did considerable work on the standardization of the angles of injection. He attempted to make the matter of injecting the nerves an absolute mathematical certainty.

Harris reporting in 1922 on the results of the injection treatment deprecates any rule of the thumb method, which will determine the angle and the line of insertion of the needle to reach the foramen ovale or the foramen rotundum.(55) He believes that the treatment is wholly dependent upon an accurate working knowledge of the anatomy and zygomatic and sphenomaxillary fossa. His records at this time show that freedom from the neuralgia may be practically guaranteed for twelve months if the nerve has been properly hit and in the majority of his cases, the immunity from pain has been much longer, ranging up to thirteen years in the case of a third division neuralgia. Four and five years is a quite common period for the immunity to last in his experience.

Haertel (56) reported one hundred cases in 1924 which he treated with his technic of alcohol injection. He injected the whole Gasserian ganglion in grave cases and where this was possible, a permanent cure resulted. When the injection was only partial, especially with preservation of the sensibility of the cornea, recurrence was the rule in from six months to four years. Some of these patients were cured by reinjection. None of his patients died.

By 1932 Harris had probably the greatest number of alcoholic injections to his credit than any other living man, and his twenty six years of practice on eleven hundred cases qualified him to speak authoratively on this subject.

He (57) believes that no person suffering from Trigeminal Neuralgia should undergo the open operation until it has been shown that a satisfactory injection of the ganglion cannot be performed. He is convinced that there can be no guarantee against eventual recurrence of neuralgia unless there is produced total and permanent Trigeminal anaesthesia. This can only be brought about by the destruction of the Gasserian ganglion. There is no foundation to the statement that a second injection is useless, because as Harris states there is no possibility of the nerve becoming immune to alcohol.

Contrary to Harris's belief that the Gasserian ganglion must be obliterated for a cure of this condition, Morris (58) believes that evidence has accumulated during the course of the last few years to suggest that what is called injection of alcohol into the Gasserian ganglion does not describe what happens and that the alcohol affects the sensory root of the ganglion more than the ganglionic tissue itself. Morris believes that the greater percentage of failures to inject the Gasserian ganglia in most cases is due to either a small foramen ovale, a superficial pterygo-sphenoid ossification, a narrow external pterygoid plate, or the presence of an accessory ossification.

The uniformity of results obtained by a number of different men who have used Alcohol injections in great

numbers of cases have helped to clarify many points regarding the results of alcohol injection. Horrax and Poppen (59) performed seven hundred sixty-nine injections. The largest group of these have been deep injections at the foramen ovale for third division pain. There have been three hundred eighty-eight such injections for an average relief of over fourteen months, the shortest period of relief being nine months and the longest eight years. Injection of the second division at the foramen rotundum has been performed one hundred ninety times for an average relief of over twelve months.

In twelve cases the Gasserian ganglion was injected purposely either partially or completely. These injections were performed upon patients who either were regarded as unfit for sensory root section or who did not wish to undergo an operation. Relief from a total ganglion injection, of course is permanent, and from a partial one is permanent for the peripheral distribution corresponding to the ganglion cells which were destroyed.

Horrax and Poppen believe that in no case should surgery be tried until the patient has had at least one previous effective alcohol injection. This is done in order to give the patient a sensation of numbness which necessarily follows such an injection, or operation, so they will have a previous conception of the feeling. The second reason for giving a

preliminary alcohol injection is to be sure in doubtful cases that one is dealing with true "Tic Douloureux." If it produces immediate anaesthesia of the nerve injected and stops the patients pain, there is then no question about the diagnosis.

Grant found that in a series of three hundred cases the second division was successfully infiltrated with alcohol in sixty eight per cent on the first attempt and either on the second or the third in twenty-two percent of the cases. The third division was blocked effectively at the initial trial in fifty-five per cent of the cases. Second division injections gave relief from pain for an average of fourteen months. Third division injections gave relief from pain for over sixteen months as an average. Grant (II) noted that the disadvantages of alcohol injection are the fact that it is a painful procedure, that even in experienced hands, the nerve may not be successfully blocked, and that occasional temporary external rectus of facial palsy may result.

The average duration of relief from pain in one hundred fifty cases treated by Flynn (I4) was seventeen months. Cases which were injected for a second time remained free of pain for an average of twelve months. He attributes the difficulty with the second injection to trauma and fibrosis of the nerve from the first injection, and a widening of the foramina due to osteoporitic changes in their margins.

New developments in the field of alcohol injection as the treatment of Trigeminal Neuralgia involve efforts to make the treatment more exact and less a matter of chance. Putnam and Hampton use a modification of Haertel's method of injection into the Gasserian ganglion in which the puncture is made during a brief period of anaesthesia and the position of the needle is established by means of roentgenograms taken during the procedures. They use a new anaesthetic, N-methylcyclohexyl Methylmalonylurea. It was chosen because it has the advantages of safety and of prompt and brief action. They use a sclerosing agent composed of ninety per cent alcohol or Quinine-Urea and not more than two cubic centimeters in any injection. (60)

Irger (61) urges an intra mandibular approach to the Gasserian ganglion in contra distinction to Haertel's extra-mandibular route. It is based on the finding that the foramen ovale is in a sagittal plane with the top of the articular tubercle of the mandible and in line with the angle of the jaw, thus forming an isosceles triangle which gives one the proper measurements and directions. The advantages of this procedure are supposed to make it possible to definitely judge the distance beforehand, to exclude the damaging of nerves, to minimize the perils of damaging minor vessels, and to abolish any difficulty in finding direction towards the foramen ovale and the Gasserian ganglion.

