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UNIVERSITE MOHAMMED V DE RABAT
FACULTE DE MEDECINE ET DE PHARMACIE
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TRIGEMINAL NEURALGIA: TREATMENT MODALITIES AND CLINICAL RESULTS, A RETROSPECTIVE STUDY OF 101 CASES

THESIS

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Dedications

To ALLAH, the most gracious and the most merciful

To my parents,

Dr.CHAHBAR ABDELAZIZ and Dr.AMNOUH MEHDIA:

I am eternally grateful for you, being there by my side in
every step in my life, making all kind of sacrifices in order
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Thank you for your unconditional support.
Thank you for pushing me to achieve the best,
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I love you beyond words can describe and beyond distances,
you are always in my mind.
YNWA

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List of Abbreviations

AAN **:** American academy of neurology

AICA **:** Anterior inferior cerebellar artery

ASA **:** American society of anesthesiologists

BNI **:** Barrow neurological institute

CBC **:** Complete blood count

CN **:** Cranial nerve

CPA : Cerebellopontine angle

DTTT **:** Dorsal trigemino-thalamic tract

EFSN **:** European federation of neurological societies

GKRS : Gamma-Knife radiosurgery

IHS **:** International headache society

MS **:** Multiple sclerosis

MVD **:** Microvascular decompression

NVC **:** neurovascular conflict

PBC **:** Percutaneous balloon compression

PICA **:** Posterior inferior cerebellar artery

PTN **:** Painful trigeminal neuropathy

REZ **:** Root entry zone

SCA **:** Superior cerebellar artery

TC **:** Radiofrequency thermocoagulation

TN **:** Trigeminal neuralgia

TZ **:** Transition zone

VTTT **:** Ventral trigemino-thalamic tract

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Introduction

I. Anatomy of the trigeminal nerve (CNV)

1. Generalities

The trigeminal nerve (CN) is the fifth and the largest pair of cranial nerves (V).

It is a mixed nerve that consists primarily of a sensory contingent responsible of cutaneomucous sensibility of the face and a motor contingent for masticatory muscles.

Having its root in the area of cerebellopontine angle cistern, the trigeminal nerve emerges on the lateral surface of the pons, entering the trigeminal ganglion (Gasserian ganglion, or semilunar ganglion), this ganglion lies near the cavernous sinus and internal carotid artery and gives rise to three nerve branches: the *ophthalmic (V1), maxillary (V2), and mandibular (V3)* divisions of the trigeminal nerve.

Like every cranial nerve, the trigeminal nerve has real origins (several nuclei inside the brainstem) as well as apparent origins (showing the location of emergence of the nerve from the brainstem), a nerve trunk and divisional branches.

Embryology: The trigeminal nerve is derived from an ectodermic formation: the neural tube. The motor contingent of the TN is derived from the ventral wall of the neural tube (Basal plate). The sensory contingent is derived from the dorsal wall (Alar plate). The cranio-spinal ganglions (the Gasserian ganglion for example) are derived from the ganglionic crest that is externalized in the back of the neural tube with sensitive roots of cranial and spinal nerves.

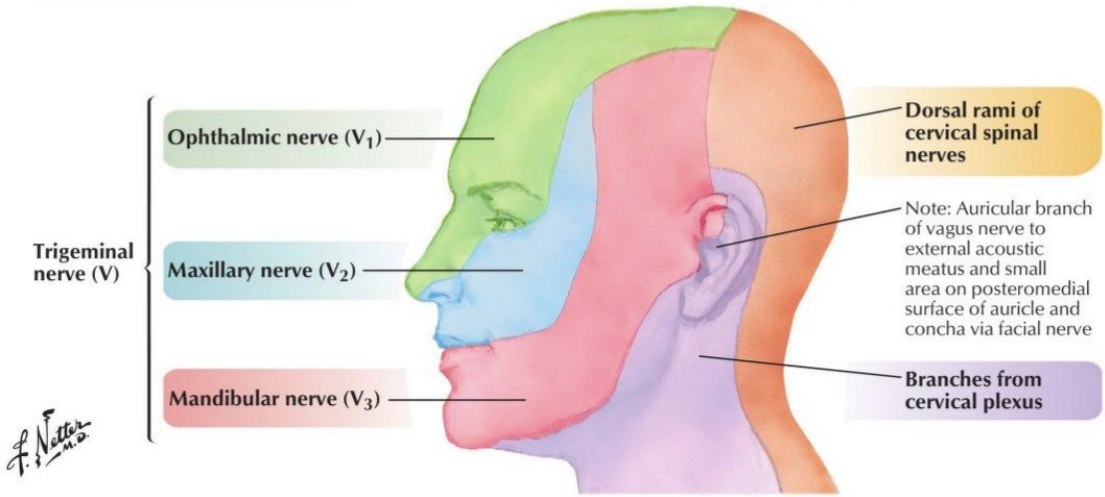

Figure 1 : Territory of sensory innervation of the face by the three branches of the trigeminal nerve [1].

2. Nuclei of the trigeminal system

2.1. Sensory nuclei of the trigeminal nerve

It is a large structure that extends over the entire length of the brainstem and into the upper cervical cord. It is composed of three separate sub-nuclei: The **spinal nucleus**, the **principal nucleus** and the **Mesencephalic nucleus**.

- *The spinal nucleus*: The largest nucleus extends behind the medulla oblongata and in the spinal marrow to the second cervical myelomer where it continues with the substantia gelatinosa of Rolando, it is considered the homologue of this substance in the brainstem, while the tract is continuous with Lissauer's tract. The pseudo unipolar neurons in the trigeminal ganglion receive sensory information of the face and send it down to the spinal trigeminal nucleus where it synapses with a second order neuron, which will project to the thalamus as the ventral trigemino thalamic tract.

This nucleus has three parts, from top to bottom :

- Pars oralis: which extends from the midpons to the inferior olive.
- Pars inter Polaris: which extends from the rostral third of the inferior olive to the obex of the fourth ventricle.
- Pars caudalis: which extends to and is continuous with the dorsal horn gray matter of the cervical spinal cord.

The spinal nucleus of the trigeminal nerve receives fibers that convey the sensations of pain, temperature, and soft touch from the face and mucous membranes.

What makes this nucleus unique is that it receives sensory information from cranial nerves VII, IX and X (ear, tongue, pharynx and larynx).

- *The principal nucleus*: Also called Pontine or central nucleus, it is the prolongation upwards of the spinal nucleus and is located in the lateral pons, posterolateral to the motor nucleus of the trigeminal nerve. The fibers entering this nucleus are concerned with tactile and proprioceptive sensation.

It contains the second order cell bodies that will synapse with primary order neuronal fibers from the trigeminal ganglion.

It has two divisions: The dorso medial division and the ventro lateral division.

The dorso medial one receives input only the oral cavity, the ventro lateral division receives input from all three divisions of the trigeminal nerve.

The second order neuronal fibers transporting information from the dorso medial division form the dorsal trigemino-thalamic tract (DTTT) and the second order neuronal fibers from the ventro lateral division will be crossed and form the ventral trigemino thalamic tract (VTTT).

- *The Mesencephalic nucleus*: Extends from the main sensory nucleus to the superior colliculus of the mesencephalon. This nucleus receives proprioceptive impulses from the masticatory muscles and from muscles supplied by other motor cranial nerves. It is the only

structure in the central nervous system to contain the cell bodies of first order sensory neurons, also, it is unique in that the fibers have no cell bodies in the trigeminal ganglion, as an alternative, pseudo unipolar afferent fibers that receive proprioceptive information from the mandible sends information directly to the cell body in the nucleus then bilaterally to the motor nucleus to mediate monosynaptic masseter reflex.

2.2. Motor nuclei of the trigeminal nerve

The motor nucleus of the trigeminal nerve is situated at a midpontine level, medial to the main sensory nucleus of the trigeminal nerve, near the floor of the fourth ventricle and lateral to the Mesencephalic nucleus. Receiving input from the cortex bilaterally The axons leave the pons in the motor root of the trigeminal nerve, and then join the mandibular branch of the nerve innervating the different masticatory muscles (the masseter, temporalis, and medial and lateral pterygoid muscles) as well as to the tensor tympani, tensor veli palatine, mylohyoid muscles and to the anterior belly of the digastric muscle.

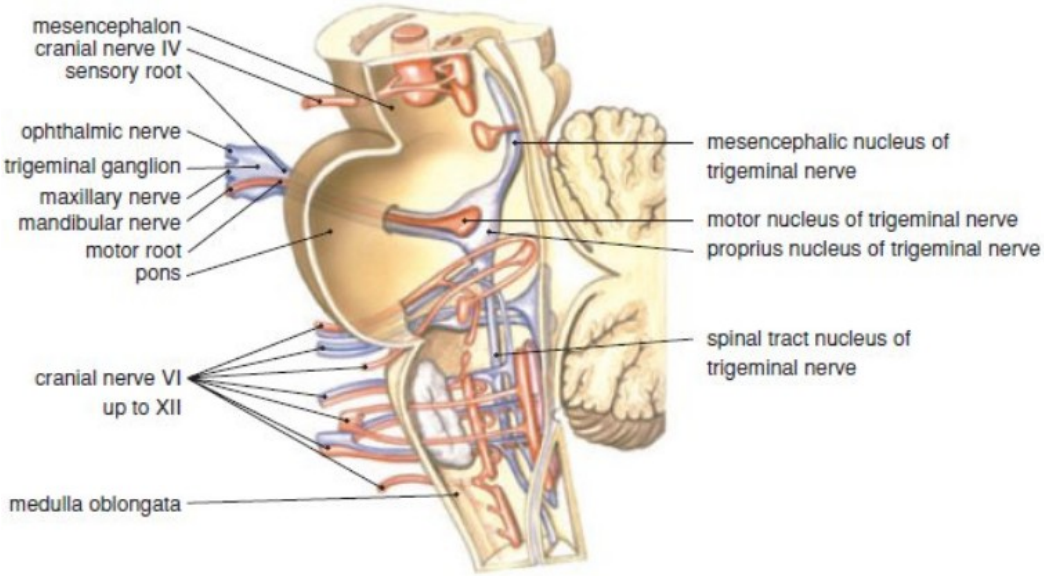

Figure 2 : Schematic diagram of trigeminal nerve nuclei in brainstem [2].

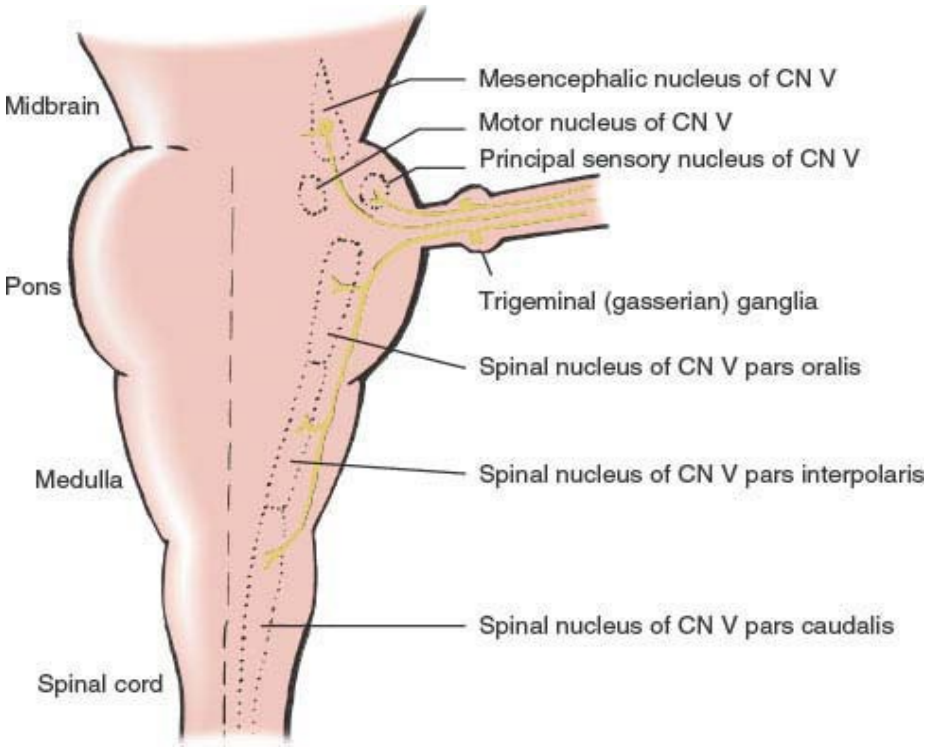

Figure 3 : Schematic diagram showing different parts of spinal nucleus and trigeminal nerve nuclei in brainstem [3]

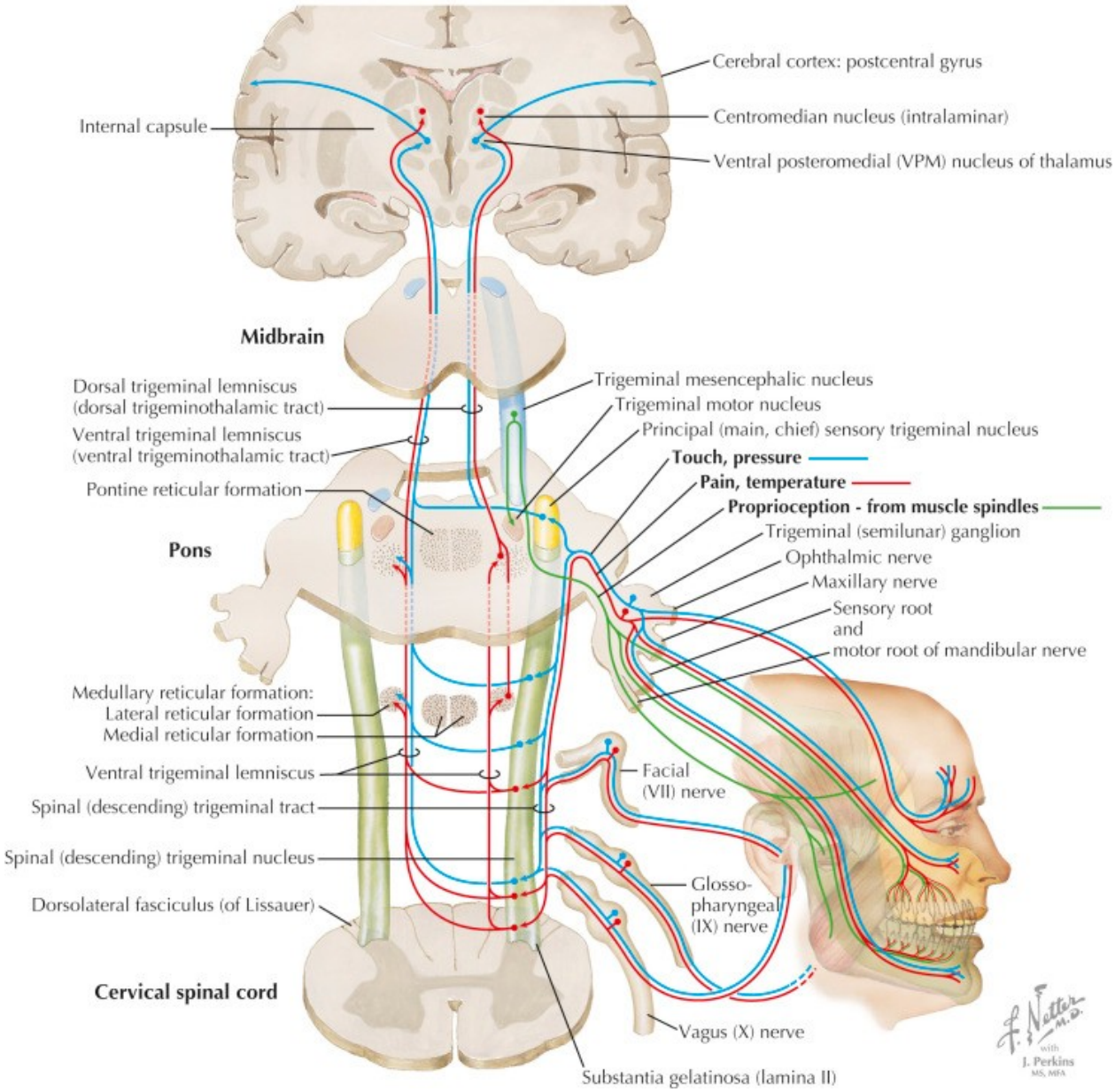

Figure 4 : Schematic diagram of the tracts of the trigeminal nerve [1].

3. Segments of the trigeminal nerve

There are four segments located respectively in the middle cerebral fossa, in the trigeminal cave, in the upper edge of the petrous bone and in the posterior cerebral fossa (Cisternal segment). [4].

3.1. In the middle cranial fossa

The trigeminal nerve is formed of three terminal branches :

- The ophthalmic nerve V1 passes through Superior orbital fissure
- The maxillary nerve V2 passes through the foramen rotundum.
- The mandibular nerve V3 passes through the foramen ovale.

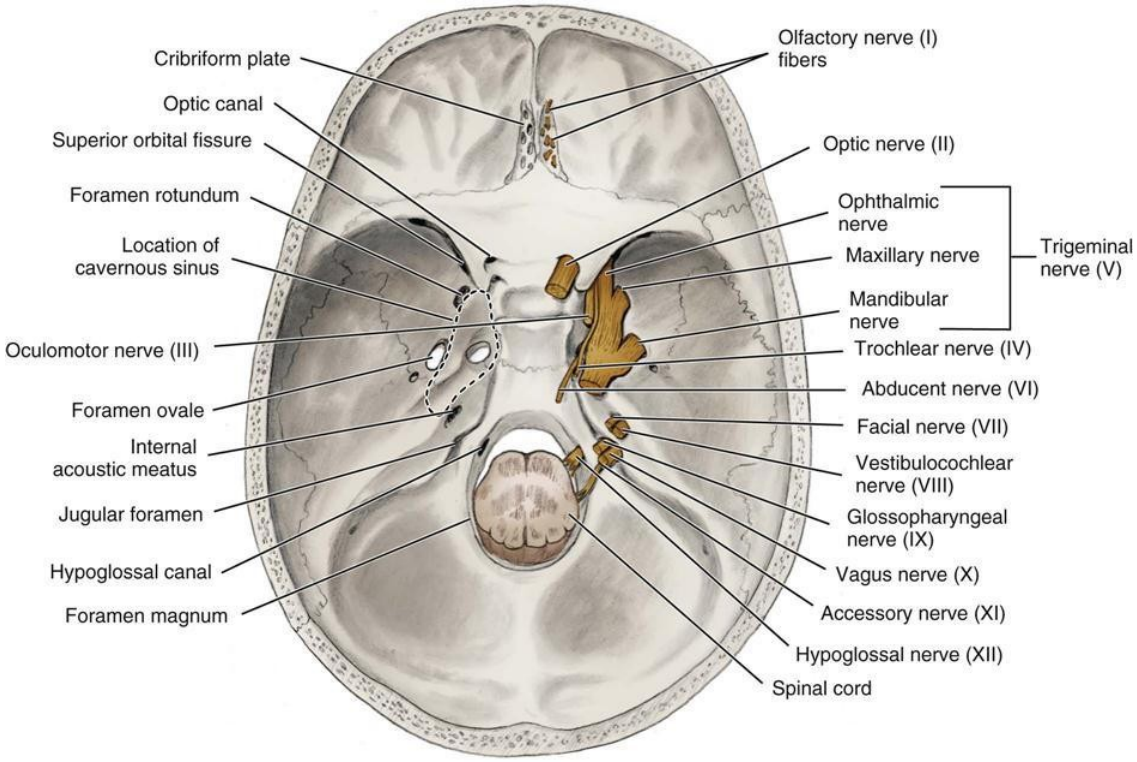

Figure 5 : schematic view of the skull base showing different cranial nerves [5] .

3.2. In the trigeminal cave (Meckel's cave)

The Gasserian ganglion rests on a bone depression of the antero superior face of the petrous bone. It is contained in a fibrous lodge: The Meckel cave, formed by a diverticulum of the Dura mater from the posterior fossa. This Dural diverticulum contains cerebrospinal fluid because the arachnoid sheath of the posterior root extends into the cavum to form the trigeminal cistern. The vascularization of the Gasserian ganglion is ensured by twigs of the small meningeal artery.

The Gasserian ganglion, or semilunar ganglion, presents:

- A convex anterior edge where the peripheral branches originate.
- A concave posterior edge from which emerge multiple radicles that cluster at the upper edge of the petrous bone to form the posterior root; between their emergence from the ganglion and the superior border of the petrous bone, they form a triangular plate, also called the "triangular plexus" because there are numerous anastomoses between them; this is a transition zone between the Gasserian ganglion and the posterior root proper; this triangular plexus is housed in the posterior part of the Meckel cave.
- An inferior surface, in relation to both the deep and superficial petrosal nerves running through the fibrous layer forming the floor of the Meckel cave, which covers the bone surface of the antero superior face of the petrous bone.
- An upper surface, adhering to the Dura mater of the ceiling of the Meckel's cave and connected, through it, with the infero internal edge of the temporal lobe.
- Within, the Gasserian ganglion is related to the lateral face of the cavernous sinus and to the intra cavernous carotid and ocular motor nerves, namely: oculomotor nerve (or third pair) and trochlear nerve (or fourth pair).
- In the outside, the ganglion is related to the trunk of the middle meningeal artery, located at its emergence from the small round hole through which it enters the skull, 3 mm in front of the lateral part of the ganglion.

Anatomical dissections under a microscope, stimulation and surgical section experiments have shown that there is a somatotopy of sensory fibers within the Gasserian ganglion and the triangular plexus. Thus, the contingent of the ophthalmic nerve is located at the upper part of the ganglion, the contingent of the mandibular nerve is at the infero-external part and the contingent of the maxillary nerve to be situated between the two.

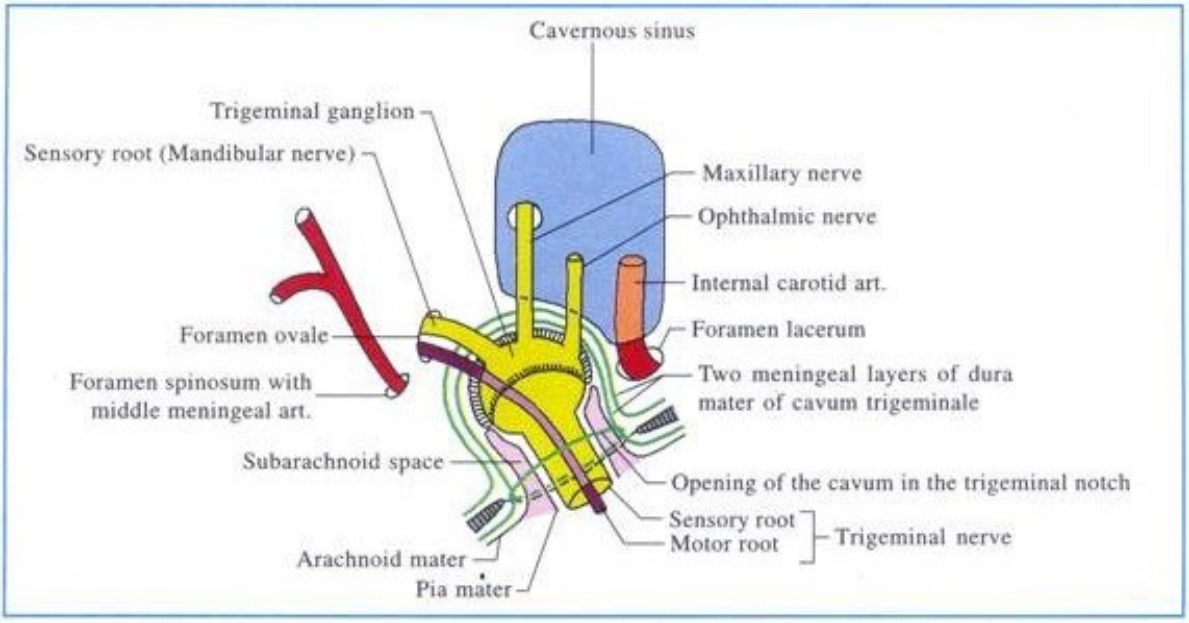

Figure 6 : Trigeminal ganglion in cavum trigeminale with relations (viewed from above). [6]

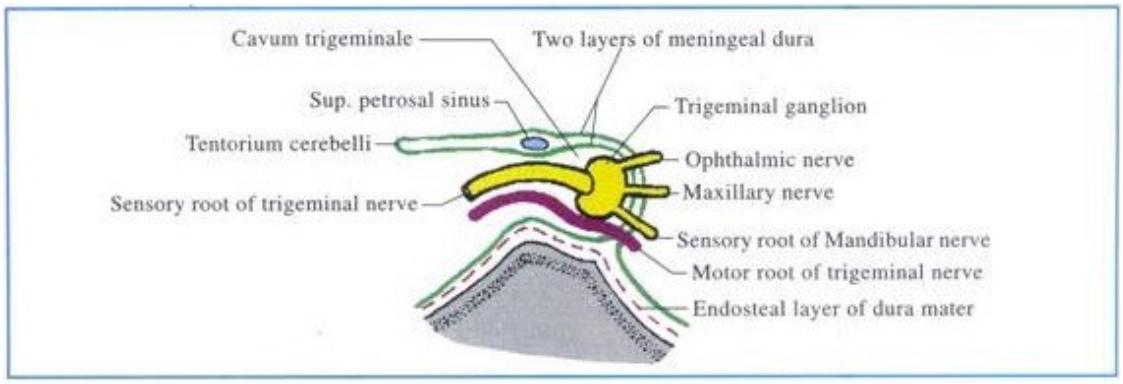

Figure 7 : A sagittal section through cavum trigeminale showing its boundaries and contents. [6]

3.3. At the superior edge of the petrous bone

At this level, the posterior sensory root that comes from the grouping of sensory rootlets of the trigeminal nerve will branch out to give birth of the trigeminal plexus next to the trigeminal incise and inside the Meckel's cave.

This plexus is limited by the great circumference of tentorium cerebelli, and the upper petrosal sinus.

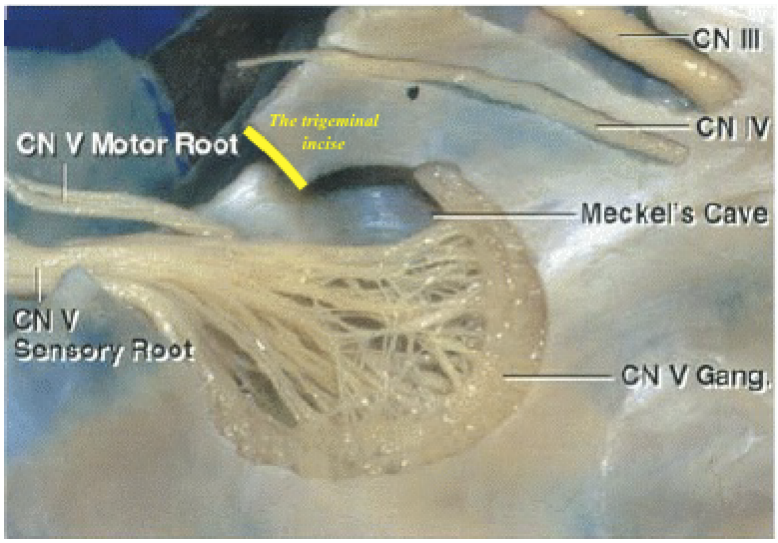

Figure 8 : Lateral view of the right trigeminal nerve. [7]

3.4. Cisternal segment in the posterior cerebral fossa

The portion of the trigeminal nerve, between its emergence of the trigeminal ganglion and its Pontic penetration, is called the Cisternal segment. This segment is also called Retro Gasserian portion.

The (CN V) is related Above and inside to:

The superior cerebellar artery which arises from the basilar artery and which bypasses the mesencephalon to go back to join the occipital lobe.

Also there is the trochlear nerve (CN IV) under the tentorium cerebelli.

Outside: We find the acoustic-facial bundle and the lower antero-inferior cerebellar artery which also arises from the basilar artery.

Also, in relation with the (CN V) we find the superior petrous veins which are going to drain in the superior petrous sinuses and which are going to be formed by the anastomosis of several venous confluences which are: the ponto-trigeminal vein, the transverse pontine vein and other veins with cerebellar destination.

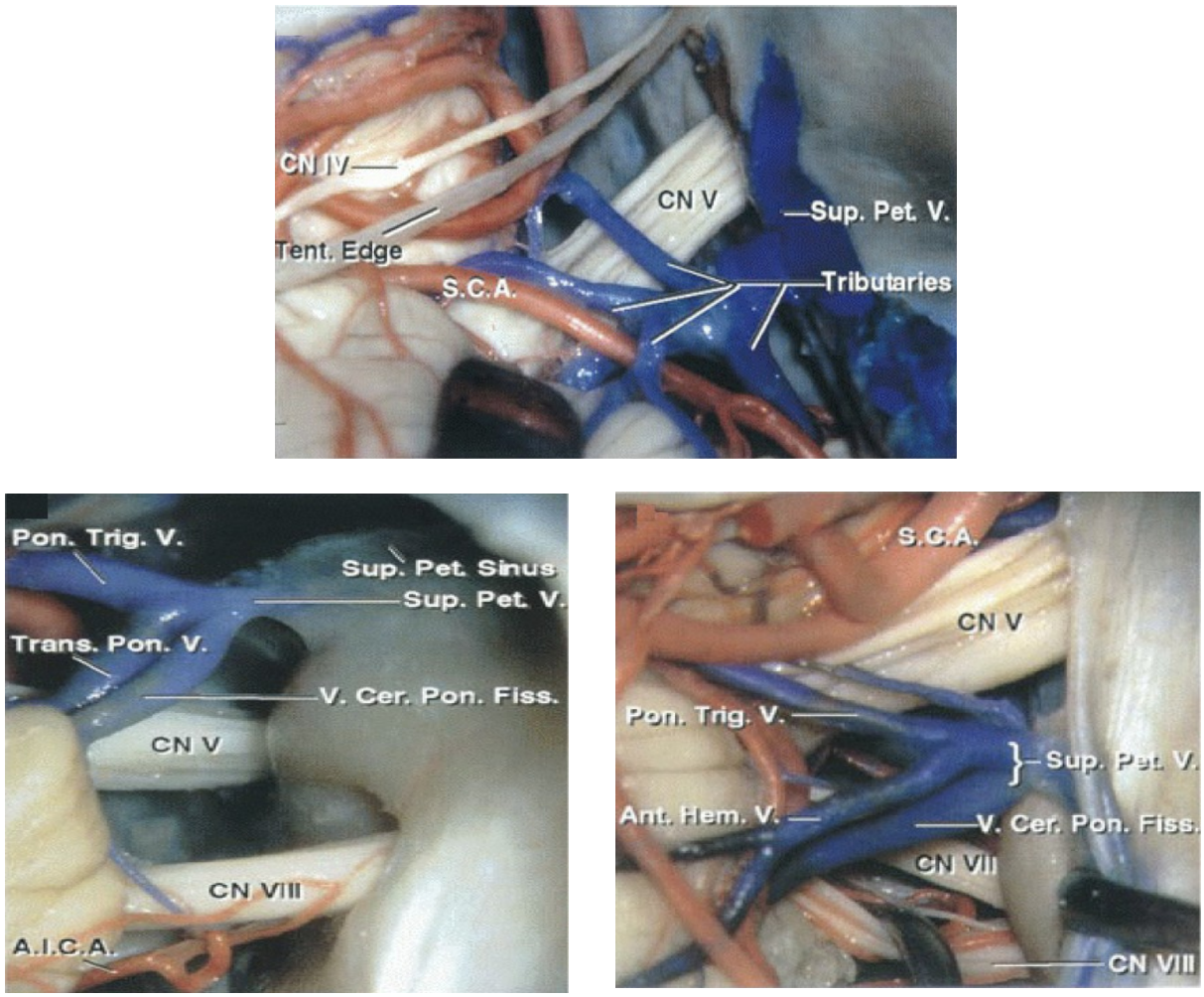

Figure 9 : Venous system in relation with the (CN V). [7]

It may exist at this level (Cisternal portion), a conflict between the trigeminal nerve and both the superior and antero-inferior cerebellar arteries, originating from the basilar artery, forming a loop near the nerve, responsible for trigeminal neuralgia.

We found also the superior petrosal veins that drain into the upper petrosal sinus.

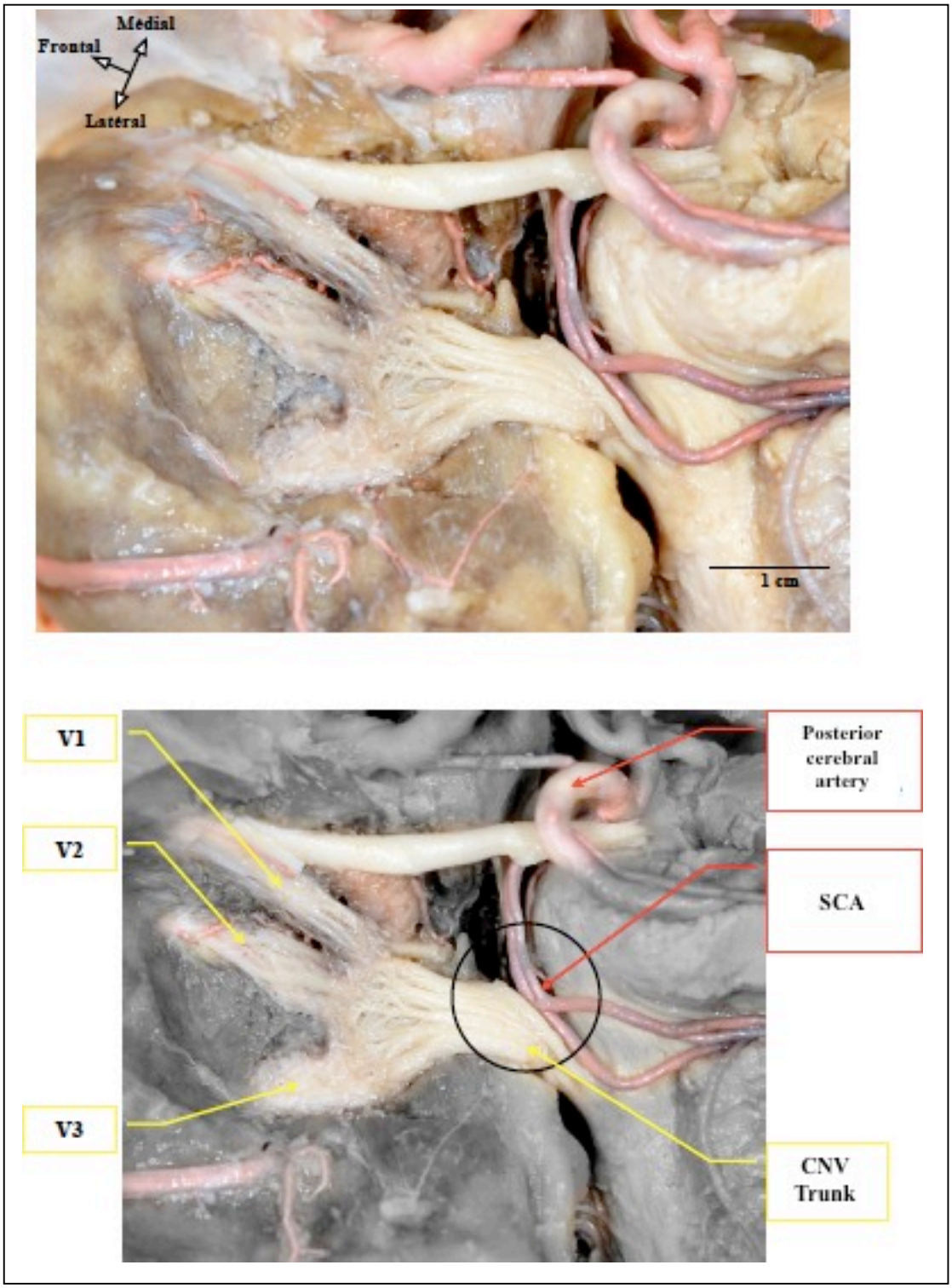

Figure 10 : Upper lateral side view of the left cerebellopontine angle [8].

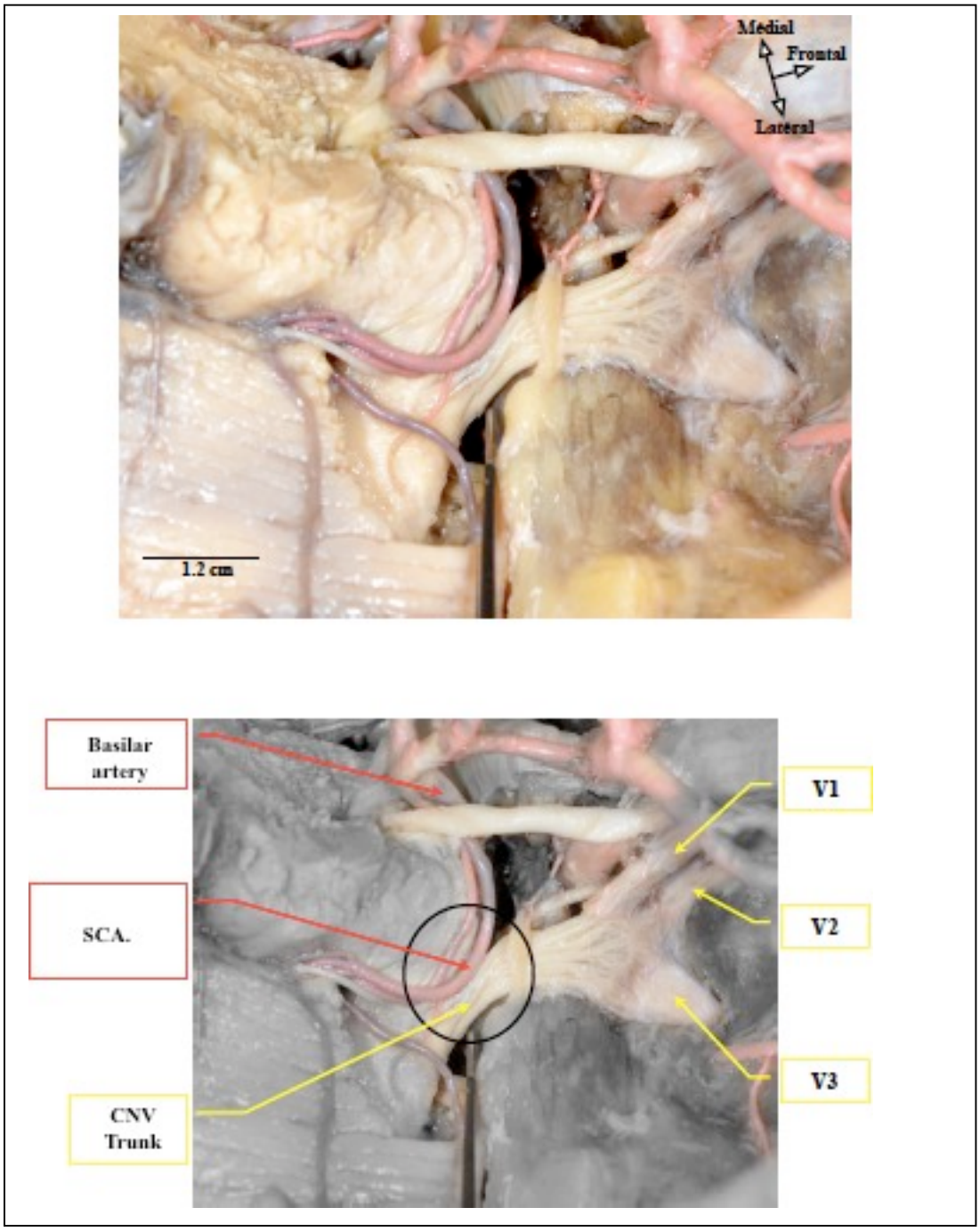

Figure 11 : Upper lateral side view of the right cerebellopontine angle [8].