Van Den Berg (62) has invented a new instrument which he feels will be a great aid in alcoholic injection. The instrument consists of a flat bar which fits against the zygomatic arch. At the anterior end of the bar is attached a curved spring because of which the instrument will fit on an adult head of any size. At the posterior end of the of the instrument is attached a button which fits into the external auditory meatus, and at the anterior end a V shaped piece of metal is attached which fits over the roof of the nose. The guides which are grooved for the passage of the needle are attached to the part of the instrument placed against the zygomatic arch.

The instrument is reversible and can be used on either side. Also the instrument can be rotated up or down on the two fixed points (ear and nose.) A study of the skull with the instrument in place will show that the second and third branches of the Trigeminal nerve are exactly in the axis of the two fixed points (ear and nose) of the instrument and that the guides point directly to the nerves at all times, regardless of the upward or downward rotation of the instrument.

Harris recently (63) has perfected a technic of injecting only the parts of the ganglion which he desires. For a third division neuralgia he injects only the outer two thirds of the ganglion, and for a second division he

neuralgia, he injects only the inner two thirds of the Gasserian ganglion. He claims that this procedure leaves better sensation in those parts of the face which are not affected by the neuralgia. He uses the anterior route described by Haertel because he feels that it is easier in many cases to pass the needle between the lips of the foramina.

The present status of the alcohol injections in the treatment of Trigeminal Neuralgia is that of a temporizing measure. Nerve injections offer only temporary relief. Gasserian ganglion injections offer permanent cure, but must be considered as equivalent to a major surgical operation on the Gasserian. Certain it is that these procedures should only be performed by individuals who understand the anatomy and the physiology of the Trigeminal nerve. Our feeling is one of conservatism. We do not agree with Harris who thinks that the alcohol treatment should be used to the exclusion of any surgical procedures. Nor do we agree with Hyndman (64) who believes that alcohol injections should take its place among the obsolete treatments for Trigeminal Neuralgia. Alcohol injection should be used as an adjunct to surgical treatment. Improvements in technic may strengthen the position of this treatment in the future.

SURGICAL TREATMENT

Although "Tic Douloureux" has been recognized as a clinical entity for centuries, its relationship to the Trigeminal nerve was long unsuspected because the source and function of the cranial nerve was unknown. Thru Galen's period until Meckel's careful dissection of the fifth nerve in 1748, the Facial nerve was believed to supply not only motor but also sensory function to the face. It was not strange therefore that Galen should be the first to propose to section the Facial nerve for the relief of the facial neuralgia. No record of any worthwhile work on the surgical treatment of this condition is apparent until early in the eighteenth century, although some authors (65) believe that strolling montebanks and itinerant surgeons occasionally cut for this neuralgia by making an incision on the side of the face near the ear. The cut no doubt was made in an effort to sever the Auriculo*Temporal nerve.

Early in the eighteenth century Marishall, the court surgeon to Louis XIV sectioned the Facial nerve for the relief of the Neuralgia. Probably the earliest record of surgical treatment of Trigeminal Neuralgia is that of Schlichting (4) who in 1748 sectioned the Infraorbital nerve for the relief of pain with only temporary results. Lngier according to Krause was supposed to have cut the Facial nerve at the Stylomastoid foramen in 1778.

These early attempts at surgical treatment were of course done without any anatomical or physiological basis. It was the experimental contribution to nerve functions which permitted the first rational therapy for this condition. Experimental proof of the sensory function of the fifth nerve and the motor function of the seventh nerve was produced simultaneously by Magendie and Sir Charles Bell about 1821. Neurectomy of the peripheral branches of the Trigeminal nerve quickly became the recognized treatment, even though the pain always recurred. One of the outstanding pioneers in neurectomy was Auguste Bernard (65) who in 1836 described his operation in the anticipation that permanent relief would result. The general acceptance of this operation is shown by the fact that by 1869 Wagner had done one hundred thirtyfive peripheral neurectomies.

Not satisfied with less than permanent relief, surgeons sought to excise the nerve nearer the source of the nerve, and the boldest attack is that of John Carnochan who in 1855 excised the Superior Maxillary nerve from its exit at the foramen rotundum outward for a distance of more than an inch, at the same time removing Meckel's ganglion. Carnochan's operation was viciously mutilating, nevertheless patients who had suffered any length of time welcomed any deformity if relief from pain would result. Carnochan's first report (65) described three cases one of which had

no recurrences after fourteen months. The failure of Carnochan's operation to afford permanent relief in but a few cases of Trigeminal Neuralgia stimulated surgeons to renewed effort to attack the fifth nerve within the skull. However, a number of various treatments were used before any acceptable general course had shown good results. Rowland suggested the extraction of the molar teeth, and afterwards piercing its socket, so as to penetrate the antrum and even injecting stimulating fluids into that cavity without any rational grounds for such practice. Walsham and Horsely (66) began to advocate a nerve stretching procedure in 1885 but this procedure never attained any popularity. Horsely also used to perform a ligature of the Common Carotid artery, but the procedure was too vicious and unsuccessful.

Further progress in the surgical treatment of this condition awaited the advent of anaesthesia and the introduction of aseptic surgery. The first suggestion of a more radical treatment was made by Mears in 1884, when at the end of a report on a neurectomy, he wrote, "If in any case, I believed that the morbid condition had invaded the Gasserian ganglion I would not hesitate to enlarge anteriorly the foramen ovale and by traction draw down the ganglion, and proceed in a cautious manner to break it up or remove it by section with small blunt pointed scissors." Mears (30) had no opportunity of carrying out this operation himself.