4. Peripheral and terminal branches

Three major branches emerge from the trigeminal ganglion:

- The first division (**V1, the ophthalmic nerve**), exits the cranium through the superior orbital fissure and entering the orbit to innervate a territory of skin covering the anterior part of the temporal region, the forehead, the upper eyelid and the dorsum nasi. Its mucosal territory concerns the frontal sinus, the sphenoid sinus and the nasal septum.

Sensorial information from the bulbar and palpebral conjunctiva and from the cornea also passes through the ophthalmic nerve.

Branches: Nasocialiary nerve – Frontal nerve – Lacrimal nerve.

- The second division (V2, the maxillary nerve), exits through a round hole, the foramen rotundum, into a space posterior to the orbit, the pterygopalatine fossa, it re-enters a canal running inferior to the orbit, the infraorbital canal, and exits through a small hole, the infraorbital foramen, to innervate a territory of skin covering the middle part of the temporal region, the lower eyelid, the zygoma, the upperlip, the lateral part of the ala nasi, and the vestibule of the nasal fossa. Its mucosal territory concerns the soft and hard palate, the tubal orifice, the upper pole of the tonsil, the maxillary sinus, the gingiva and the maxillary alveoli and teeth.

Branches: Zygomatic nerve- Palatine nerve- Infraorbital nerve.

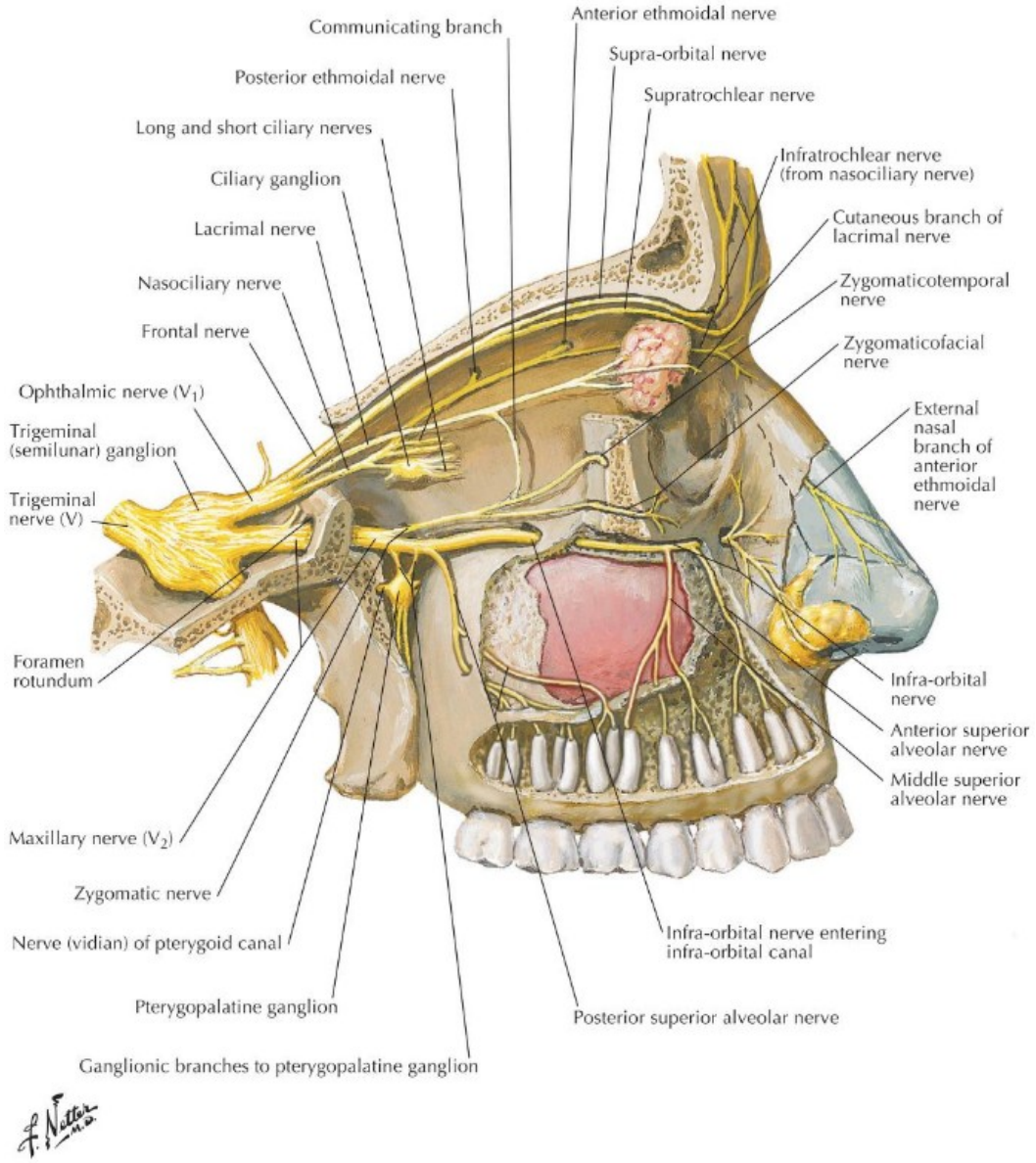

Figure 12 : The branches of the ophthalmic (V1) and the maxillary (V2) divisions of the trigeminal nerve [1].

- The third division (**V3, the mandibular nerve**), exits the cranium through an oval hole, the foramen oval.

It innervates a territory of skin covering the posterior part of the temporal region, the anterior part of the earlobe, the anterior and superior walls of the external ear canal, the lower lip and the chin. Its mucosal territory concerns the anterior two-thirds of the tongue, the medial aspect of the cheek and the floor of the oral cavity, the gingiva and the mandibular alveoli and teeth.

As mentioned before, the mandibular nerve also carries trigeminal motor fibers that innervate the masticator muscles (masseter, temporal, internal and external pterygoid, mylohyoid, anterior body of the digastric and the tensor palati).

Branches: Temporal nerves- pterygoid nerves- Lingual nerve- Inferior alveolar nerve.

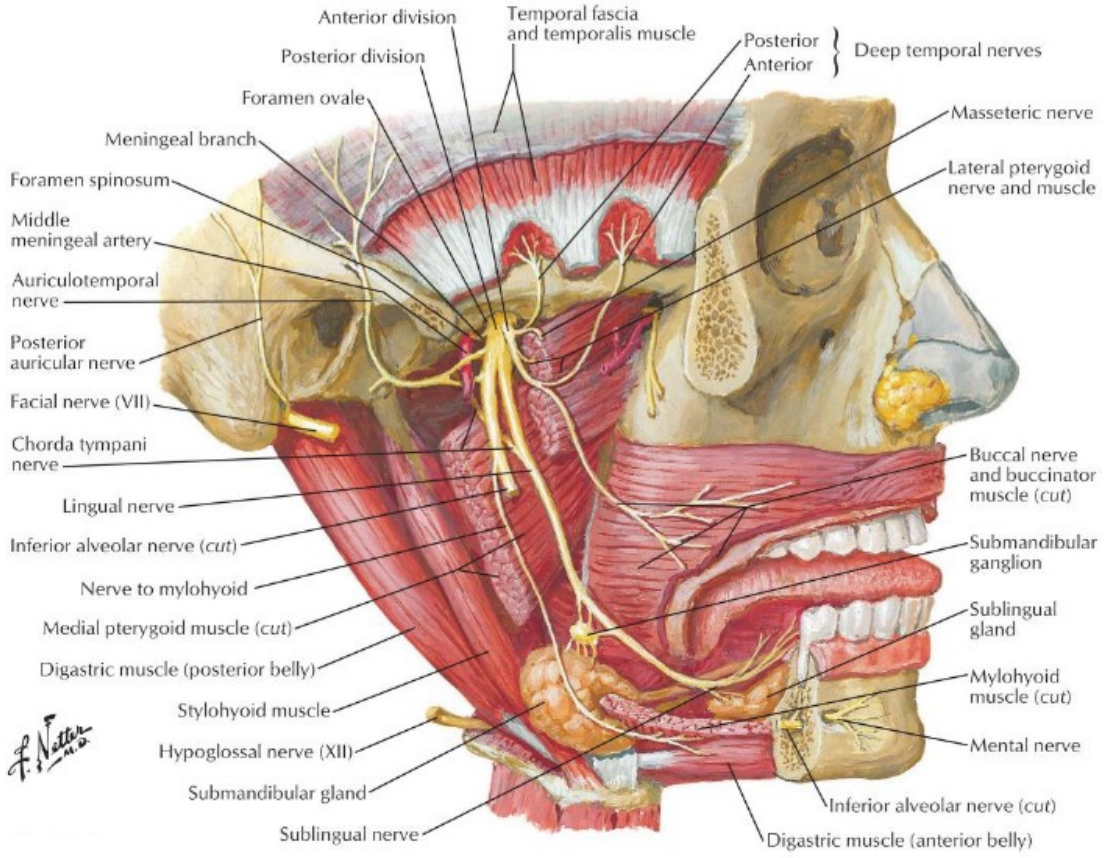

Figure 13 : The branches of the mandibular (V3) division of the trigeminal nerve [1].

5. Blood supply of the trigeminal roots

The root of the trigeminal nerve consists of the motor portion (root) and the sensory portion (root). Both roots are supplied by the trigeminal arteries, which may originate from the basilar artery and its side branches: the superior cerebellar artery, the posterolateral, superolateral and inferolateral pontine arteries, the trigemino-cerebellar and the anterior inferior cerebellar arteries (AICA).

Concerning venous supply, the trigeminal nerve is supplied by the largest pathway of the posterior fossa, the superior petrosal vein (Dandy's vein) and it branch (The lateral pontine vein), the transverse pontine vein as well as different branches of the Mesencephalic vein.

Any disruption of blood flow through the vertebral artery or posterior inferior cerebellar artery would interrupt the processing of sensory information from the trigeminal nerve.

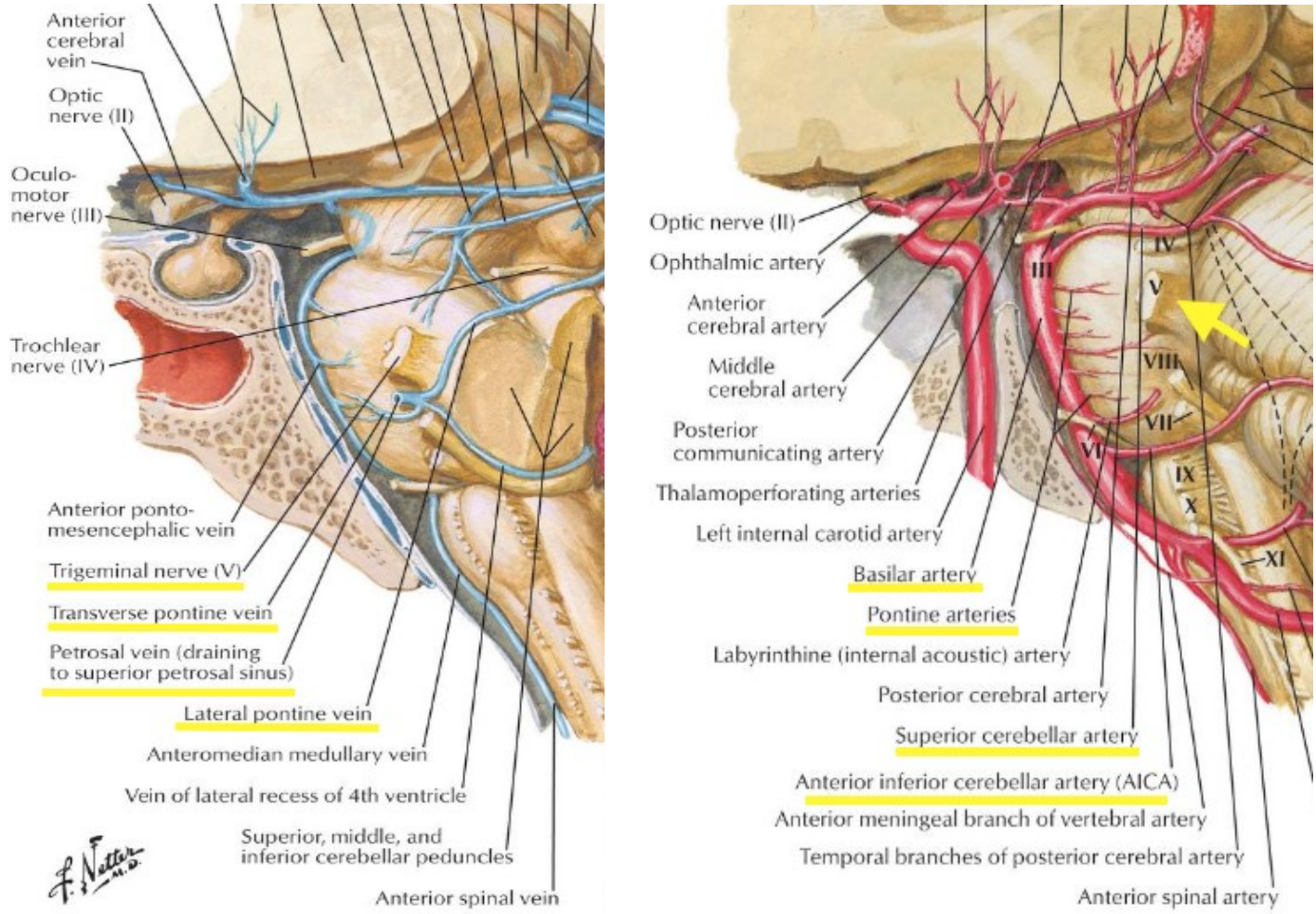

Figure 14 : The blood supply (Arterial & Venous systems) of the trigeminal roots [1].

II. History of the Trigeminal Neuralgia

Early descriptions of Trigeminal Neuralgia can be deducted from the writings of Hippocrates **(circa 460-377 BC)**, Galen **(circa 129-200 or 216 AD)**, Aretaeus of Cappadocia **(150 AD)** and Avicenna, but these descriptions were vague and not clearly corresponding with what we now call Trigeminal neuralgia.

The first suitable descriptions of TN as a clinical entity date back to **1671** by German physician Johannes Laurentis Bausch **(1605-1665)** suffering himself from the disease.

The first full description was given by philosopher and physician John Locke (1632-1704) in **1677**.

In **1756**, French surgeon Nicolaus Andre described trigeminal neuralgia as a convulsive behavior, saying that grimaces of facial pain of patients belongs to the type of diseases as tetanus or spasms, he believed that the cause was a local disease process or "vivous nervous liquids" irritating nerves and causing painful shocks.

He used the term *tic douleureux* to describe the pain his patients suffered from and facial spasms he documented.

Nearly seventeen years later after Andre's description, an English physician, John Fothergill, described trigeminal neuralgia in his book *medical observations and inquiries* in **1773** and presented it to the medical society of London.

He presented the condition as "a painful affection of the face" and not a convulsive disorder, affecting more elderly people especially women, he also affirmed that it could be related to tumors.

In **1778**, John Hunter, a British anatomist and surgeon, has more clearly characterized this pathology as a form of "nervous disorder" with reference to pain of the teeth, gums, or tongue where the disease "does not reside".

In **1782**, Thouret, a French physician, considered trigeminal neuralgia to be an affection of face nerves especially those in the distribution of the infra orbital and lower jaw.

In **1802**, Chaussier, a French physician, has given a classification of the pathology based on the three trigeminal divisions but included also the VIIth nerve.

Near the 1820s, Charles Bell, a Scottish anatomist and surgeon, admitted the separate functions of the 2 nerves and that trigeminal neuralgia was truly localized to trigeminal nerve.

In **1891**, Sir Victor Horsley, a British physician, proposed the first open surgical procedure for Trigeminal Neuralgia, involving the section of the preganglionic rootlets of the nerve.

In **1913**, Electrocoagulation of the trigeminal nerve as a way of treatment, was first described and attempted by A.Réthi.

In **1925**, Walter Dandy, an American neurosurgeon, preconized the partial sectioning of the nerve in the posterior cranial fossa.

In that procedure, he found out that the nerve was being compressed by vascular loops, he noted that, "The sensory root is frequently indented, lifted up or bent at an angle by the artery", "This I believe is the cause of tic douleureux".

In **1931**, Kishener developed a stereotactic approach for insertion of an insulated needle through the foramen ovale for electrocoagulation of the Gasserian Ganglion using monopolar cautery.

In **1967**, With the help of the operative microscope, Peter Jannetta, an American neurosurgeon, confirmed the theory of Walter Dandy.

It was W. Gardner who was the first, to perform a decompression of the trigeminal sensory root by moving the artery away from the nerve without sectioning the nerve root.

Later, Jules Hardy, a Canadian physician, will modify the technique of Jannetta by adopting the retro-mastoid pathway while the French Neurosurgeon Marc Sindou will help to codify the MVD technique that we know today.

In **1971**, Lars Leksell, a Swedish neurosurgeon, used stereo tactically focused radiation (Gamma Knife technique) targeted to the trigeminal ganglion in order to treat a small number of patients with TN.

In **1974**, Sweet and Wepsic introduced radiofrequency thermal lesioning of preganglionic trigeminal rootlets.

In **1983**, Mullan and Lictor introduced percutaneous balloon compression of the Gasserian ganglion as a way of treatment and refined in **1996** by Brown and colleagues.

III. Epidemiology of the Trigeminal Neuralgia

This rare pathology alone represents 80% of all facial pain. Its incidence in the population seems to be changing since the advent of new retrospective studies.

The first studies referencing classical trigeminal neuralgia estimated about 4 new cases per 100,000 inhabitants per year [9].