The earliest surgical attack upon the Gasserian ganglion was that of William Rose (67) who instituted its removal for the treatment of Trigeminal Neuralgia in 1890. Rose devised and carried out an operation in which he excised the Superior Maxillae, trephined the base of the skull with the foramen ovale as a center and curetted the Gasserian ganglion away. Although Rose cured the neuralgia, he lost the patient's eye and encountered a wasting of the Temporal, Buccal and other muscles along with a circumscribed anaesthesia of the cheek, and a loss of sensation and taste on the anterior half of the tongue. The amount of ganglion actually removed or destroyed must have been small for he made the following comment, "It is interesting from the clinical and physiological aspects to observe the rapid diminution of the anaesthetic area, and it would appear that the distribution of the sensation is taken up by the neighboring branches." It is now clear that the ganglion was not removed but the initial loss of function was due to its injury by trauma. In 1892 Rose began to advocate leaving the upper segment of the ganglion alone. He (68) thought that this would help alleviate the eye conditions so prevalent in his early cases. He suggested that interference with one part of the ganglion may induce degenerative changes in the remainder which will effectually prevent a recurrence of the malady and yet will not be sufficient to cause permanent damage to the eye.

Andrews of Chicago (69) working independently published a description of an attack on the Gasserian ganglion precisely similar to that of Rose. He thought that this operation would be superior to all the other operations that had been devised, because it would remove what he thought was the seat of the disease, the ganglion. These two operations received little recognition. They yielded at once to the superior method which appeared during the same year.

Reports of the intracranial operations of Hartley and Krause were published almost simultaneously. They were practically identical in conception and execution. Hartley (70) undertook this operation because of a patient who altho he had already had neurectomies and neurotomies, still had his Trigeminal Neuralgia. Each of these men performed temporal craniotomy and stripped the dura from the middle fossa of the skull until the second and third branches of the nerve appeared. The efforts of each were directed towards intracranial section of the peripheral branches of the Gasserian ganglion and not to the ganglion itself. As such the procedure was really little superior to the mere superficial operations, then in vogue. Krause (3) is credited with the real contribution to the treatment of this condition, the removal of the Gasserian ganglion. The importance of this step is emphasized by the then prevailing belief championed by Horsely (66) that removal of the ganglion was impossible.

because of its close attachments to the wall of the cavernous sinus.

Krause practiced the extirpation of the entire ganglion. The chief difficulties with this operation was the removal of the inner or ophthalmic portion of the ganglion, which is adherent to the outer wall of the Cavernous sinus. Another source of considerable trouble in this operation was the arrest of hemorrhage which obscured the ganglion. (5) Several modifications of Krause's original operation resulted. In his original description Krause advocated the use of an osteoplastic flap for closing the opening of the skull. Hersely (20) introduced the use of a trephine without any replacement of the bone. Intracranial tension so common after Krause's early operation was relieved in this manner. Cushing believing that the evolution of the operation depended on procedures to avoid hemorrhage which hindered the operation introduced a low temporal approach. This (71) approach emphasized passage underneath an arch made by the Middle Meningeal artery, so that the artery remains uninjured. Cushing believed that satisfactory results depended upon a histologic identification and preservation of the ganglion during its removal.

Tiffany (72) recommended an intentional incision of the dura in order to empty the area of the cerebro-spinal fluid. This procedure a seemingly minor point of technic

added in 1896 contributes greatly to the ease and safety of the operation. The additional room obtained not only facilitates manipulation in a restricted operative field, but it also reduces trauma to the Temporal lobe from traction. Moreover it at once reduced the venous oozing which often impeded the operator's progress. Tiffany expressed the hope that deliberate partial section of the Gasserian ganglion, especially the lower two thirds might be available. He also suggested the possibility of saving the motor root of the Trigeminal nerve, and emphasized its importance.

Hutchinson (30) analyzing numerous previous cases felt that some practical steps lessen the number of complications so common in the Gasserian operation, should be made. Working on the premise that in most cases, the ophthalmic division is not involved or only slightly so, Hutchinson began to investigate the advisability of a partial removal of the Gasserian ganglion. He noted that the nerve bundles forming the ophthalmic division run thru the upper edge of the ganglion and by section it is practical to remove almost the whole of the latter and yet to preserve the sensitiveness of the eye. By this method the need for suturing together the eyelids and for constant protection of the corneal surface from dust was avoided. The results of a Gasserian operation are usually anaesthesia from the chin to high up on the forehead, and from the

middle line to the Temporal fossa. If the ophthalmic division has been spared, the forehead and the greater part of the nose, the upper eyelid, and conjunctiva will retain their sensation. Anaesthesia of the inner surface of the lips, the gums, and hard and soft palate will be complete. The nasal cavity and the anterior two thirds of the tongue are insensitive. The Masseter, Temporal, and the two Pterygoid muscles are entirely deprived of their nerve supply. The main risks of the operation are shock, Hemorrhage of the Cavernous sinus, and Septic infection. The mortality rate steadily decreased with greater use. Hutchinson collected statistics to prove that the mortality of this operation was gradually decreasing before section of the posterior root became more popular:

Collector	Year	Cases	Deaths	Percent of deaths
Tiffany U.S.	1896	108	24	22
Marchand France	1897	95	17	18
Pret France	1903	181	34	19
Krause Germany	1907	36	8	22
Horsely England	1905	120	6	5
Hutchinson England	1908	70	3	4

In the modified form of the operation the risks were

diminished in the following respects:

- I. There was no anaesthesia of the cornea.
2. There was no damage to the Oculomotor nerve or the Cavernous sinus.
3. There is less damage and hemorrhage in the brain.