New studies have shown that the prevalence of classical neuralgia was fluctuating depending on the region of the world in which one was located and the samples studied. However, several studies show incidences ranging between 10 and 25 new cases for 100.000 inhabitants per year [10] [11] [12].

Most of the time, it occurs in individuals with ages over fifty years.

The National Institute of Neurological Disorders and Stroke (NINDS) notes that trigeminal neuralgia is more common in women than men.

Additionally, there is evidence that the disorder runs in families, likely as a result of an inherited blood vessel formation. [13]

IV. Clinical description of the Trigeminal Neuralgia

We define two main types of trigeminal nerve algies based on clinical semiology and etiology of the neuralgia:

- The essential (classical) neuralgia (also called type 1 or typical neuralgia).
- The symptomatic neuralgia (also called type 2 or atypical neuralgia).

The International Headache Society (IHS) issued the following definition of typical trigeminal neuralgia. [14]:

Paroxysmal seizures of facial pain lasting for few seconds to less than 2 minutes, affecting one or more branches of the trigeminal nerve and meeting the following criteria:

- Severe intensity, acute, superficial, "Electric shock-like, shooting or stabbing"
- Provoked by stimulation of a trigger zone or by triggering factors (shaving, tooth brushing, …).

- The crisis is stereotyped for each patient.
- It may develop without apparent cause or be a result of another diagnosed disorder.
- Trigeminal neuralgia is defined by four clinical elements : characteristics of the pain, topography, triggers, and negativity of the neurological examination.

1. Characteristics of the pain

The pain is intense and paroxysmal, in form of electric shocks (typical- type 1).

It can be sometimes described as a grinding or tearing sensation, more rarely as a burning sensation (type 2).

Intensity of the pain can be noted for each patient according to the BNI score (Barrow Neurological Institute) before surgery or in postoperative follow-up.

Table I: Barrow neurological institute score for pain intensity.

Score	Pain description
I	No pain, no medications
II	Occasional pain, no medications required
III	Some pain, adequately controlled with medications
III a	No pain, continued medication
III b	Persistent pain, controlled with medication
IV	Some pain, not adequately controlled with medications
V	Severe pain or no pain relief

The painful attacks are brief, of the order of a second, but they can be grouped into bursts that last 1 to 2 minutes. The beginning and the end of the crisis occur suddenly.

The frequency of these attacks determines the severity of the disease; it is variable and can reach up to ten per day in benign forms. There are rare advanced evolved forms, consisting of subintractive attacks (painful attacks so close that one begins when the previous one is not yet finished).

The pain mostly occurs in daytime and does not seem to interfere with sleep.

The intensity of the pain is always very important and mostly described as unbearable.

During the attack, the patient stops and ceases all activity, tenses, with a clone discharge at the hemi face, performing the "tic pain" (motor reflex).

Some violent attacks maybe accompanied by vasomotor phenomena:

- Congestion of the hemi face,
- Conjunctival injection,
- Lacrimal, nasal or oral hyper secretions.

2. Topography

This pathology, almost always unilateral, can affect one or more branches of CNV. However, if the neuralgia affects only one territory of the trigeminal nerve, it can finish by touching a second one.

The most affected branch in 35% of cases is the V2 followed by the V3 (29%) and more rarely the V1 (4%). It is also possible to have two affected territories concomitantly (about 19% of cases) [15].

It seems that the right side is more often affected by approximately 60% against 40% in the left side [16].

3. Triggering factors

The factors triggering the pain are characteristic but they can sometimes be absent. The Pain can be triggered directly by physical stimulation or by indirect provocation.

The direct stimulation is done on a cutaneous large territory, more rarely mucous, called "trigger zone".

Indirect stimulation occurs during everyday movements: Smiling, Talking, brushing teeth, …

Thermal and electrical impulses are generally ineffective.

4. Negativity of the neurological examination

This fourth semiological element is essential to make the diagnosis of type 1 trigeminal neuralgia. The purpose of the neurological examination is to check the absence of any signs of neurological deficit. If it is not the case, the diagnosis of type 2 trigeminal neuralgia can be made.

This neurological examination consists of looking for the absence of hypoesthesia in the territories innervated by the CNV as well as the absence of pyramidal or cerebellar syndromes.

Table II: Comparison of type 1 and type 2 trigeminal neuralgia.

	Type 1 neuralgia	**Type 2 neuralgia**
Patient's age	- Usually around 50 years old and above	- Usually around 50 years old and above
Characteristics of the pain	- Paroxysmal - Stabbing - Electric charge of few minutes	- Burning sensation/ Tingling - Continuous pain
Topography	- Affects one or more territories of the CNV - Unilateral	- Affects one or more territories of the CNV - Bilateral
Triggering factor	- Direct stimulation (trigger zone) - Indirect stimulation : speaking, …	- No trigger zone
Neurological exam	Normal	- Sensory trouble - Motor trouble

5. The IHS classification of the trigeminal pain

1. Trigeminal neuralgia
1.1. Classical trigeminal neuralgia
1.1.1. Classical trigeminal neuralgia, purely paroxysmal
1.1.2. Classical trigeminal neuralgia with concomitant continuous pain
1.2. Secondary trigeminal neuralgia
1.2.1. Trigeminal neuralgia attributed to multiple sclerosis
1.2.2. Trigeminal neuralgia attributed to space-occupying lesion
1.2.3. Trigeminal neuralgia attributed to other cause
1.3. Idiopathic trigeminal neuralgia
1.3.1. Idiopathic trigeminal neuralgia, purely paroxysmal
1.3.2. Idiopathic trigeminal neuralgia with concomitant continuous pain
2. Painful trigeminal neuropathy
2.1. Painful trigeminal neuropathy attributed to herpes zoster
2.2. Trigeminal post-herpetic neuralgia
2.3. Painful post-traumatic trigeminal neuropathy
2.4. Painful trigeminal neuropathy attributed to other disorder
2.5. Idiopathic painful trigeminal neuropathy

V. Imaging and Trigeminal Neuralgia

The positive diagnosis of essential neuralgia is primarily clinical and requires no further examination in theory.

However, thanks to its better differentiating properties between tissues and its non-ionizing character, the MRI is the gold standard radiological examination to help give the appropriate diagnosis and has almost overcome CT that is used only if MRI is contraindicated for the patient.

The CT protocol should be including (after IV administration of iodinated contrast material) helical or volume acquisition scans from the orbital roof to the mandibular symphysis with a slice thickness under 3mm and no inter slice gap. Coronal, axial and sagittal plane reconstructions should be performed.

CT scan is supplementary to MRI for tumors located in the skull base.

An accurate MR imaging 1,5T with signal's digital transmission shows higher clarity.

The MRI is performed in order to highlight mainly: [17] [18]:

- An Inflammatory cause like multiple sclerosis or infectious lesions, vascular or ischemic lesions (Stroke, cavernous venous malformation …) and the brain stem tumors (gangliomas, metastatic disease, …).
- The affections of the Cisternal segment of CNV and Meckel's cave: showing a neurovascular conflict (Degree, nature of the compressing vessel, location along the nerve) in classical TN or a tumor neoformation (meningiomas, schwannomas …)
- A malformation of the base of the skull or the occipitocervical hinge (Arnold-Chiari malformation).
- In order to highlight the neuro-vascular conflict, the MRI must have special sequences that are complementary. The use of 3D-T2-high-resolution sequence makes it possible to obtain millimeter-order fine-T2-weighted images. They present a good contrast between the cerebrospinal fluid that appears in hyper signal and the vasculonervous structures that appear in hypo signal. These sequences are designated in different ways

according to the constructors:

- CISS: construction interference in steady-state, at Siemens®;
- FIESTA: fast imaging emplying steady-state acquisition, at GE Medical Systems®;
- DRIVE: drive equilibrium, at Philips®.
- SPACE: Sampling perfection with application-optimized contrasts by using different flip angle evolution.

The 3D-T2 sequence must be completed by an angio-MR-time-of-flight (ARM-TOF), which offers good visualization of the hyper signal arteries contrasting with the hypo signal cerebrospinal fluid. The nerves are distinguished by an intermediate signal. Thus, this sequence makes it possible to make in evidence the arterial images in hyper signal, and differentiates the nerve elements from the arteries. It is possible to suppress visibility of the venous network by applying a higher presaturation band. The 3D-T1 with gadolinium-enhanced sequences combined with the 3D time-of-flight (TOF) angiography, make it possible to visualize the venous structures in hyper signal.

The imaging features for the diagnosis of the trigeminal neuralgia caused by a neurovascular conflict are:

- The contact at the TZ between central and peripheral myelination of CNV.
- Atrophy and displacement of the nerve.
- The offending vessel is an artery.
- The contact is perpendicular.

MRI can be used also for post surgical control of the microvascular decompression and evaluate the results of the procedure (Teflon® pad being hypo intense on CISS sequences).

Concerning Multiple sclerosis, in the acute phase, lesions show high signal intensity on T2 and FLAIR and low-intermediate signal intensity on T1 images with enhancement after the administration of marker (Gadolinium). In the chronic phase, lesions are hypo intense on T1 (image of a black hole) and no enhancement after Gadolinium injection.

In case of hemorrhagic lesions, T2 imaging protocol should be included to view the 'bloom' effect of the hematic component.

In most of time, Tumors appear as isointense or hypo intense on T1-weighted images and hyper intense on T2-weighted images as well as an avid enhancement after contrast injection and must be completed by a CT scan adding important diagnostic information.

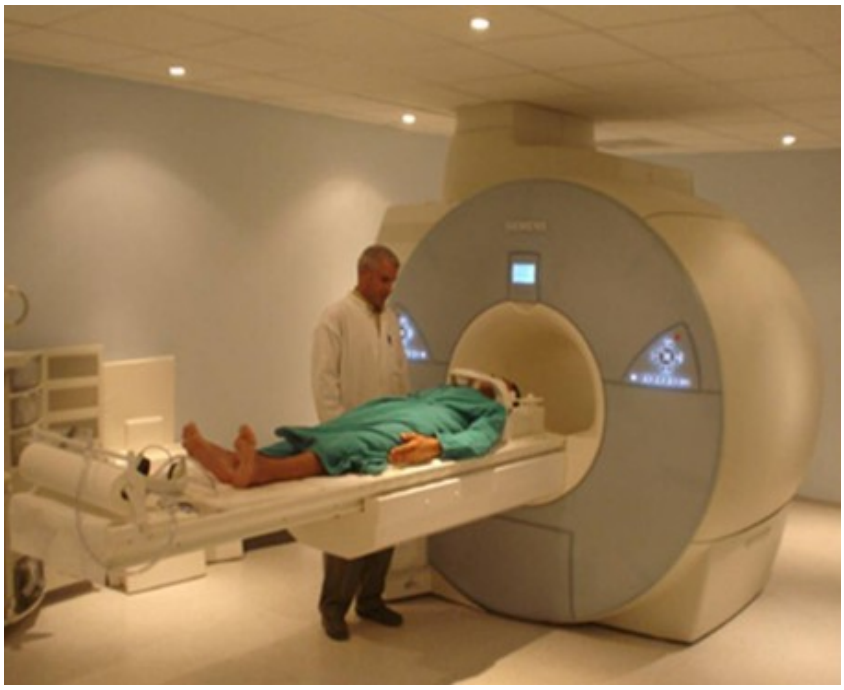

Figure 15 : Photo of MRI 1,5 tesla taken in Hassan 2 foundation in HSR Rabat [19].

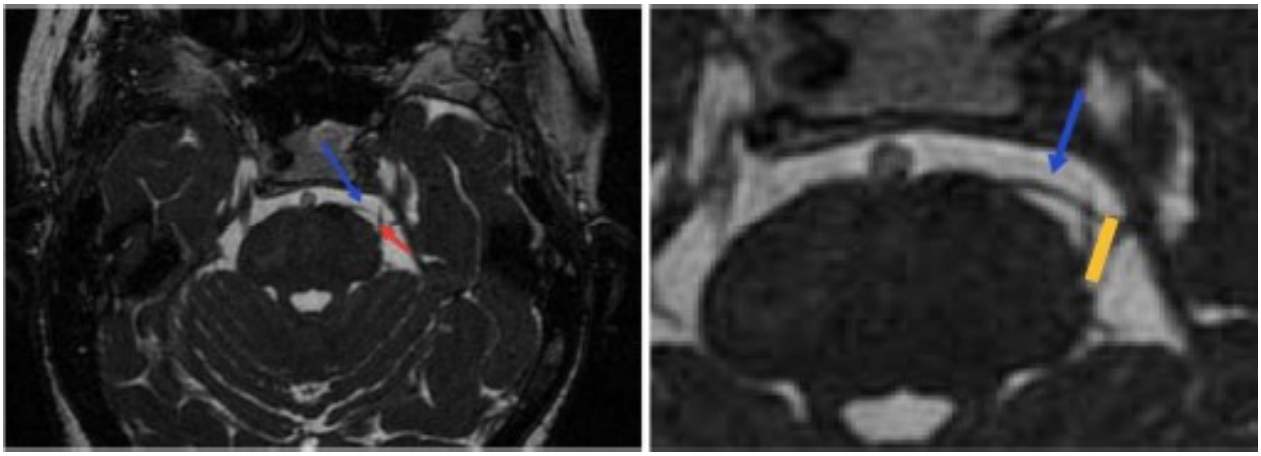

Figure 16 : Axial section of a voluminal T2 sequence showing a cross-section at right angles to the left V (blue arrow) by a vascular structure (red arrow) at the level of REZ measured at 5mm from its emergence (yellow line). [19].

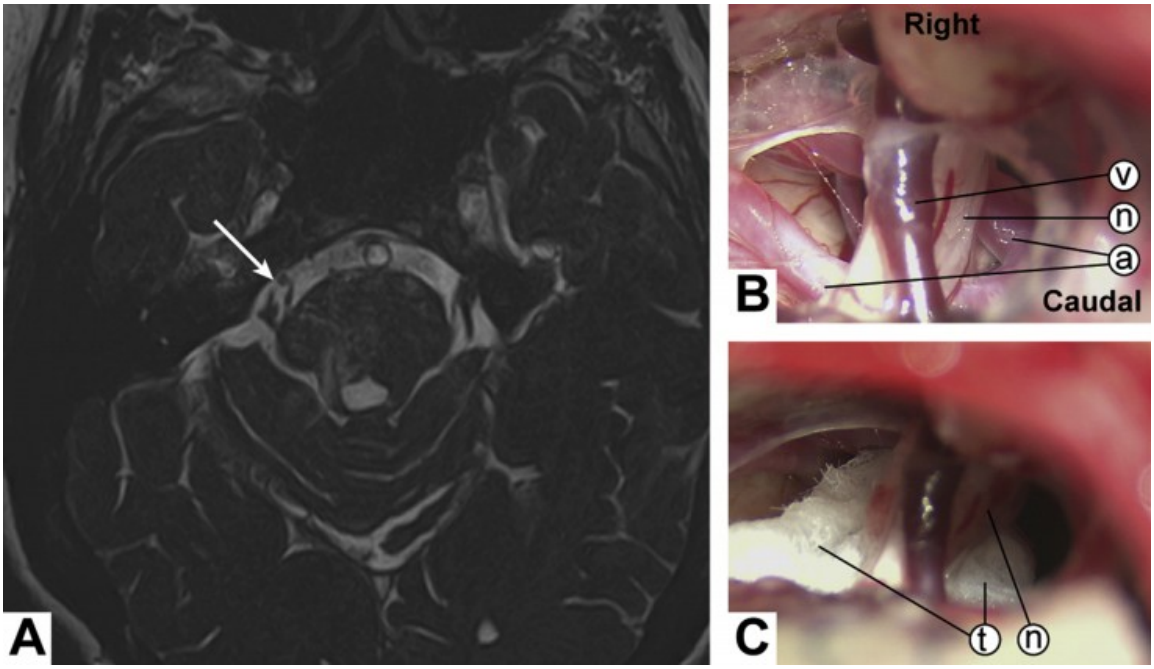

Figure 17 : True positive MRI and intraoperative findings showing a NVC.

A= Neurovascular conflict on the right side (arrow). B= Intraoperative photograph of the SCA (a) Ventral to the trigeminal nerve (n), with the petrosal vein (v) lying posterior to the nerve. C: Teflon® sponge barrier **[20].**

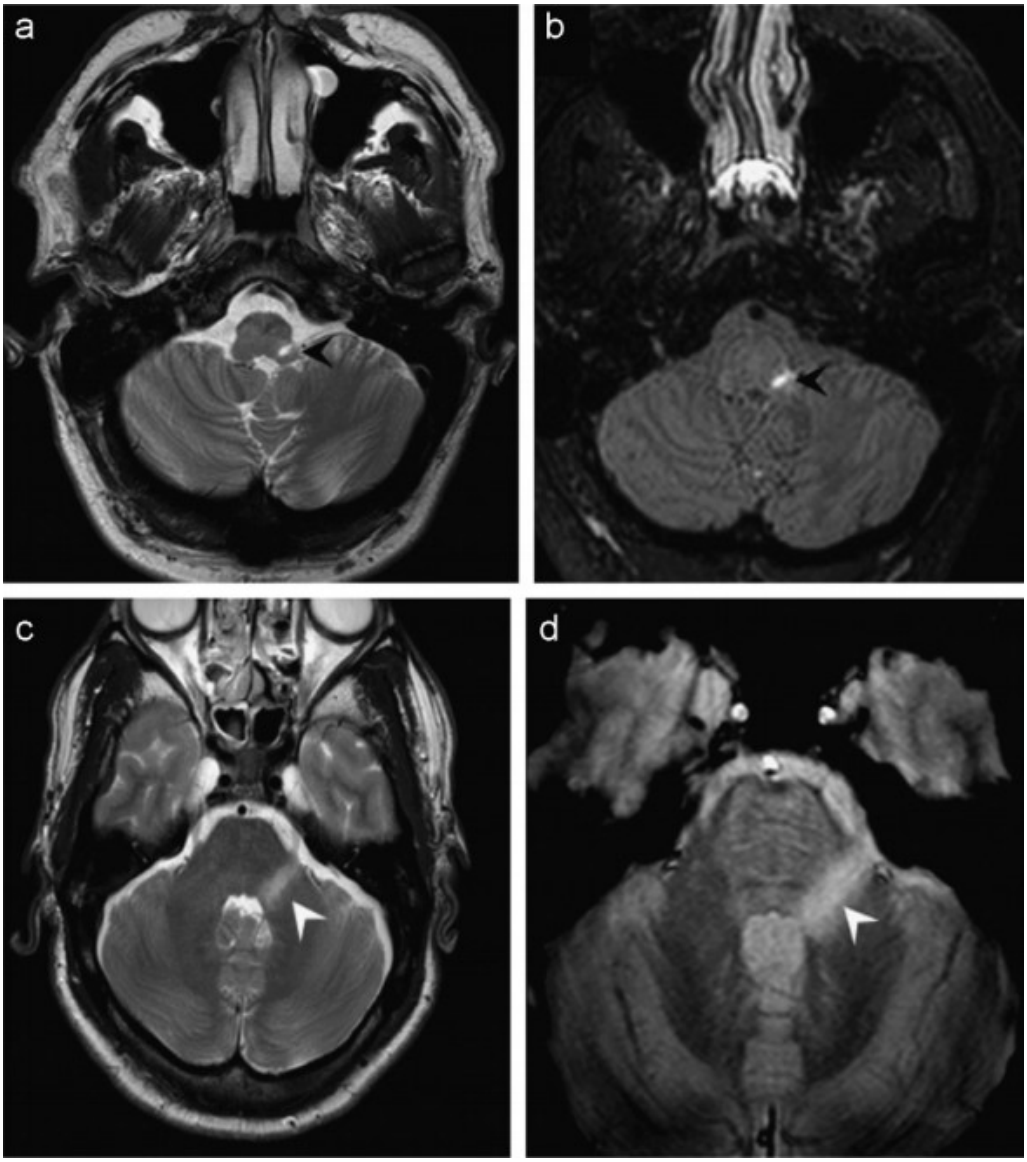

Figure 18 : MRI images showing MS lesions [21].

(a) A linear plaque in the intrapontine fasicular part of the trigeminal nerve (black arrowhead)-T2-weighted image, (b)Gadolinium-enhaced T1-weighted image, (c) A lesion in the spinal nucleus and tract (white arrowhead)-T2-weighted image, (d) m-FFE.

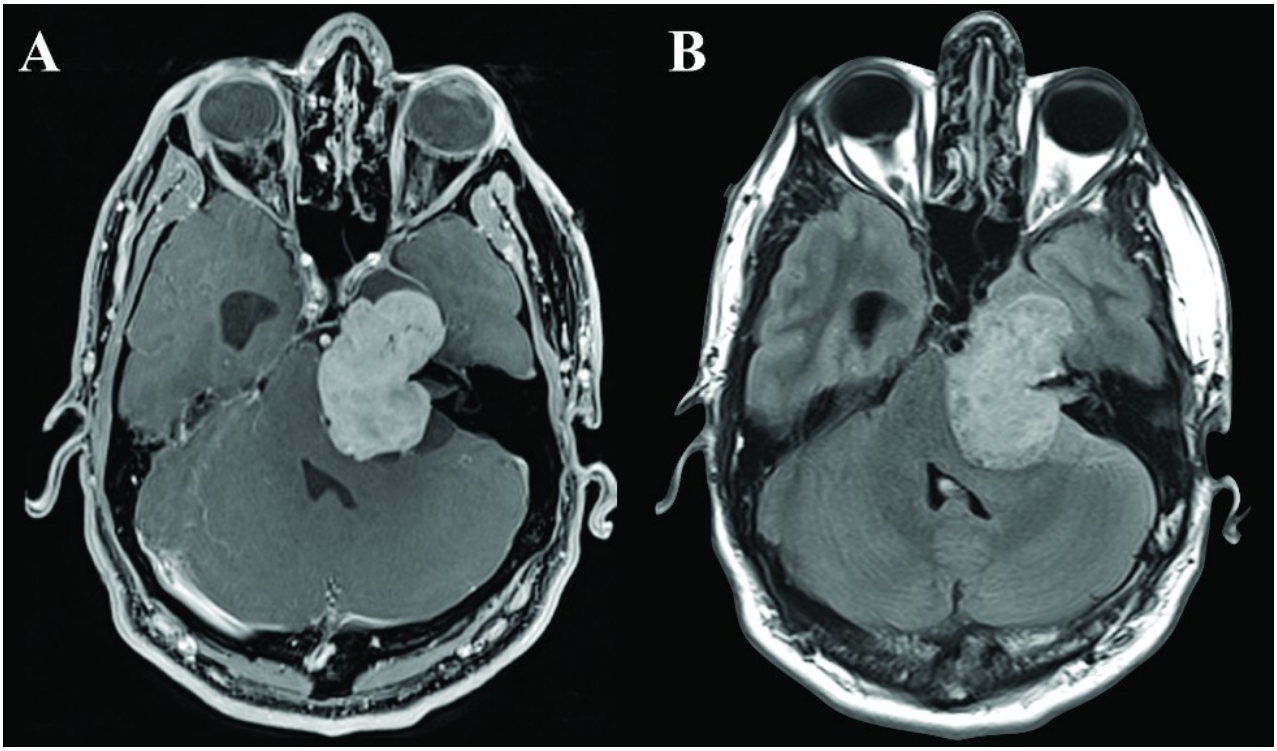

Figure 19 : Trigeminal schwannoma: Magnetic resonance imaging (MRI) revealed a contrast-enhancing T1 hypo intense (A) and a fluid-attenuated inversion recovery (FLAIR) hyper intense (B) mass in the left middle and posterior fossa. [22]

VI. The pathophysiology of the Trigeminal Neuralgia

The pathophysiology of the disease remains very controversial because, for a long time, it was completely unknown, however, today, with the modernization of imaging techniques, two main hypotheses have been retained [23]:

- The peripheral hypothesis: One or several surrounding anatomical structures could come to compress the root of the trigeminal nerve and would be the origin of the neuralgia.
- The central hypothesis: a paroxysmal activity in the brain structures upstream of the brainstem or even within the central trigeminal system could lead to a crisis similar to that of epilepsy in the trigeminal nerve thus causing facial neuralgia.

Even if nothing completely validates this theory, it seems that in most cases the etiology is ultimately a mixture of these two hypotheses: the demyelination of the trigeminal nerve root by peripheral structures, such as an artery, would lead to reduction of the corresponding nervous message.

In response to this disorganization of the afferent message, there is a hyper excitability of central neuronal system, causing an electrical discharge, resulting in neuralgia.

VII. Etiology of the Trigeminal Neuralgia

Most authors agree that ipsilateral neurovascular compression is the cause of TN.

It was Dandy, a surgeon who in 1929 was the first to observe the presence of vessels compressing the nerve at the level of the cerebello-Pontine angle or root entry zone (REZ).

This idea was then re-introduced in the second half of the 20th century by Jannetta who added that the vascular compression site could be located in the transition zone between central and peripheral type myelination.

It is the cerebello-Pontine angle that is admitted as a marker between the central portion and peripheral portion of the nerve. We thus understand that the junction between the two types of myelination (proximal oligodendrocyte-myelinated component and distal Schwann cell-myelinated component) is not always perfect, explaining that a vessel located at this transition zone (TZ or Obersteiner-Redleich zone) may cause nerve damage and therefore generate a TN.

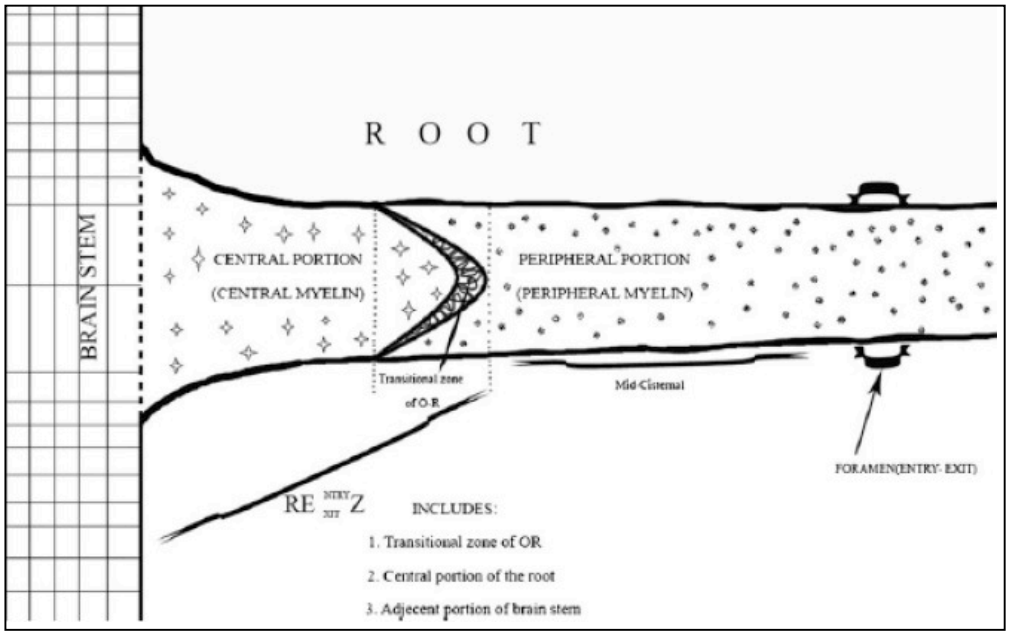

Figure 20 : The root entry/exit zone (REZ), which can be considered as consisting of three components:(1) transitional zone of Obersteiner-Redlich, (2) central myelin portion of the root, (3) adjacent portion of the brainstem [8].

The arguments in favor of the NVC theory are numerous. First, modern imaging techniques as well as observations made during direct-approach surgeries (when treating TN) show the presence of a neurovascular conflict in 88% of cases [24] [25].

This compression seems to be due in general to an abnormal position of a vessel (vascular loop) and more rarely to a malformation of a vessel at the level of the cerebellopontine angle. The vessel involved appears to be the superior cerebellar artery in 88% of cases, the anteroposterior cerebellar artery in 25.1% of cases, a satellite vein of the trigeminal nerve in 27.6% of cases, or another artery in 3.5% [24] [26], An ectasis of the basilar artery can also be implicated but this fact is extremely rare.

Thanks to a prospective study done by M.Sindou [26] concerning 560 patients presenting TN due to NVC we have the following classification of the neurovascular conflict:

- Type 1: The vessel or vessels are in contact with the root of the nerve without deformation of the nerve, this represents 17,6% of the population.
- Type 2: The vessel or vessels cause displacement or deformation of the root of the nerve. It represents 49.2% of the population.
- Type 3: The vessel indenting the nerve root causing nerve atrophy, compression can be described as severe. It represents 33.2% of the population.

DeSouza *et al.*presented an update to M.Sindou's classicifation [27]:

- Type 1; Proximity of the vessel to the TN.
- Type 2: Contact without any disturbance between the vessel and the nerve.
- Type 3: The vessel is compressing the nerve.
- Type 4: Distortion and indentation of the nerve.

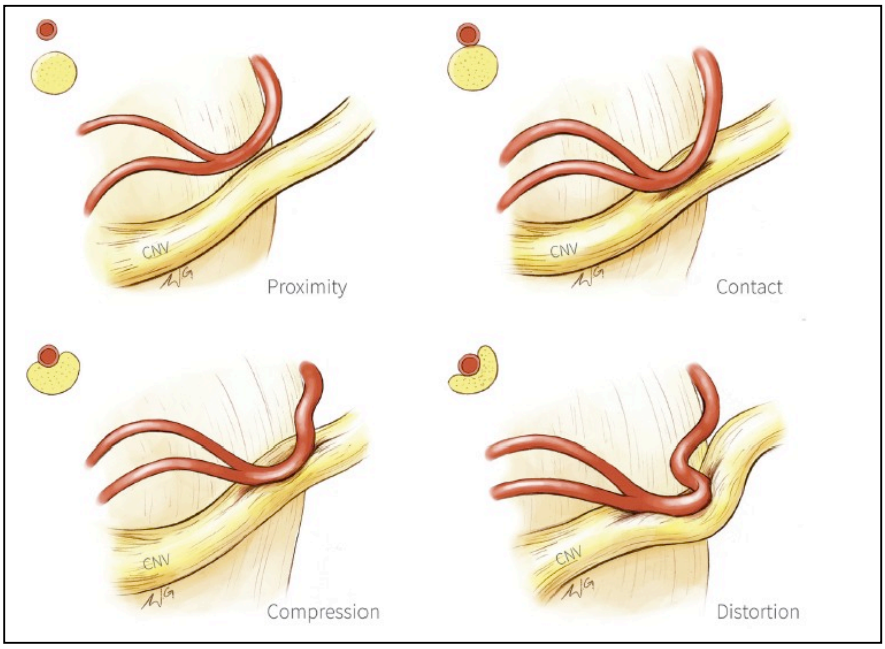

Figure 21 : Different types of trigeminal neurovascular conflict [27).

Table III: The involvement rate in a neurovascular conflict of different vessels through five studies in the context of essential neuralgia of the trigeminal nerve. [8]

Artery	Barker, 1996 (1204 cases)	Apfelbaum, 2000 (406 cases)	Li, 2004 (62 cases)
Superior cerebellar	75%	75%	58%
Anterior inferior cerebellar	10%	15%	39%
Posterior inferior cerebellar	1%	Data not available	13%
Basilar	1%	1,5%	Data not available
Vertebral	2%	Data not available	Data not available
Labyrinth	Less then 1%	Data not available	Data not available
Unspecified small	15%	Data not available	Less then 1%

It also appears that

- Arachnoiditis
- An atrophy of the nerve root
- A marked angulation of the nerve at its crossing with the edge of the petrous bone

Can be implicated.

These abnormalities may be associated with TN [26].

Also, due to aging, vessels become larger (megadolichoarteries) and their walls become thicker under the effect of atherosclerosis. Hypertension and hypercholesterolemia are also risk factors of TN. [26].

The association between TN and multiple sclerosis (MS) has now been established for years since a patient with MS has a significantly increased risk of developing trigeminal neuralgia: 1 to 7% of patients with MS develop a TN.

This shows that demyelination plays an important role [25] [28].

Also, despite their rarity, representing less than 0,5% of histologically proved intracranial tumors, primary tumors of the CNV and Meckel's cave are not to be forgotten etiologies, one third of these lesions are trigeminal schwannomas with the remainder consisting of meningiomas, lipomas, and epidermoid tumors [29]

VIII. Differential diagnosis of the Trigeminal Neuralgia

Pathologies causing oro-facial pain are numerous and complex, their symptomatology diverges according to their etiology.

The main differential diagnosis of TN is the painful trigeminal neuropathy which corresponds to the former trigeminal neuropathies and secondary trigeminal neuralgia, it is related to a compression, irritation, destruction or demyelinization of the trigeminal nerve, that is not secondary to neurovascular compression.

The IHS defined the painful trigeminal neuropathy regarding the etiology given rise to the neuropathy, namely: The multiple sclerosis and the Post herpetic neuralgia: continuous pain, tingling, related to a history of zoster (migration of varicella zoster virus from the Gasserian ganglion to the pontine sensory fibers), often V1 is affected.

Other differential diagnoses:

- Cluster headache: Orbital longer lasting pain, causes patient to wake up from sleep, autonomic symptoms.
- Hemorrhagic lesions of brainstem.
- Short-lasting Unilateral Neuralgiform headache attacks with Conjunctival injection and Tearing: Ocular, autonomic symptoms.
- Glossopharyngeal neuralgia: Pain in tongue, mouth or throat triggered by swallowing, talking or chewing.
- Intracranial tumors.
- Listeria Rhombemcephalitis
- Neuralgia of CNVII.
- Atypical odontalgia.
- Migraine: Pain is longer lasting with photophobia and phonophobia, in relation with family history.
- Sinusitis.
- Paroxysmal hemicranias: Pain in forehead or eye, autonomic symptoms, responds to treatment with indomethacin.

Patients & Methods

I. Objectives of the study

- To review surgical treatment modalities of the classical trigeminal neuralgia.
- Compare the efficacy of each surgical technique in short and mid-terms.
- Identify the side effects of each surgical technique and draw conclusions.

II. Presentation of the study

It is a retrospective study done at the neurosurgery department of "Hôpital des spécialités" in Rabat, reviewing 101 cases of patients who underwent between the year 1993 and the year 2018 a surgical treatment of classical trigeminal neuralgia using microvascular decompression, percutaneous radiofrequency thermocoagulation or percutaneous balloon compression of the Gasserian ganglion.

All data were obtained by reviewing patients' clinical observations as well as their chart records and calling up patients for follow-up.

1. Inclusion criteria

Are included in the study:

- Patients having a classical trigeminal neuralgia resistant or intolerant to medical treatment.
- Patients operated.

2. Exclusion criteria

The number of patients found in the database, hospitalized for a trigeminal neuralgia symptomatology, was 111 patients.

10 patients were excluded because of the following reasons:

- Patients with images of tumors or inflammatory abnormalities in CT scan or MRI...
- Incomplete data in medical files.
- Non operated patients.

III. Evaluation criteria

In this study, we compare percutaneous radiofrequency thermocoagulation, percutaneous balloon compression of the Gasserian ganglion and microvascular decompression in short and mid-terms.

- The range of short-term follow-up period was 3 months after surgery.
- The range of mid-term follow-up period was 1 to 2 years after surgery.

1. Short-term follow-up

- Postoperative surveillance of the efficacy of a certain technique was based on whether we have:
  - An immediate pain relief (No pain and no postoperative drug intake).
  - A partial relief with the need of postoperative drug intake.
  - No relief at all.

  As well as a second criterion that is :

  - The postoperative complications rate.
- *At short-term, patients partially relieved but still need post operative drug intake can be considered equal to those relieved without drug intake.*

2. Mid-term follow-up

- Efficacy is based on the following criteria:
  - Complete pain relief
  - No recurrence of the pain.
- *At mid-term, patients that still need post operative drug intake can be considered equal to those with no relief and thus, failure of the operation.*

IV. Statistical methods

- Patients database was summarized and classified in an SPSS software system sheet (version 22), in which diagrams and statistical analyses were performed as well.
- Analytic statistics were made using non parametric tests.
- We expressed quantitative variables as mean ± Standard deviation (SD).
- We expressed qualitative variables as percentages.
- We used KHI 2 test (Chi square) to compare pain relief, complications rates and recurrence criteria in different surgical techniques.
- Kruskal-Wallis was used to compare age distribution and surgical outcomes.
- We used a significance level of 0,05.

Results

I. Statistics of the demographic data

1. Frequency

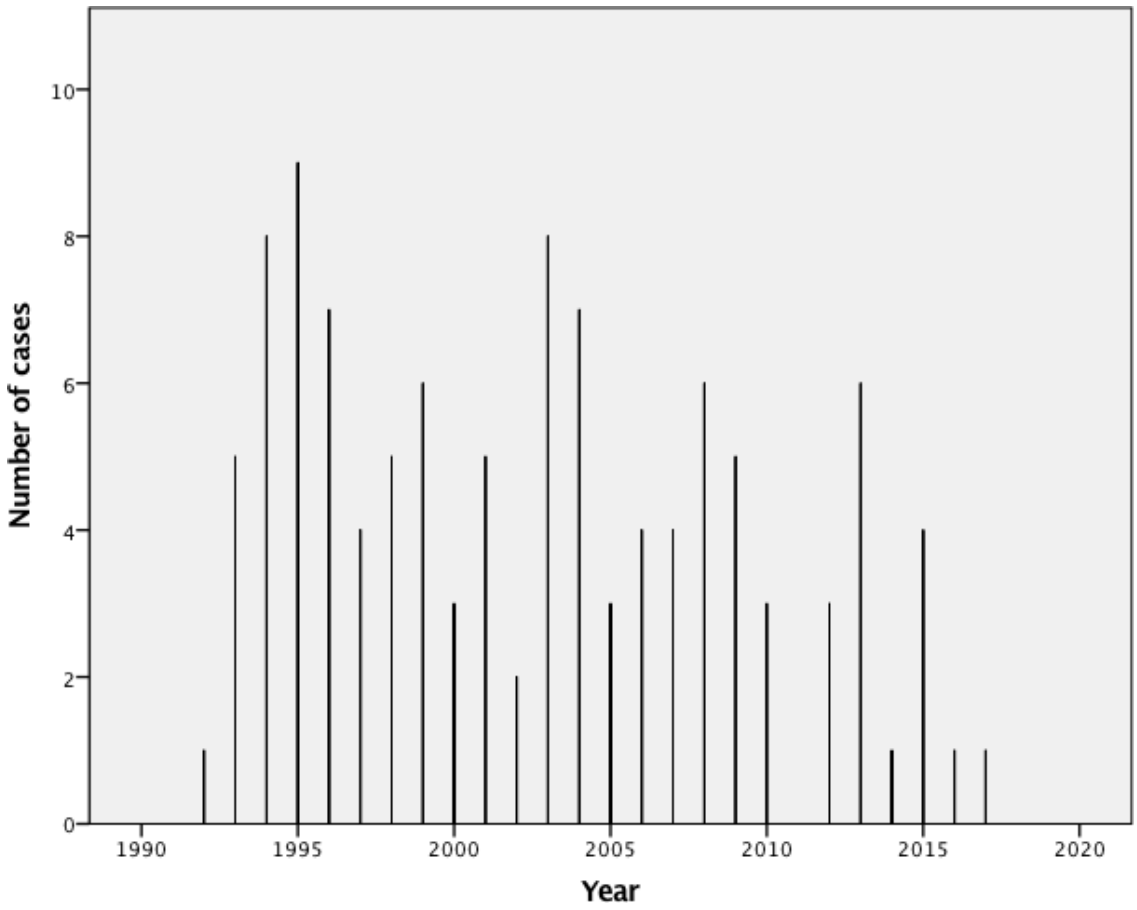

Figure 22: Distribution by years of patients benefiting from a surgical treatment of TN.