There were no recurrences in Hutchinson's series. (73)

The use of Gasserectomy diminished considerably soon after the introduction of an operation in which the sensory root of the Trigeminal nerve was sectioned near the Gasserian ganglion. It was Spiller (3) who in 1898 thought that if it could be shown that the sensory root of the Gasserian ganglion does not unite after its fibers are divided, then division of this root would probably be a less serious operation than the removal of the entire ganglion, and might have the same effect in the relief of pain. Three years later Spiller and Frazier reported the successful case of intra cranial division of the sensory root of the Trigemimus. At that time Spiller brought forward in support of his operation, the literature on non-regeneration of the pathways of the spinal cord after division, and thought that, after section of the sensory root of the Trigemimus, the results would be the same. In his operation Frazier used the majority of improvements that had been suggested in the approach for the Gasserian ganglion.

Frazier was not the first to use this operation as an aid to the treatment of this neuralgia. Horsely (74) had reached the sensory root by an intradural approach, retracting the Temporal bone, but the patient died. Frazier succeeded where Horsely failed because he approached the sensory root extradurally.

The operation of sectioning the sensory root of the Trigeminal nerve became the operation of choice in the succeeding years. However, operations on the peripheral portion of the nerve continued to be practiced. Probably the most interesting of these operations was that introduced by Robert Abbe in 1900. (75) He resected the peripheral branches of the nerve and then interposed a piece sterilized gutta percha tissue more than one inch long and half an inch wide, over both foramina. He (76) reported five cases in 1903 with perfect results. This procedure never gained much popularity because most men did not believe in the interposition of any foreign body in the skull.

From 1900 to 1925 the contributions of Frazier and Spiller overshadowed all other work on the surgical treatment of this disease. Their first contribution of any major importance was the introduction of the subtotal resection of the sensory root behind the Gasserian ganglion in 1915. The basis for this work (77) was the results of his early work in 1901. From this work he concluded that the nerve

fibers of the sensory root of the fifth nerve in both its intra cerebral and extra cerebral portions maintain the same relative positions. He reasoned then that if the nerve fibers of the sensory root do not mingle freely without regard to order, the nerve fibers of the Gasserian ganglion also probably preserve a definite order of arrangement.

In a paper written with Frazier in 1904 (78) he referred to experimental work which he did with Marchi's method. He found that when only the external part of the sensory root was divided, the degeneration in the spinal root of the Trigeminal nerve in the Pons and Medulla was only in the dorsal part of the root. From this it followed that the fibers of the inner portion of the sensory root occupied the ventral portion of the descending spinal root. The result of this experimental work was an operation in which the outer two thirds of the sensory root of the Trigeminal nerve was resected, and the inner one third of the posterior root was left intact so as to maintain sensation in the eye, and abolish the neuroparalytic keratitis which had resulted in the majority of the early operations in which a total root resection had been done.

In 1925 Frazier (79) published his experience with the first twenty-five cases of subtotal section, the result of ten years work. The results proved his original supposition; namely that if the ophthalmic portion of the root

is conserved, keratitis as a complication can be avoided. Frazier also thought that the results of his cases proved Spiller's premise that the outer third of the ganglion contains mainly fibers of the Mandibular portion of the Trigeminal nerve, that the middle third of the ganglion is composed of fibers of the Maxillary portion of the nerve, and that inner part of the ganglion contains fibers of the Ophthalmic portion of the nerve.

Studies by Whitehead (80) in 1925 seem to confirm this theory. Embryologically he found that the Ophthalmic region of the Gasserian ganglion is widely separated from the remainder of the ganglion by the fact that the site of the formation of the Ophthalmic nerve is widely separated from that of Maxillary and Mandibular nerves which form very close to each other. The fibers of the sensory root run parallel and became arranged in separate bundles by the enveloping supporting tissue and do not tend to intermingle.

Frazier added still another great improvement to the surgical treatment in 1919 when he showed that the motor root of the Trigeminal nerve could be isolated and saved during the subtotal operation. He was aided in this work by the morphological work on the anatomy of the Trigeminal nerve by Whitehead and by the introduction of the use of an illuminated retractor.(37) Whitehead showed that in

the early stages of development, the motor root emerges from the Pons immediately central to the entering sensory root. As development proceeds, this relationship changes, so that the point of emergence of the motor root becomes immediately cephalad to the point of entrance of the sensory root. The motor root emerges from the Pons as a separate bundle at two different levels, and the fibers emerging from the dorsal level are apparently of the Mesencephalic nucleus. The motor root as it passes across the Mesencephalic ganglion is joined by the peripheral sensory fibers that have arisen from the sensory cells in the Maxillary region of the ganglion.

The Frazier operation (81) advocating a Temporal approach, and the preservation of the motor and the inner or Ophthalmic fibers of the sensory root is the accepted operation today. In his hands the operation had a mortality of less than one per cent in 1928, and the mortality rate has declined to less than one half percent recently. (37) Frazier stresses a number of helpful points which he thinks keeps the mortality rate down. He does not operate patients with a blood pressure over two hundred. As a precaution against Keratitis, one drop of one percent Atropine Sulphate is instilled in the eye, the night before and the morning of the operation. He operates all patients in the sitting position because when the field of operation is on the

the level with the field of the operator's eyes, the patient requires less Ether, and there is less bleeding in this position. He removes the bone below the level of the Middle Meningeal artery.

Frazier makes a small perforation in the center of the dura to allow the escape of Cerebrospinal fluid. He keeps the field bloodless with a metal aspirator and a dental tampon. He believes that the facility of the fractional division of the sensory root will depend upon the liberality of the exposure. All bleeding however slight should be controlled before wound is closed. If the entire root is sacrificed, corneal complications are prevented by keeping the lids closed and using Atropin for four days with Boric acid irrigations.

Success with Frazier's operation has been successful in the hands of many workers. Horrax and Poppen reporting in 1935 (59) performed the radical operation of the sensory root on two hundred four patients without a fatality or a serious operative complication. Grant (17) found that the use of the subtotal operation lowered his percentage of complications considerably. He had one fatality in one hundred cases operated by Frazier's method. Jefferson (82) recommends the subtotal operation for all patients under seventy. Taylor (34) recommends this operation as being much safer than alcoholic injection of the ganglion.

Grant (83) reviewing nine hundred forty-nine operations in 1938 strongly recommends the subtotal resection of the sensory root with preservation of the motor root as the best procedure of choice. When the age and general health of patients suffering from Major Trigeminal neuuaalgia is considered, an operative mortality of one and one half percent is extremely satisfactory. Little or no reason seems to exist for a refusal to attempt to relieve the pain of even the most debilitated of these sufferers.

Recent anatomical studies advanced by various investigators attempt to prove that Frazier's operation is not based on anatomical facts. Van Nouhuys (84) believes that he has proved that the sensory root of the fifth nerve is not composed of three parts that correspond to the three peripheral branches form the Gasserian ganglion. From this evidence Van Nouhuys concludes that the operation cannot be regarded as an absolutely reliable procedure. Stibbe (85) from his experimental work on monkeys showed a crossing and a segregation of the fibers of the sensory root of the fifth nerve into spinal and principal nucleus fibers which he interprets as a functional division into pain and touch fibers. He further found a large number of sensory nerve cells in the sensory root. These were in scattered groups quite close to the Pons. Thus, he believes that section of the root distal to these as practiced by Frazier

does not rule out the possibilities of regeneration of fibers. On the other hand, Wilkins and Sachs (86) in recording the areas of sensory loss following partial section of the posterior root in a series of twenty-six cases, found evidence that, while there was some crossing and interlacing of the fibers in a variable arrangement, in general the partial section could be performed satisfactorily by divisions.

A most important modification of the operation on the sensory root was contributed by Dandy in 1925. (87) He suggested sectioning a selected part of the root near its entrance into the Pons, and later described an operation by which the sensory root was exposed thru a suboccipital approach. (3) In this approach Dandy exposed the sensory root by incising the Dura, elevating the Cerebellum, and opening the Cisterna Lateralis between the Auditory nerve and the Tentorium. He listed the advantages of the operation over Frazier's method as: (88)

- I. There is no post operative Keratitis due to the ease and rapidity with which the fifth nerve is divided.-It has been shown that the Keratitis is dependent on the amount of trauma inflicted upon the nerve.
2. The motor root has never been injured since the route has been employed because it is at a greater

distance from the sensory root than at any other point in its course.

3. The Facial nerve is never injured because it is at a safe distance.
4. Sensation approaching the normal is retained over the entire domain of the Trigeminal irrespective of the branch involved in the pain.
5. The approach is bloodless after the Dura is exposed.
6. The operation is much easier and quicker to perform.

Dandy's approach has not much support among any of the operators. Hyndman (64) believes that from a surgical standpoint, the Cerebellar approach is preferred, but it requires experience in the Cerebellar fossa. Greater care is necessary than in the sub Temporal approach. Van Waggenen (89) concluded after using this approach that there is no difference in the type or distribution of the sensory loss between Dandy's and Frazier's operations. Preservation of the motor root has undoubtedly been easier and more assured by the posterior fossa route than by the Temporal route.

Two other new methods of approach to the sensory root have recently been described. Buttin (28) has devised a technic by means of which the posterior root may be approached. It consists of incision over and behind the ear and removal of the bone of the upper wall of the auditory canal

and part of the floor of the middle fossa without opening of the Tympanic cavity. The Dura is then elevated off the floor of the middle fossa as far as the tip of the Pyramid and over the ganglion. Maxwell (90) has described his modification of the Temporal approach. He gains entrance thru the Dura beneath the Petrosal sinus and thus gains access to the root in its course between the Pons and the Cave of Meckel.

A number of other surgical attacks have been advanced for the treatment of Trigeminal neuralgia, but have as yet to be accepted because of their questionable relief. Gross (24) is an enthusiastic booster of Alveolectomy, an operation originally designed by Shearer of Omaha, as a surgical procedure for those cases of Trigeminal Neuralgia which can be attributed to dental origin.

Many men believe as Frazier does, (12) that the rich Sympathetic supply to the Trigeminal nerve is not without significance. Pleth has had one of the largest series of Trigeminal Neuralgia for which Sympathectomy was performed. He (91) performed a Cervical Sympathectomy on fifty cases with no mortality and permanent relief. Pleth believes that the reason for the good results is that the parts where the pain is located are suffering from anemia and that the cutting of the Sympathetic produces a vaso paralysis with subsequent vasodilation so that the anemic parts

become permanently flooded with blood. Flothew ('92) performed a left dorsal Sympathetic ganglionectomy for a case of Trigeminal Neuralgia. There was an uneventful recovery with a residual Horner's syndrome. McKechnie (93) believes that the success of Sympathectomies demonstrate that the condition may be caused by some abnormal vasomotor influence in the Gasserian ganglion. Whether all cases are vasomotor in origin can only be cleared up by more experimental work, but he believes that the results of this operation justify a more extensive trial.

SUMMARY

Haven (28) presents probably the most concise and up to date summary of the status of our understanding of Trigeminal Neuralgia.

"The exact etiology and pathology of Trigeminal Neuralgia is still obscure. The diagnosis of the syndrome has been placed upon a fairly satisfactory basis. Methods for the relief of the suffering patient have far outstripped our basic understanding of the condition. It is possibly to be regretted that relief from the pains of Trigeminal Neuralgia must be accompanied by a loss of some types of sensory perception over the affected zones. May we hope that as our knowledge of the condition increases even better methods of treatment will be evolved."

SUPPLEMENT

Although the series of cases of Trigeminal Neuralgia admitted to the University Hospital is limited, the author thought it might be interesting to compare our available cases with other series already in the literature.