- In this study, the number of patients operated is decreasing with time.
- The highest number of patients treated was in 1995 and the lowest numbers are found around 2016 and 2018.

2. Age

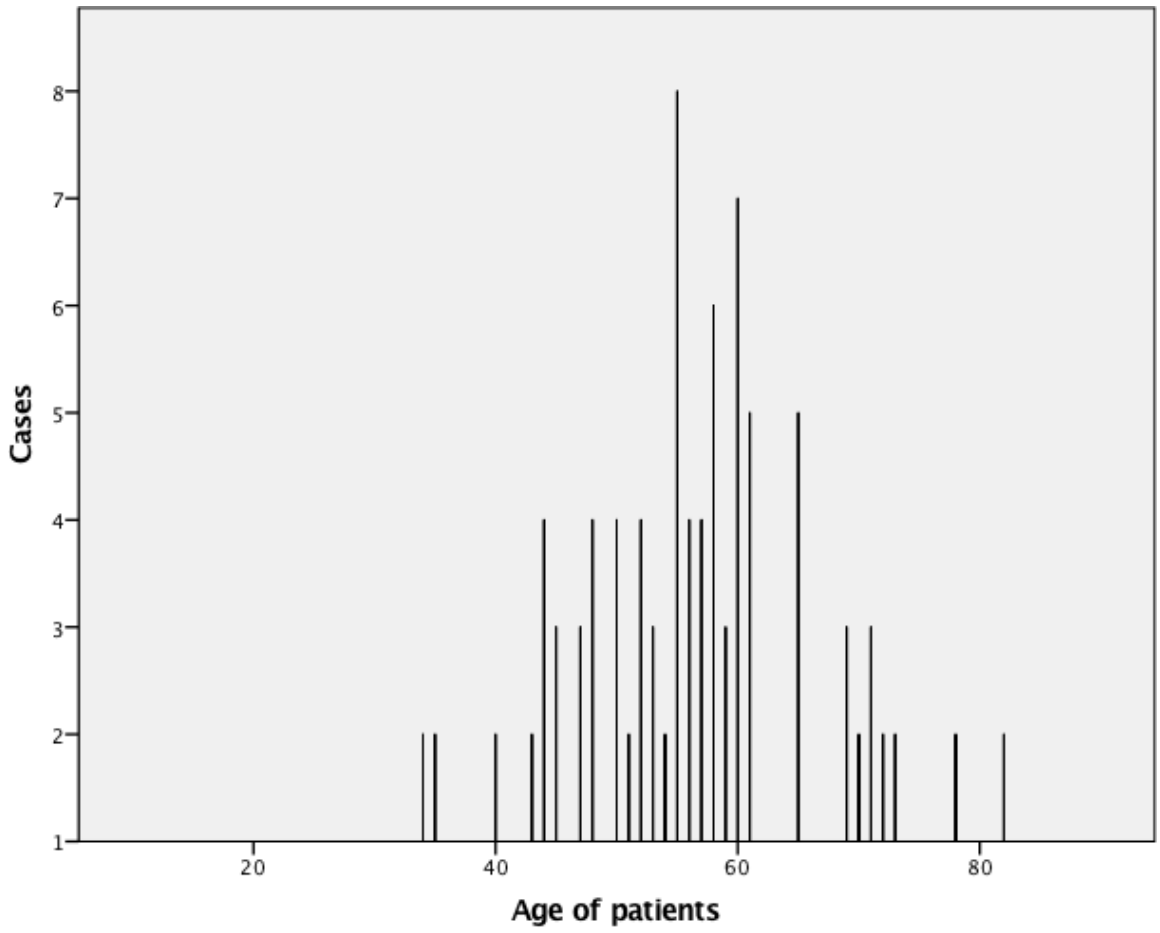

Figure 23 : Distribution by age of patients benefiting from a surgical treatment of TN.

- The mean age of patients in this study is 55,93 ± 12,342 years old, ranging from 15 to 82 years old. The most affected age is 55 years old with 8 cases.

3. Gender of the patients

Table IV: Distribution of patients operated.

Gender	Number of patients	Percentage (%)
Male	45	44,60
Female	56	55,40
Total number of patients	101	100

- In this study, women were more affected than men.

4. History of the patients

4.1. Medical history

Table V: History of medical abnormalities of patients operated.

History	Number of patients	Percentage (%)
No history of previous medical abnormalities	77	76,20
History of cardiovascular abnormalities (High blood pressure, Atherosclerosis, …)	16	15,80
History of neurological abnormalities	01	1,00
History of other type of abnormalities	07	6,90
Total number of patients	101	100

- In this group of study, the majority of the patients had no history of previous medical abnormalities followed by those who had history of cardiovascular abnormalities.

NB: The only case with a past neurological abnormality was about a history of meningitis.

Table VI: Percentage of patients under medical treatment.

Patients following a medical treatment	Number of patients	Percentage (%)
Yes	17	16,80
No	84	83,20
Total number of patients	101	100

- The majority of patients in this study were not following any medical treatment.

Table VII: Percentage of patients with and without dental care.

	Number of patients	Percentage (%)
No dental care	48	47,70
Dental care	53	52,50
Total number of patients	101	100

- In this study, the numbers of patients with or without dental care were nearly the same.

4.2. Surgical history

Table VIII: Percentage of patients who underwent a surgical treatment before.

History	Number of patients	Percentage (%)
No history of previous surgery	83	82,20
History of at least one neurosurgical operation	05	04,90
Other types of surgery	13	12,90
Total number of patients	101	100

- In this study, the majority of patients had no history of previous surgical operations.
- The lowest rate was the one of patients who underwent at least one surgical operationbefore.

4.3. Familial history of TN

Table IX: Number of patients presenting familial history of TN.

History of TN in the family	Number of patients	Percentage (%)
Yes	02	02
No	99	98
Total number of patients	101	100

- In this study, nearly all patients had no history of trigeminal neuralgia in the family.

II. Statistics of the clinical data

1. Lateralization

Table X: The sides affected with the trigeminal neuralgia.

Side of the affection	Number of patients	Percentage (%)
Left side	56	55,40
Right side	45	44,60
Total number of patients	101	100

- In this study, the majority of patients had trigeminal pain in the left side.

2. Division involved

Table XI: Divisions involved in the patients of our study.

Division	Number of patients	Percentage (%)
V1	07	6,90
V2	22	21,80
V3	16	15,80
V1V2	17	16,80
V2V3	30	29,7
V1V2V3	09	8,90
Total number of patients	101	100

- In this study, the order of divisions affected is the following:

  V2V3 (29,70%) > **V2** (21,80%) > **V1V2** (16,80%) > **V3** (15,80%) > **V1V2V3** (8,90%) > **V1** (6,90%)

3. Pain characteristics

3.1. Type of pain

Table XII: Types of pain from which patients of the study were suffering.

	Number of patients	Percentage (%)
Electric charge-like	101	100

- In this study, all patients suffered from an electric charge-like type of pain.

3.2. Intensity of the pain

Table XIII: Intensity of pain from which patients of the study were suffering.

BNI Scale	Number of patients	Percentage (%)
III a	01	01
III b	46	45,50
IV	53	52,50
V	01	01
Total number of patients	101	100

- In this study, the majority of the patients had an intensity scaled type IV in the BNI score (Some pain, not adequately controlled with medications), followed by intensity type III b (Persistent pain, controlled with medication).

3.3. Number of attacks per day

Table XIV: Number of attacks per day in the patients of the study.

Number of episodes/ day	Number of patients	Percentage (%)
1 episode	01	01
2 or more episodes	100	99
Total number of patients	101	100

- In this study, nearly all patients had 2 or more episodes of pain per day.

3.4. Duration of attacks

Table XV: Duration of pain attacks.

Duration	Number of patients	Percentage (%)
Between 1 minute and 30 minutes	96	95
Between 30 minutes and 1 hour	03	03
1 hour or more	02	02
Total number of patients	101	100

- In this study, nearly all the patients suffered from pain that lasts between 1 minute and 30minutes.

4. Imaging Techniques and results

Table XVI: Imaging techniques used and results.

Imaging technique	Normal	Neurovascular conflict	Total number of patients
CT-scan	39	0	39
MRI	41	21	62
Total number of patients	80	21	101

- In this study, all patients benefited from CT-scan as a first line imaging ruling out causes of a secondary TN such as tumors of the CPA, …
- However, 51% of patients benefited from MRI scans and showed signs of neurovascular conflict.

III. Statistics of the surgical data

1. Number of the patients treated by each technique

Table XVII: Number of patients treated by each technique.

Technique	Number of patients	Percentage (%)
MVD	26	25,7
TC	44	43,6
PBC	31	30,7

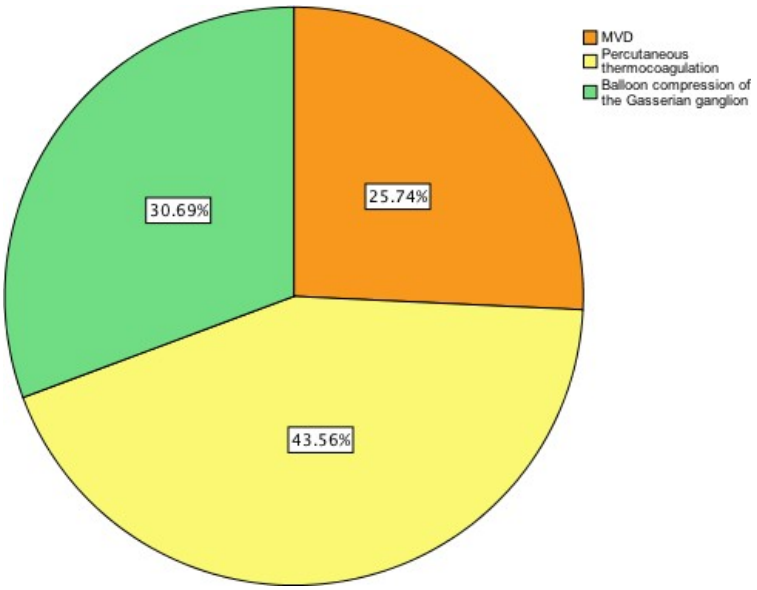

Figure 24 : Number of patients treated by each technique.

- In this study, the majority of the patients benefited from TC, followed respectively byPBC and MVD.

2. Age of the patients treated by each technique

Table XVIII: Mean age of patients treated by each surgical technique.

Technique	Mean age
MVD	51,77 ± 9,905
TC	54,89 ± 12,664
PBC	60,48 ± 12,575

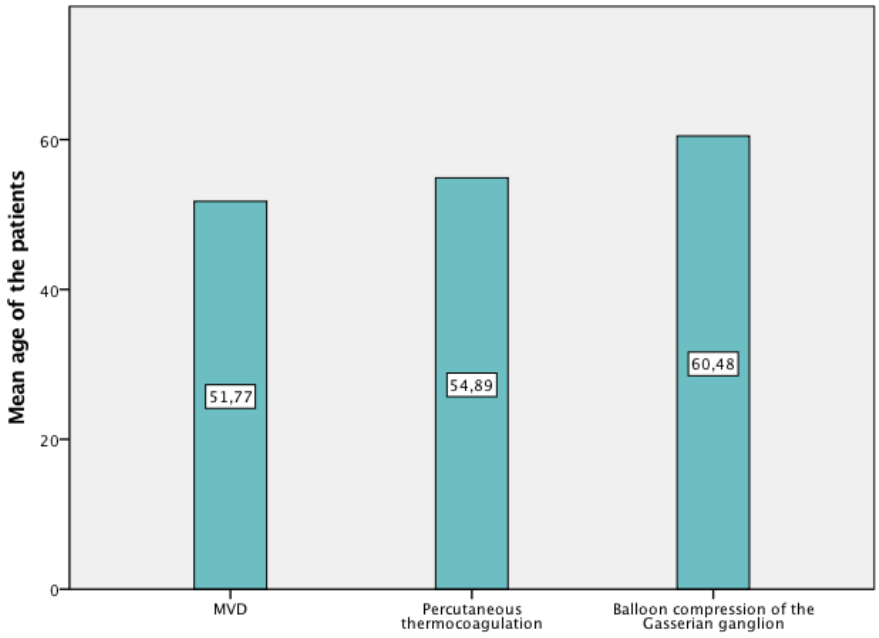

Figure 25 : Mean age of patients treated by each surgical technique.

- In this study, all the techniques (MVD, TC, PBC) are designated for people aging 50years old and above.

3. Gender of the patients treated by each technique

Table XIX: Gender of patients treated by each technique.

	MVD	TC	PBC
Male	50%	40,09%	45,16%
Female	50%	59,09%	54,83%

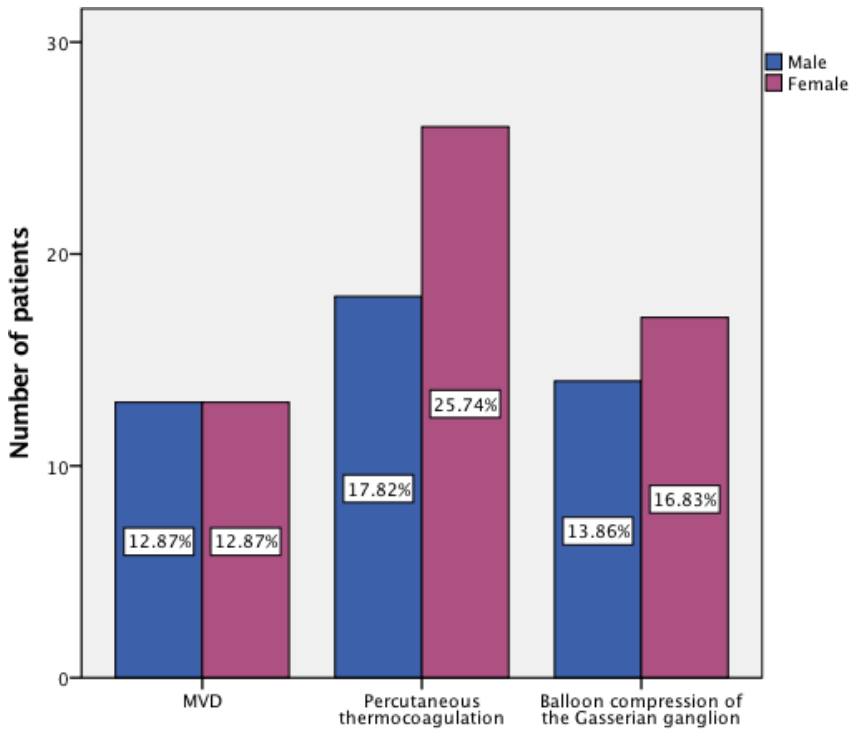

Figure 26 : Gender of patients treated by each technique.

- In our study, female patients benefited more from TC and PBC, unlike the MVD from which both male and female patients benefited equally.

4. Type of the offending structure detected with imaging techniques :

Table XX: Types of offending vessels detected causing TN.

	Number of patients	Percentage (%)
SCA	14	13,9
PICA	01	01
Vein	10	9,9
Artery + Vein	01	01
Arachnoiditis	07	6,9

- The SCA is the affecting structure found more in the patients of this study.

5. Technique used for each division

Table XXI: The surgical treatments used for each CNV division involved.

	V1	V2	V3	V1V2	V2V3	V1V2V3	Total number of patients
MVD	01	**07**	04	05	05	04	26
TC	02	09	10	07	**13**	03	44
PBC	04	06	02	05	**12**	02	31
Total number of patients	07	22	16	17	30	09	101

- In our study, MVD was used more to treat TN affecting V2.
- TC and PBC were used more to treat TN affecting V2V3.

IV. Short-term follow-up

1. Degree of Pain relief

Table XXII: Degree of Pain relief at short-term compared in different types of surgical treatments.