There were no startling differences noted. Our Series show that the incidence of Trigeminal Neuralgia is equal in men and women. Most investigators have found the neuralgia to be predominantly right sided, while our series shows it to be more predominant on the left side. Most of the patients referred to the University Hospital for treatment of the condition have suffered from the neuralgia on the average of about six years; some more, some less. The average age of the individual suffering from Trigeminal Neuralgia in our series averages sixty-four years.

The results from the therapy used in our series shows clearly that the operative treatment is the only successful treatment of this condition. The majority of cases treated by surgery had a complete cure. Alcohol injections have not been very successfully used in the University Hospital. Other modes of treatment used in these cases (Xray and Alveolectomy) have been unsuccessful. The only exact treatment which will promise relief and cure is subtotal posterior root resection behind the Gasserian ganglion of the Trigeminal nerve.

Case Reports

Hosp. No.	Sex	Age	Side	Duration	Therapy	Result in Hosp.	Follow up
51197	M	81	Left	2 month	X ray	Cure	Recurrence in 39 days
51216	F	60	Left	6 years	Alveolectomy	Cure	Recurrence in 1 year
					Subtotal Post. Root Resection	Cure	None
51259	F	70	Left	4 years	Subtotal Post. Root Resection	Cure	No Recurrence
52182	M	74	Left	15 years	Alcohol Injections	Unsuccessful	-
53272	F	47	Left	4 months	Subtotal Post. Root Resection	Cure	-
54806	F	35	SLeft	5 years	Subtotal Post. Root Resection	Cure	-
56605	F	68	Left	3 weeks	Alcohol Inject.	Cure	Recurrence in 3 years
					Alcohol Inject.	Unsuccessful	Milder U
57966	F	76	Right	13 years	Alcohol Inject.	"	" " Unsuccessful
					Trethylene	"	" " "
					Gelseminum	"	" " "
					Xray	"	" " "
60376	M	57	Left	4 years	Subtotal Post. Root Resect.	Cure	No Recurr.
60973	F	72	Right	2 year	Alcohol Inject.	Unsuccessful	Unsuccessful
62399	M	55	Left	7 years	Alcohol Inject.	Unsuccessful	
					Subtotal Post. Root Resection	Cure	No Recurr.
62293	M	73	Left	3 years	Subtotal Post. Root Resection	Cure	No Recurr.
Summary	6M; 6F;	Av. Age 64;	Side-10Left; 2 Right;	Duration-Av. 5 years plus			

REFERENCES CITED

- I. Anstie, Francis F. Neuralgia and the Diseases that Resemble It, Philadelphia, Pa. Lindsay and Blakiston, 1860
2. Lewy, F. H. The First Authentic Case of Major Trigeminal Neuralgia and Some Comments on the History of this Disease, Annals of Medical History, 10; 247-250; 1938
3. Dandy, W. E. An Operation for the Cure of "Tic Douloureux" Partial Section of the Sensory Root at the Pons, Archives of Surgery 18Pt.I; 687-734, 1929
4. Davis, L. and Haven H. Surgical Anatomy of the Sensory Root of the Trigeminal Nerve, Archives of Neurology and Psychiatry 29; 1-18, 1933
5. Harris, Wilfred, Neuritis and Neuralgia, London, England, H. Milford, Oxford University Press, 1926
6. Rowland, Richard, Treatise on Neuralgia, pps. 240-250, Philadelphia, Pa. Carey and Hart, 1841
7. Davis, L. Trigeminal Neuralgia, J. Am. Dental Assoc. 21; 961-969, 1934
8. Maloney W. J. and Kennedy R. F. The Sense of Pressure in the Face, Eye, Tongue, Brain, 34; 1-28; 1911
9. Davis, L. Deep Sensibility of the Face; Archives of Neurol. and Psych. 9; 283-305; 1923
10. May, C. and Horsely, V. Mesencephalic Root of the Fifth Nerve, Brain, 33; 175-203; 1910
11. Grant, F. C. Alcohol Injection in the Treatment of Trigeminal Neuralgia, J.A.M.A. 107; 771-774; 1936
12. Frazier, C. H. Pain Phenomena of the Face, Their Origin and Treatment with Special Reference to Trigeminal Neuralgia, Am. Journ. of Med. Science, 169; 469-476; 1925
13. Horrax G. and Poppen, J. L. Trigeminal Neuralgia, Experiences with, and Treatment Employed in 468 Patients during past 10 Years, Surg. Gyn. and Obst. 61; 394-402; 1935

REFERENCES CITED (cont.)

14. Flynn, C. W. Treatment of Trigeminal Neuralgia with Especial Reference to Alcohol Injection, Southern Medical Journal, 28; 330-336; 1935
15. Adson, A. W. The Diagnosis and Surgical Treatment of Trigeminal Neuralgia, Annals of Otol. Rhinol. and Laryngology, 35; 601-631; 1926
16. Harris, W. Trigeminal Neuralgia and Its Treatment, Lancet, I; 567-569; 1931
17. Grant, F. C. Major Trigeminal Neuralgia, American Journ. of Surgery, 27; 430-434; 1935
18. Adson, A. W. Trifacial Neuralgia and Its Treatment, Northwestern Medecine, 22; 156-160; 1923
19. Harris, W. Treatment of Trigeminal Neuralgia, Lancet, 2; 1591-1592; 1909
20. Horsely, V. Trigeminal Neuralgia, pps. 1-41; London, Eng. Medical Publishing Co. 1897
21. Hurd, Edward Payson, A Treatise on Neuralgia, pps. 31-35; Detroit, Michigan, G. S. Davis, 1890
22. Keegan, J. J. Surgical Treatment of Neuritis and Neuralgia, Nebr. State Med. Journ. 16; 129-141; 1931
23. Melchior, M. M. Teeth and Trigeminal Neuralgia, International Journal of Orthodontia, 15; 1214-1228; 1929
24. Gross, S. Alveolectomy-A Surgical Procedure for Trigeminal Neuralgia of Local Origin, Medical Record, 99; 470-474; 1921
25. Harris, W. The Role of the Sympathetic in Sensory Conduction and Certain Neuralgias, Brit. Med. Journ. 2; 112-115; 1936
26. Frazier, C. H. Problems in Diagnosis and Treatment, New York State Journ. of Med. 3K. 1137-1140; 1931
27. Ellis, C. W. Has "Tic Douleureux a Definite Etiology, Archives of Otolaryngology 15; 218-221; 1932