	Relief	Relief with medical treatment	No relief
MVD	73,07%	19,23%	7,69%
TC	63,63%	34,09%	2,27%
PBC	48,38%	48,38%	3,22%

- MVD has the highest rate of immediate pain relief at short-term with no associated medical treatment
- PBC has the highest rate of pain relief at short-term with medical treatment being associated as a complement of the surgical treatment.
- Failure of the technique at short-term was found more in MVD than TC or PBC.
- We calculated the p-value based on KHI2 to define whether the results above are significant or not.
- p= 0,183 (No significant difference)

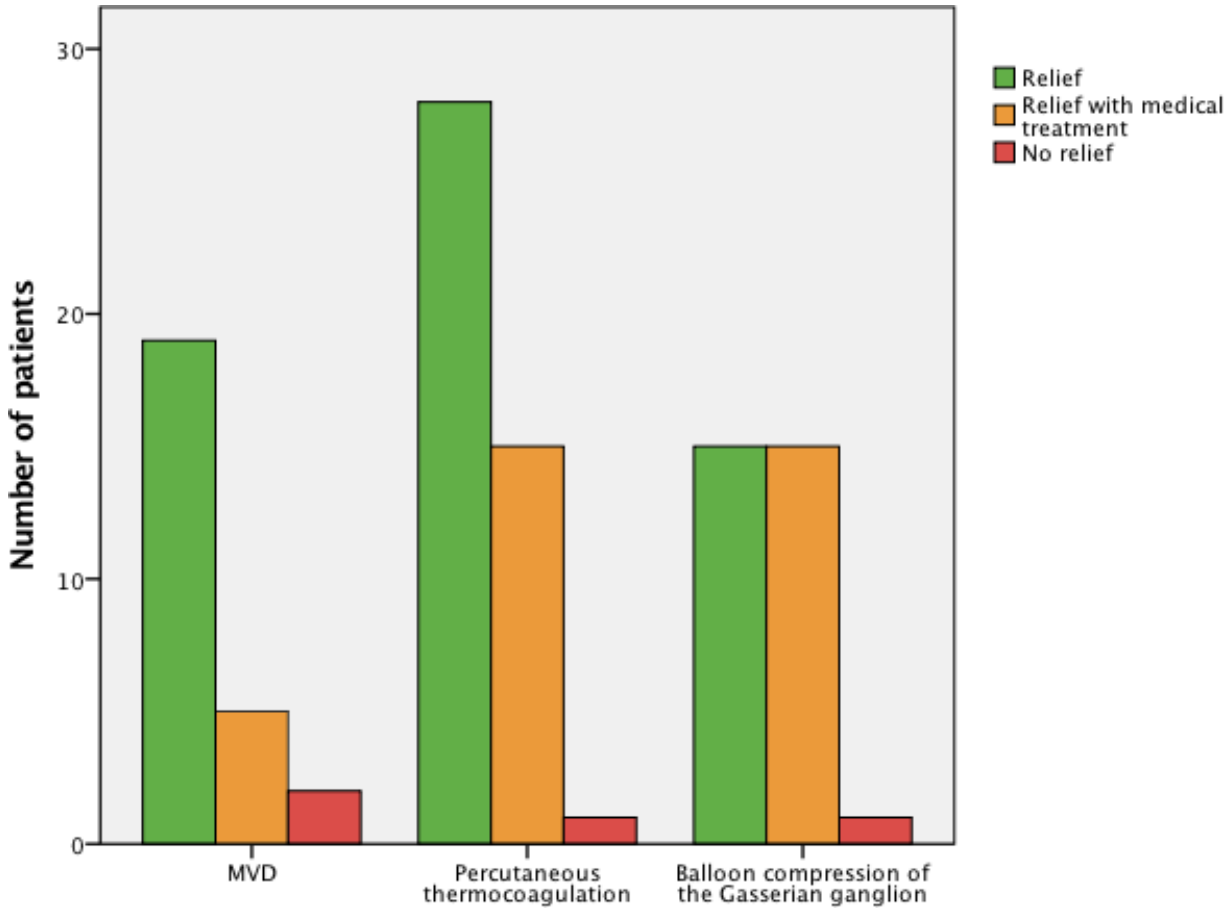

Figure 27 : Degree of pain relief at short-term compared in different types of surgical treatments.

Table XXIII: Clinical data of pain versus relief at short-term.

	Relief at short-term	*P value*
Age	**Relief :** 55,97±10,634 **Relief with drug intake :** 55,40±14,898	0,927
Gender	**MVD :** M : 92% F : 92% **TC :** M : 100% F : 96% **PBC :** M : 92% F: 100%	**MVD :** 0,881 **TC :** 0,375 **PBC :** 0,499
Side	**MVD :** Left : 100% Right : 84,61% **TC :** Left : 100% Right : 94,44% **PBC :** Left : 94,11% Right : 100%	**MVD : 0,024** **TC :** 0,477 **PBC :** 0,499
Division	**MVD :** V1 : 100% V2 : 100% V3 : 75% V1V2 : 100% V2V3 : 80% V1V2V3 : 100% **TC :** V1 : 100% V2 : 100% V3 : 100% V1V2 : 100% V2V3 : 92,3% V1V2V3 : 100% **PBC :** V1 : 100% V2 : 100% V3 : 93,75% V1V2 : 100% V2V3 : 91,66% V1V2V3 : 100%	**MVD :** 0,559 **TC :** 0,85 **PBC :** 0,982
Intensity	**MVD :** IIIb : 100% IV : 83,33% **TC :** IIIa : 100% IIIb : 100% IV : 61,53% **PBC :** IIIb : 93,75% IV : 100%	**MVD :** 0,156 **TC : p <0,001** **PBC :** 0,338

2. Complications rates

Table XXIV: Complication and no complication rates in different types of surgical treatments.

	No complication	Complication
MVD	65,38%	34,61%
TC	50%	50%
PBC	61,29%	38,70%

Table XXV: Rates of Complications compared in different types of surgical treatments.

	Ipsilateral hemi facial numbness (%)	Anesthesia dolorosa (%)	Cheek hematoma (%)	Hypoacousia (%)	Facial palsy (%)	Severe headache (%)
MVD	15,38	0	0	7,69	0	11,53
TC	29,54	11,36	6,81	0	2,27	0
PBC	38,7	0	0	0	0	0

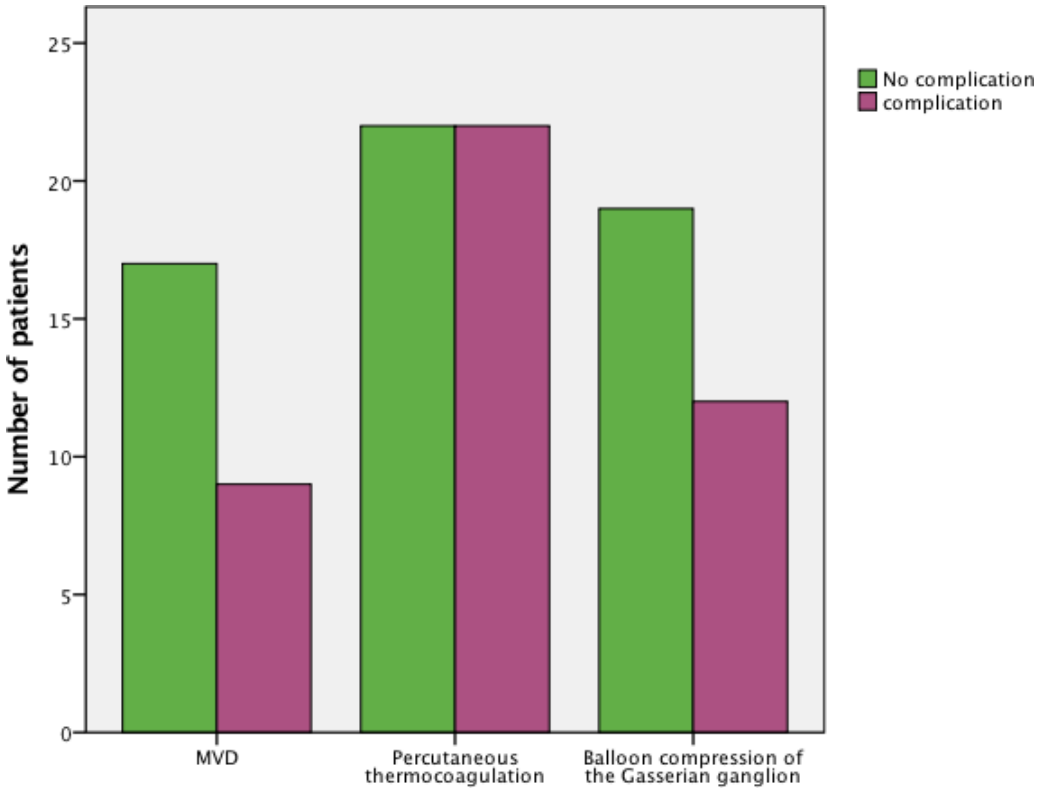

Figure 28 : Complication and no complication rates versus different types of surgical treatments.

- The MVD and the PBC show both lower rates of complications compared to the TC, which has 50% chance of showing postoperative complications.
- Complications found in the MVD are : Ipsilateral hemi facial numbness, Hypoacousia and severe headache.
- Complications found in the percutaneous techniques : Ipsilateral hemi facial numbness, anesthesia dolorosa, cheek hematoma and facial palsy.
- We calculated the p-value based on KHI2 to define whether the rates of complications in different techniques above are significant or not.
- p= 0,003 (Significant difference).

Table XXVI: Clinical data of pain versus no complications criterion.

	No Complications	***P value***
Age	55,60± 12,095	0,706
Gender	**MVD :** M : 69,23% F : 61,53% **TC :** M : 38,88% F : 57,69 % **PBC :** M : 64,28% F: 58,88%	**MVD :** 0,495 **TC :** 0,306 **PBC :** 0,756
Side	**MVD :** L : 69,23% R : 61,53% **TC :** L : 46,15% R : 55,55% **PBC :** L : 41,17% R: 85,71%	**MVD :** 0,707 **TC :** 0,688 **PBC :** 0,756
Division	**MVD :** V1 : 100% V2 : 57,14% V3 : 75% V1V2 : 60% V2V3 : 60% **TC :** V1 : 100% V2 : 66,66% V3 : 40% V1V2 : 57,14% V2V3 :46,15% **PBC :** V1 : 85,7% V2 : 68,18% V3 : 43,75% V1V2 :52,94 % V2V3 : 66,66% V1V2V3 : 50%	**MVD :** 0,527 **TC :** 0,436 **PBC :** 0,314
Intensity	**MVD :** IIIb : 78,57% IV : 50% **TC :** IIIa : 100% IIIb : 25% IV :65,38 % **PBC :** IIIb : 68,75% IV : 53,33%	**MVD :** 0,053 **TC :** 0,22 **PBC :** 0,37

V. Mid-term follow-up

1. Pain relief

Table XXVII: Pain relief at mid-term compared in different types of surgical treatments.

	Relief	Relief with medical treatment	No relief
MVD	76,92%	0%	23,07%
TC	70,45%	4,54%	25%
PBC	74,19%	6,45%	19,35%

- MVD has the highest rate of pain relief at mid-term with no associated medical treatment
- The rate of failure at mid-term is found slightly more in the TC.
- We calculated the p-value based on KHI2 to define whether the results above are significant or not.
- p= 0,753 (No significant difference)

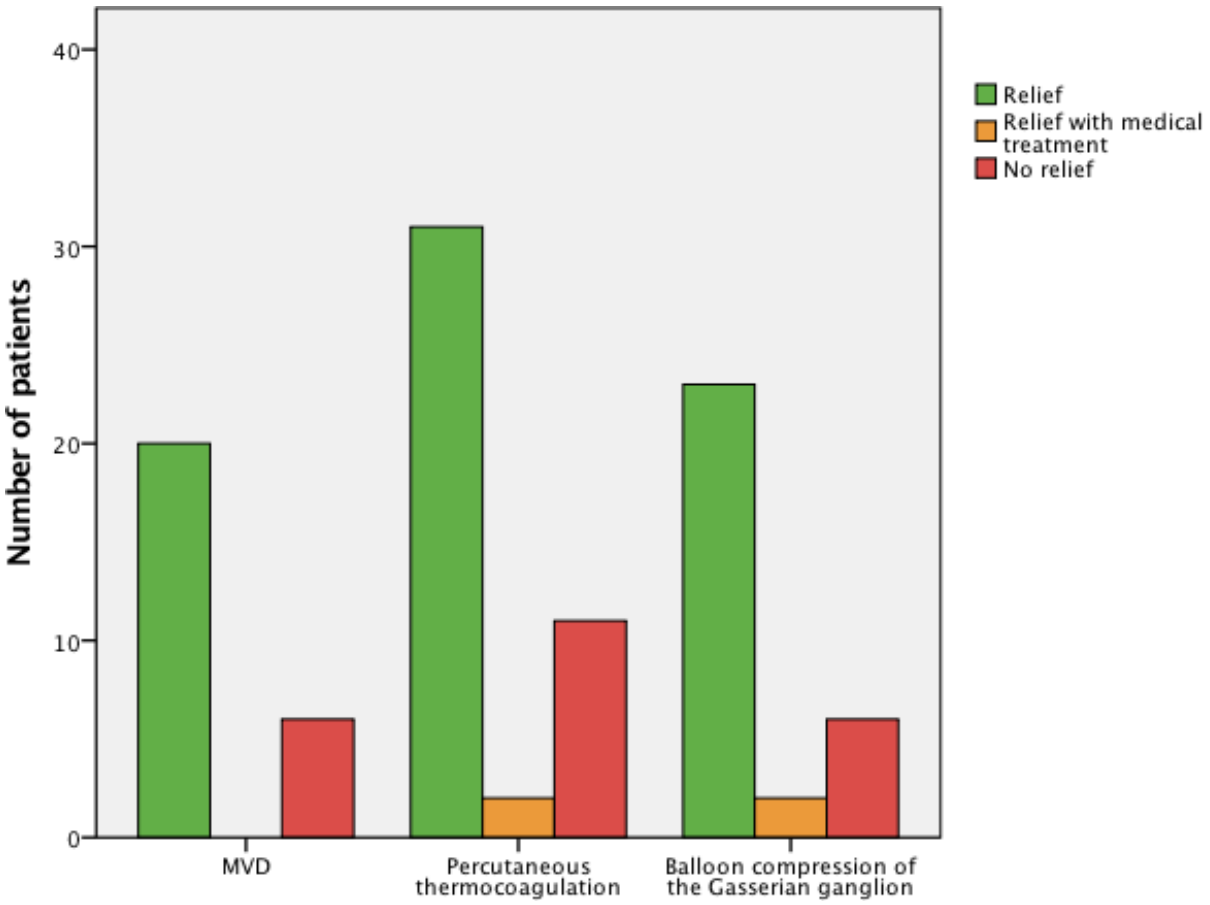

Figure 29 : Mid-term pain relief compared in different types of surgical treatments.

Table XXVIII: Clinical data of pain versus relief at mid-term.

	Relief at mid-term	*P value*
Age	56,73±11,46	0,39
Gender	**MVD :** M : 76,92% F : 76,92% **TC :** M : 83,33% F : 61,53% **PBC :** M : 64,28% F: 82,35%	**MVD :** 1 **TC :** 0,229 **PBC :** 0,244
Side	**MVD :** L : 69,23% R : 84,61% **TC :** L : 80,76% R : 55,55% **PBC :** L : 82,35% R: 64,28%	**MVD :** 0,352 **TC :** 0,096 **PBC :** 0,063
Division	**MVD :** V1 : 100% V2 : 85,71% V3 : 50% V1V2 : 80% V2V3 : 80% V1V2V3 : 75% **TC :** V1 : 100% V2 : 83,33% V3 : 50% V1V2 : 100% V2V3 : 66,66% V1V2V3 : 66,66% **PBC :** V1 : 71,42% V2 : 77,27% V3 : 56,25% V1V2 : 94,11% V2V3 : 66,66% V1V2V3 : 77,77%	**MVD :** 0,806 **TC :** 0,679 **PBC :** 0,555
Intensity	**MVD :** IIIb : 78,57% IV : 75% **TC :** IIIa : 100% IIIb : 62,5% IV : 76,9% **PBC :** IIIb : 68,75% IV : 80%	**MVD :** 0,829 **TC :** 0,323 **PBC :** 0,365

2. Pain recurrence, one to two years after a surgical operation

Table XXIX: Rate of pain recurrence at mid-term in different surgical techniques.

Technique	Recurrence (%)
MVD	15,38
TC	27,25
PBC	22,51

- In our study, it seems that the rate of recurrence of the trigeminal pain at mid-term was higher in the percutaneous techniques compared to the MVD.
- We calculated the p-value based on KHI2 to define whether the results above are significant or not.
- p= 0,133 (N.S)

Table XXX: Clinical data of pain versus recurrence.

	Recurrence	***P value***
Age	55,74±13	0,941
Gender	MVD : M : 7,69% F : 23,07% TC : M : 27,77% F : 38,46% PBC : M : 35,71% F: 41,17%	MVD : 0,277 TC : 0,462 PBC : 0,756
Side	**MVD :** L : 30,76% R : 0% **TC :** L : 23,07% R : 50% **PBC :** L : 35,29% R : 42%	**MVD :** 0,03 **TC :** 0,064 **PBC :** 0,667
Division	**MVD :** V1 : 0% V2 : 28,57% V3 : 0% V1V2 : 20% V2V3 : 0% V1V2V3 : 25% **TC :** V1 : 50% V2 : 33,33% V3 : 30% V1V2 : 0% V2V3 : 38,46% V1V2V3 : 100% **PBC :** V1 : 100% V2 : 100% V3 : 93,75% V1V2 : 100% V2V3 : 91,66% V1V2V3 : 100%	**MVD :** 0,682 **TC :** 0,08 **PBC :** 0,487
Intensity	**MVD :** IIIb : 21,42% IV : 8,33% **TC :** IIIa : 0% IIIb : 43,75% IV : 26,92% V : 100% **PBC :** IIIb : 37,5% IV : 40%	**MVD :** 0,356 **TC :** 0,295 **PBC :** 0,88

3. Re-operated patients in case of failure of the previous operation:

As a result of recurrence of the trigeminal nerve pain, a re-operation by another surgical technique has been considered.

Table XXXI: Patients re-operated because of failure of previous operation.

	Not re-operated	**Re-operated**
MVD	80,76%	19,23%
TC	72,72%	27,27%
PBC	74,19%	25,80%

- The rate of re-operation was slightly higher in the TC compared to the other techniques.
- We calculated the p-value based on the KHI2 to define whether the results above are significant or not.
- p= 0,743 (N.S)

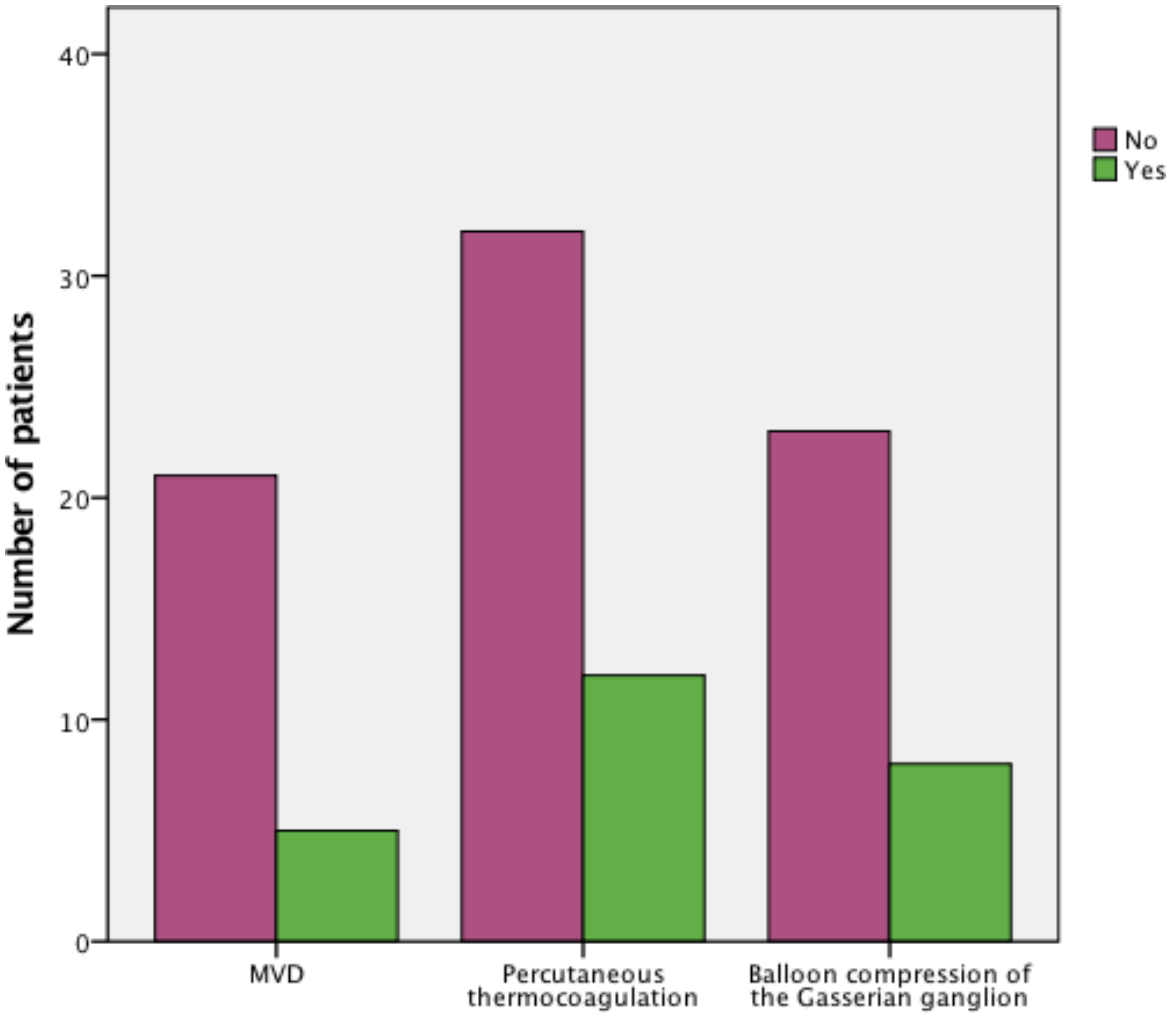

Figure 30: Patients re-operated because of failure of previous operation.