REFERENCES CITED (cont.)

28. Haven H. Collective Review, International Abstract of Surgery, 66; 226-236; 1938
29. Ball, C. R. Etiology of Tic Douleureux with Clinical Reports of New Methods of Treatment, Minn. Med. 13; 556-563; 1930
30. Hutchinson, Jonathon, On Facial Neuralgia and Its Treatment, with Especial Reference to the Surgery of the Fifth Nerve and the Gasserian Ganglion, London, Eng. J. Bale and Sons and Danielsson, 1919
31. Keen W. W. and Spiller, W. G. Remarks on Resection of the Gasserian Ganglion, Am. Journ. of Med, Sciences, 116; 503-532; 1898
32. Frazier, C. H. and Russel, E. C. Neuralgia of the Face, An Analysis of 754 Cases with Relation to Pain and Other Sensory Phenomenon, before and after operation, Arch. Neurology and Psych. II; 557-563; 1924
33. Cushing, H. The Major Trigeminal Neuralgias and Their Surgical Treatment Based on Experiences with 332 Gasserian Operations, Am. Journ. of Med. Science, 160; 157-184; 1920
34. Taylor, A. S. Surgical Treatment of Trigeminal Neuralgia, Am. Journ. of Surgery, 20; 699-706; 1933
35. Oljenick, Ignaz, Trichlorethylene Treatment of Trigeminal Neuralgia, J.A.M.A. 91; 1085-1087; 1928
36. Poppen, J. L. The Conservative Treatment of Trigeminal Neuralgia, Surg. Clinics of North Am. 14; 1187-1189; 1934
37. Frazier, C. H. Radical Operation for Major Trigeminal Neuralgia, J.A.M.A. 96Pt.I; 913-916; 1931
38. Glaser, M. A. Treatment of Trigeminal Neuralgia with Trichlorethylene, J.A.M.A. 96; 916-920; 1931
39. Tyler, C. M. Tic Douleureux Relieved with Ergotamine Tartrate, Medical Record, 142; 235-236; 1935
40. Althaus, J. A Treatise on Medical Electricity, pps. 318-320; Philadelphia, Pa. Bindsay and Blakiston, 1860

REFERENCES CITED (cont.)

41. Wolf, H. F. Diathermia in the Treatment of Trigeminal Neuralgia, Medical Record, 90; 1152-1154; 1916
42. Barré, Ionization Treatment of Neuralgia, J.A.M.A. 81; 963; 1923
43. Budden, C. W. The Treatment of Rheumatic, Neuralgic, and Allied Pains by Ionization with Sodium Salicylate, Practitioner, 96; 422-427; 1916
44. Hecht, Dorsay, The Methods and Technic of the Deep Alcohol Injections for Trifacial Neuralgia, J.A.M.A. 49; 1574-1580; 1907
45. Bennett, W. H. The Treatment of Certain Forms of Neuralgia by Osmic Acid, Lancet, 2; 1220-1223; 1899
46. Cushing, H. The Role of Deep Alcohol Injections in the Treatment of Trigeminal Neuralgia, J.A.M.A. 75; 441-443; 1920
47. Kiliani, Otto, Schloesser's Method for Trigeminal Neuralgia, Medical Record, 70; 1019-1020; 1906
48. Patrick, H. T. The Treatment of Trigeminal Neuralgia by Means of Deep Injections of Alcohol, J.M.M.A. 49; 1567-1574; 1907
49. Harris, W. The Alcohol Injection Treatment for Trigeminal Neuralgia, Lancet, 1; 1310-1314; 1909
50. Harris, W. Alcohol Injection of the Gasserian Ganglion for Trigeminal Neuralgia, Lancet, 1; 218-221; 1912
51. Pellock, L. and Potter, H. Experimental Studies of Injection of the Gasserian Ganglion Controlled by Fluorescopy, J.M.M.A. 67; 1357-1361; 1916
52. Grinker, J. A New Method of Treating Neuralgia of the Trigeminal by the Injection of Alcohol into the Gasserian ganglion, J.A.M.A. 60; 1354-1357; 1913
53. Patrick, H. The Technic and Results of Deep Injection of Alcohol for Trifacial Neuralgia, J.A.M.A. 58; 155-163; 1912

REFERENCES CITED (cont.)

54. Grant, F. E. Anatomic Study of Injection of the Second and Third Divisions of the Trigeminal Nerve, J.A.M.A. 78; 794-797; 1922
55. Harris, W. Alcohol Injection in Facial Neuralgia, Lancet, 2; 122-125; 1922
56. Haertel, Surgery in Trifacial Neuralgia, J.A.M.A. 83; 959; 1924; ab. Munchener Medizinische Wochenschrift, Munich
57. Harris, W. Observations on the Treatment of Trigeminal Neuralgia, Brit. Med. Journ. 2; 87-91; 1932
58. Merris, L. Trigeminal Neuralgia, The Anatomy of the Haertel Technic, Lancet, 1; 122-126; 1931
59. Horrax, G. and Poppen, J. L. What Shall We Do with the Patient with Trigeminal Neuralgia, New England Journ. of Med. 212; 972-975; 1935
60. Putnam, T. J. and Hampton, A. O. A Technic of Injection into the Gasserian Ganglion under Roentgenographic Control, Arch. of Neurol. and Psych. 35; 92-98; 1936
61. Irger, I. M. Alcohol Injection of the Gasserian Ganglion Annals of Surgery, 100; 61-67; 1934
62. Van Den Berg, W. J. Trigeminal Neuralgia, A New Instrument for Alcoholic Injection, Arch of Neurol. and Psych. 33; 388-390; 1935
63. Harris, W. Bilateral Trigeminal Tic, Its Association with Heredity and Disseminated Sclerosis, Annals of Surgery, 103; 161-172; 1936
64. Hyndman, O. R. Partial Section of the Fifth Cranial Nerve, Comparison of Sub Temporal and Cerebellar Approach from Surgical and Physiological Standpoint, Archives of Surgery, 37; 74-99; 1938
65. Cutter, I. S. The Surgical Attack upon Trigeminal Neuralgia-James M. Carnechan, International Abstract of Surgery, 50; 87-90; 1930

REFERENCES CITED (cont.)

66. Horsely, V. Various Surgical Procedures Devised for Relief or Cure of Trigeminal Neuralgia, British Med. Journal, 2; 1139-1143; 1891
67. Rose, W. Removal of the Gasserian Ganglion for Severe Neuralgia, Lancet, 2; 914-915; 1890
68. Rose, W. Surgical Treatment of Trigeminal Neuralgia, Lancet, 1; 295-362; 1892
69. Andrews, E. The Anatomical Relations of the Gasserian Ganglion Which Determine the Best Method of Its Removal, Chicago Med. Record, 1; 322; 1892
70. Hartley, F. Intracranial Neurectomy of the Second and Third Divisions of the Fifth Nerve, New York Medical Journal, 55; 317-319; 1892
71. Cushing, H. A Method of Total Extirpation of the Gasserian Ganglion for Trigeminal Neuralgia, J.A.M.A. 34; 1035-1041; 1900
72. Tiffany, Intracranial Neurectomy and Removal of the Gasserian Ganglion, Annals of Surgery, 19; 47-57; 1894
73. Hutchinson, J. Treatment of Trigeminal Neuralgia, Lancet, 2; 1591-1592; 1909
74. Horsely, V. An Address on the Surgical Treatment of Trigeminal Neuralgia, Practitioner, 65; 251-263; 1900
75. Abbe, R. Surgery of the Fifth Nerve for Tic Douleureux, J.A.M.A. 34; 1098-1103; 1900
76. Abbe, R. Surgical Treatment of Trigeminal Neuralgia, Annals of Surgery, 37; 1-8; 1903
77. Spiller, W. G. and Frazier, C. H. Tic Douleureux, an Anatomical and Clinical Basis for Subtotal Section of the Sensory Root, Arch. of Neurol. and Psych. 29; 50-55; 1933
78. Frazier, C. H. and Spiller, W. G. Physiological Extirpation of the Gasserian Ganglion, J.A.M.A. 43; 943-945; 1904

REFERENCES DITED (cont.)

79. Fraaier, C. H. Subtotal Resection of the Sensory Root for Relief of Major Trigeminal Neuralgia, Archives of Neurol. and Psych. 13; 378-384; 1925
80. Frazier C. H. and Whitehead, E. Morphology of the Gasserian Ganglion, Brain, 48; 458; 1925
81. Frazier, C. H. and Gardner, W. J. The Radical Operation for the Relief of Trigeminal Neuralgia, Surg. Gyn. and Obstetrics, 47; 73-77; 1928
82. Jefferson, G. Observations on Trigeminal Neuralgia, Brit. Med. Journ. 2; 879-883; 1931
83. Grant, F. C. Results in the Operative Treatment of Major Trigeminal Neuralgia, Annals of Surgery, 107; 14-19; 1938
84. Van Nouhuys, F. The Anatomy of the Gasserian Ganglion, Arch. of Surgery, 24; 451-457; 1932
85. Stibbe, E. P. Some Observations on the Surgery of the Trigeminal Neuralgia, Brit. Journ. of Surgery, 24; 122-129; 1936-37
86. Wilkins, H. and Sachs, E. Variations in Skin Anaesthesia Following Subtotal Resection of the Posterior Root, Arch. of Neurol. and Psych. 19; 29-49; 1933
87. Dandy, W. E. Section of the Sensory Root of the Trigeminal Nerve at the Pons, Hahn Hopkins Hospital Bull. 36; 105-6; 1925
88. Dandy, W. E. The Treatment of Trigeminal Neuralgia by the Cerebellar Route, Annals of Surgery, 96; 787-795; 1932
89. Van Waggenen, W. P. Some Indications for Section of the Posterior Root of the Trigeminal Nerve thru the Posterior Fossa, Annals of Surgery, 94; 1013-17; 1931
90. Maxwell, W. A Method of Approach to the Trigeminal Trunk in the Posterior Fossa Designed Primarily for Ophthalmic Division Involvement in Tic Douleureux, Austral. and New Zealand Journ. of Surg. 5; 379-388; 1936

REFERENCES CITED (cont.)

91. Pleth, V. Cervical Sympathectomy as a Means of a Permanent Cure of Facial (Trigeminal Neuralgia) Am. Journa. of Surgery, 33; 103-105; 1919
92. Flothow, P. G. Relief of Pain from a Neuralgic Viewpoint, Northwestern Medecine, 29; 69-76; 1930