4. Recurrence of the surgical techniques studied and the ipsilateral hemi facial numbness

Table XXXII: Table showing recurrence and ipsilateral hemi facial numbness rates of each technique.

	Recurrence (%)	**Ipsilateral hemi facial numbness (%)**
MVD	15,38	15,38
TC	27,25	29,54
PBC	22,51	38,7

- Concerning the percutaneous techniques, it appears that when ipsilateral hemi facial numbness is high, the recurrence rate is low.

VI. Summary of results comparing techniques and outcomes:

Table XXXIII: Comparative table of surgical techniques used for treatment of TN in this study.

Technique (%)	Number of patients (n)	Follow up period (months)	Mean age (n)	Relief at short -term (%)	Relief at Mid-term (%)	Recurre-nce(%)	Complication rates (%)	Type of complications*	NVC at the MRI (n)
MVD	26	24	51,77	92,3	76,92	15,38	34,61	IHN (15,38%) HL (7,69%) SH (11,53%)	15
TC	44	24	54,89	97,7	70,45	27,25	50	IHN (29.24%) AD (11,36%) CH (6,81%) FP (2,27%)	0
PBC	31	24	60,48	96,7	74,19	22,51	38,70	IHN (38,7%)	06

**Abbreviations:* *IHN: Ipsilateral hemi facial numbness / HL: Hearing loss/ SH : Severe headache/ AD : Anesthesia Dolorosa/ CH : Cheek Hematoma/ FP : Facial palsy.*

Discussion

Types of treatment:

- Once the diagnosis of TN is confirmed, a suitable treatment must be started.
- There are 2 possibilities, either medical or surgical treatments.
- Medical treatments are proposed in first intention.

I. Medical treatment

Not being effective in TN, classical antalgics have been replaced by antiepileptic drugs.

Their action is resumed in 2 essential points :

- Stabilization of the neuronal membrane by blocking the sodium channels, thus making it possible to reduce the release of certain excitatory neurotransmitters such as glutamate.
- Strengthening GABAergic inhibition by increasing the available amount of an inhibitory neurotransmitter: gamma-amino butyric acid (GABA).

The American Academy of Neurology (ANN) and the European Federation of Neurological Societies (EFNS) recommend anti-epileptics such as Carbamazepin and Oxcarbazepin as treatments of first intention.

▪ Carbamazepine (Tegretol®):

Antiepileptic of first generation, it is considered as the most effective and main treatment since 1962.

Treatment administration:

- In the first day, the patient takes ½ pill (100mg) in the morning and another in the evening and increases the dose by ½ pill to a whole pill per day in order to reach the effective dose between 600 to 1200 mg per day.

- The selective efficacy of this drug is a true diagnostic test, in case of immediate and total failure, the diagnosis can be reconsidered.
- Tegretol® to be taken half to one hour before meals (ex: 7 am, 11 am, 6 pm).
- When the pain is gone for three to five weeks, patient should reduce the dose to a half pill every five days to reach the minimum dose needed.

In case of complete remission, it is necessary to stop the treatment.

Side effects are frequently seen in elderly patients: Fatigue, drowsiness, nausea, vomiting, ataxia, leukopenia (CBC every 2 to 3 weeks initially then every 2 to 3 months).

If Tegretol® is not tolerated other therapies can be used.

▪ Oxcarbazepine (Trileptal®):

Antiepileptic of second generation, less effective than Carbamazepine; treatment with Trileptal® is started with a dose of 600 mg twice daily. The dosage will be increased by 300mg every 3 days until the effective dose. Its dosage can be increased up to 1800mg and even up to 2400mg in some refractory forms. For the majority of patients, the effective dose is between 600mg / day and 1800mg / day.

It may cause drowsiness, headache, vertigo, diplopia, fatigue, nausea and vomiting.

▪ Lamotrigine (Lamictal®):

Antiepileptic of second generation, taken in TN in a dose of 25 mg per day for two weeks with an increase of 25mg per day in the following two weeks, after that, increasing with 50 mg to 100 mg per day every week until pain relief.

It may cause : skin rash, shaking, drowsiness, headache, vertigo, nausea and vomiting.

▪ Phenytoin (Dihydan®)

Antiepileptic of first generation. It is a less effective drug than the previous ones and often leads to troublesome side effects : gingivitis, hirsutism, ataxia, depression ...

The starting dose is 200 mg per day to reach if necessary 400 to 500 mg per day.

▪ Gabapentin (Neurontin®):

Antiepileptic of second generation, used often in TN due to multiple sclerosis, 300mg in the first day, 300 mg 2 times a day in the second day and 300mg 3 times a day in the third day.

We can achieve 2400mg per day or even more in some patients.

▪ Clonazepam (Rivotril®):

From the benzodiazepine family, we start the treatment with 0,5mg three times a day and we escalate with 0,5 mg every 3 days to achieve a dose of 1,5 to 8 mg per day.

▪ Baclofen (Lioresal®):

Myorelaxant, used either in monotherapy or in association with Tegretol®.

Monotherapy: 5 to 10 mg, 3 times per day and escalating with 5 to 10 mg every 2 days in order to achieve the dose of 40-60mg per day (80mg maximum).

In association with Tegretol®200mg 3 times per day and Lioresal® 20 to 30mg per day. It may cause drowsiness, nausea, low blood pressure, vertigo, skin rash, accommodation disorders.

Valproic acid (Depakine®), Topiramate (Epitomax®), Pregabalin (Lyrica®) ... have also been proposed but the indications and results are debatable.

All these treatments must be taken only in case of non response to treatment with Tegretol®.

If medical treatment is insufficient or poorly tolerated, surgical treatment is adopted.

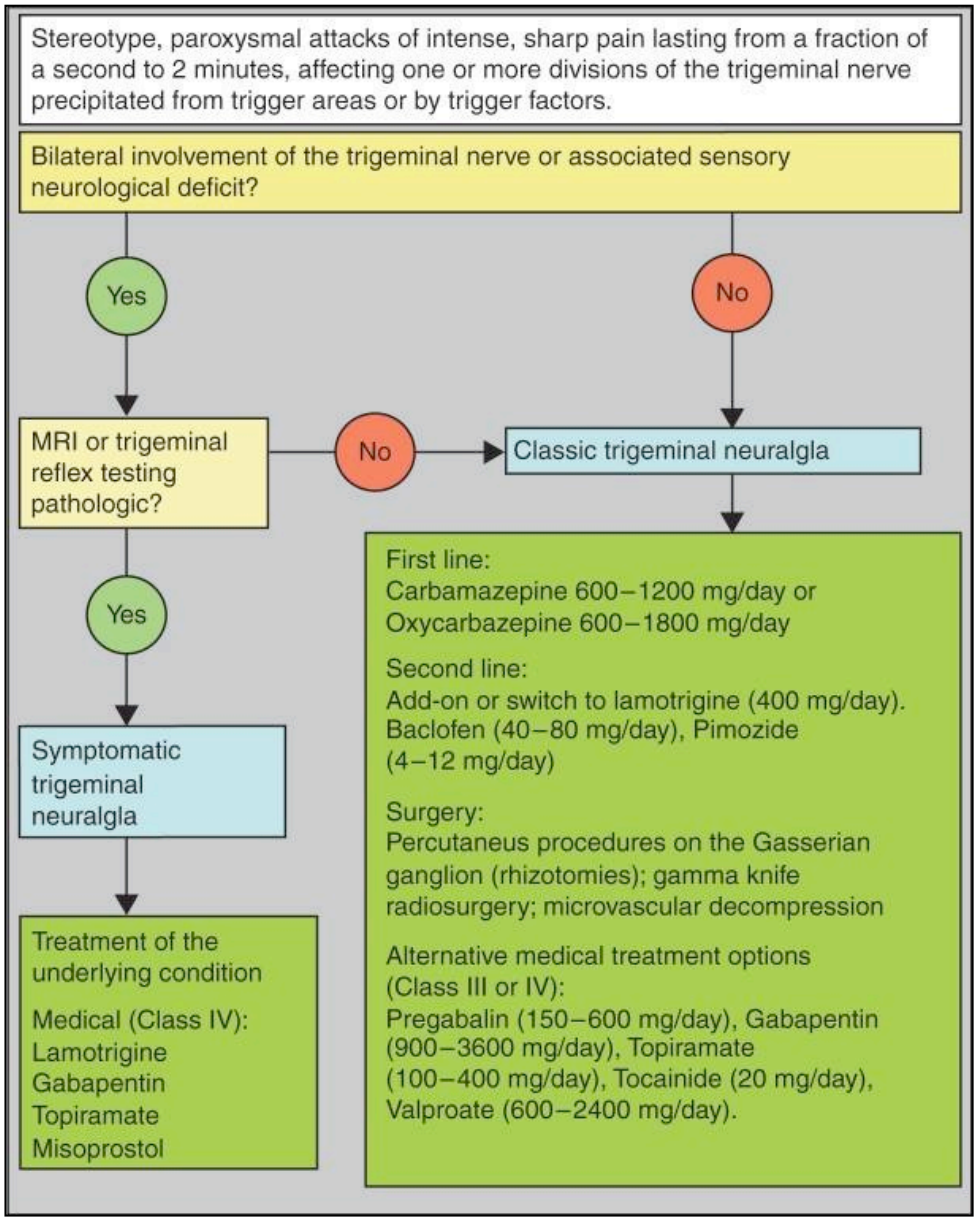

Figure 31 : Management of the trigeminal neuralgia [30].

II. Techniques of Surgical treatment

In order to pursue a surgical treatment of trigeminal neuralgia, we must make sure of existence of these criteria:

1- Resistance or intolerance to medical treatment.

2- Eliminate all differential diagnosis of a TN using MRI.

According to the European Federation of neurological societies guidelines on neuropathic pain assessment as well as the American Academy of neurology guidelines, patients not benefiting from effective doses of Carbamazepine or Oxcarbazepine are the ideal candidates for surgical intervention [31]

When surgery is required, the goal is a permanent pain relief with no morbidity or mortality.

Until today, there is no ideal surgical treatment for TN, each technique has its advantages and disadvantages.

The following diagram shows all types of surgical treatments of the TN.

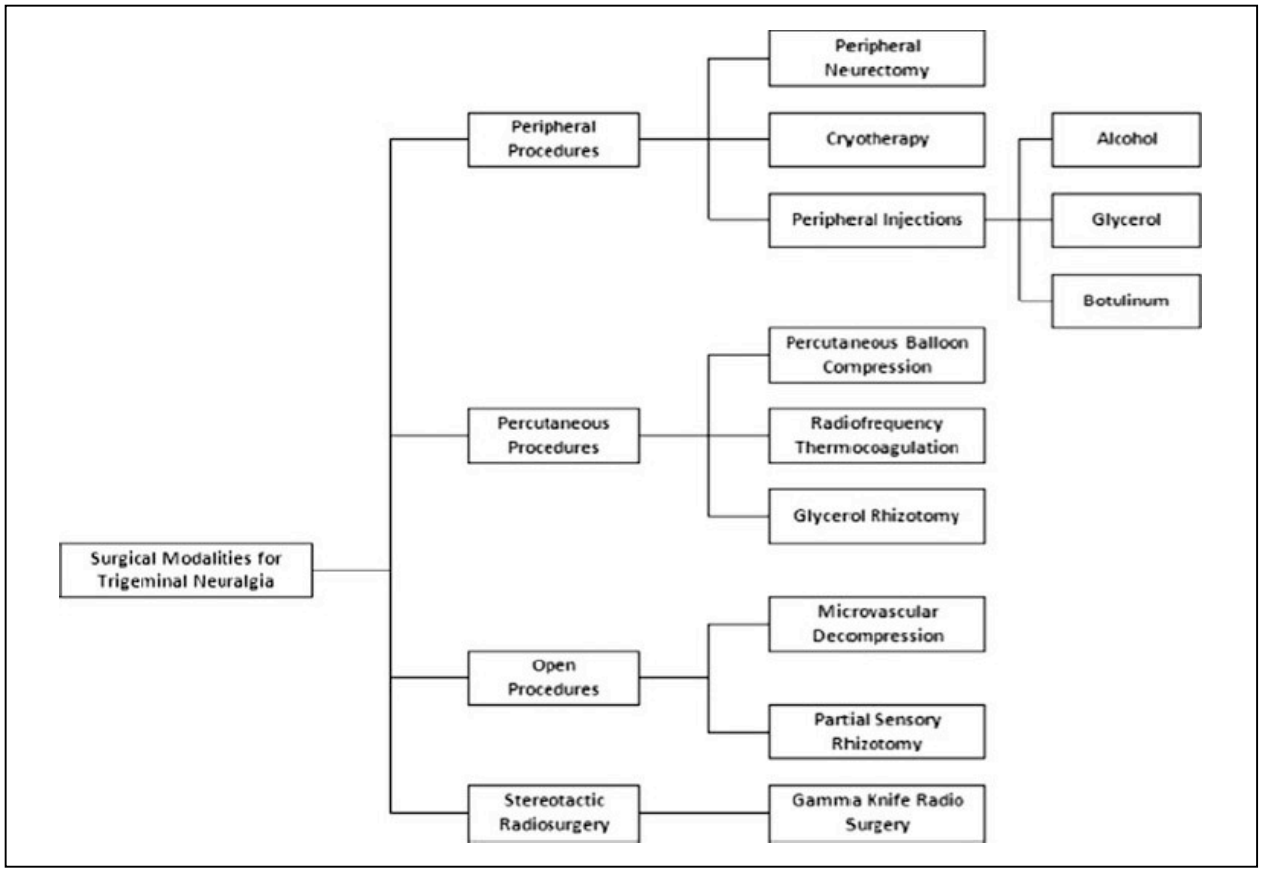

Figure 32 : Different types of surgical treatments for TN [32].

The choice of accurate surgical treatment depends on many factors:

- The age of the patient
- The general condition of the patient
- The Anesthesia consultation (ASA score).
- The desire of the patient and his family.
- The availability of the surgical technique in the hospital.
- The decision of the medical staff.

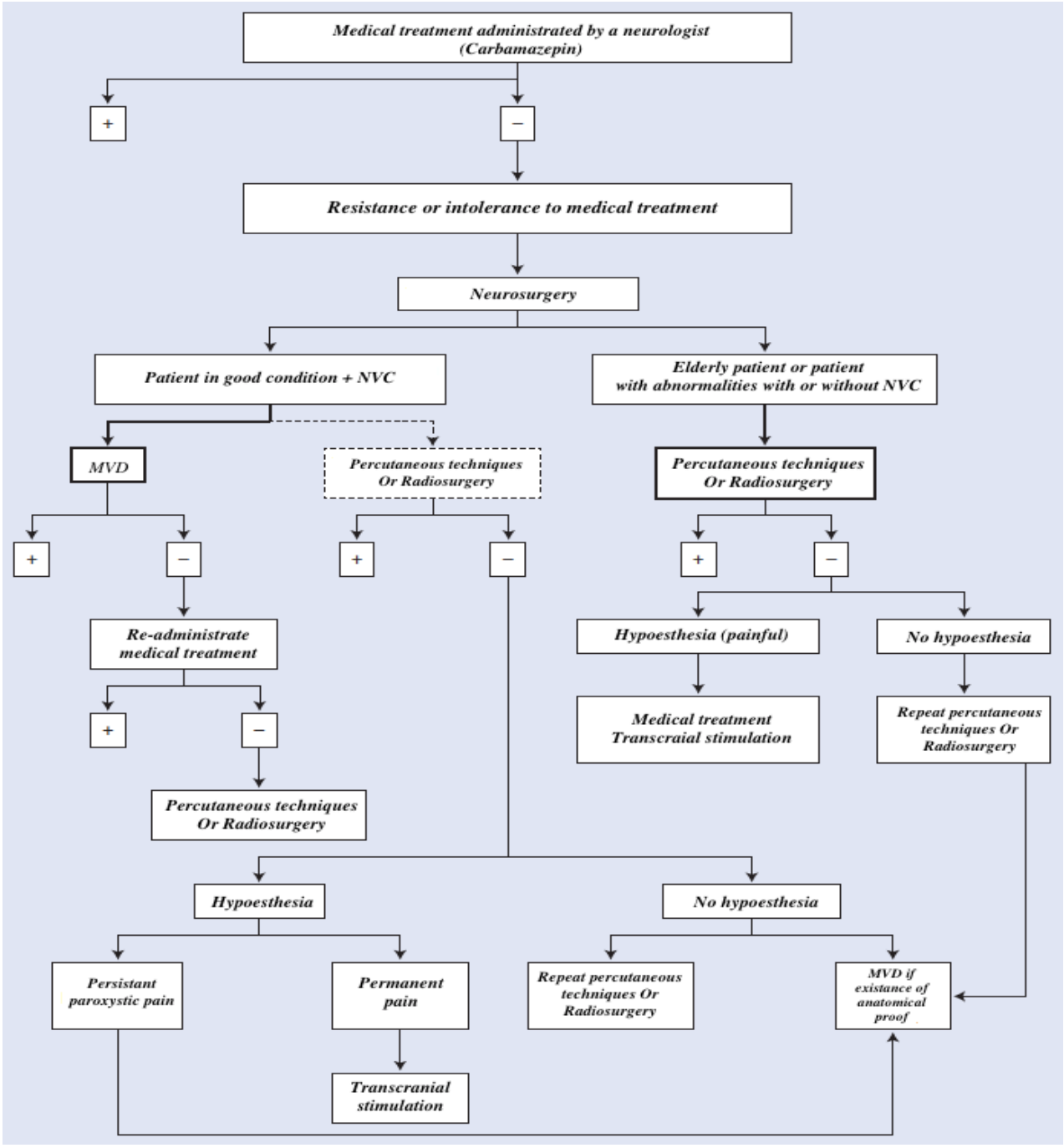

Figure 33 : Algorithm of the management of the trigeminal neuralgia by M.Sindou and Y.Keravel (Translated by A.Chahbar) [33].

1. The Percutaneous techniques [34]

HARTEL in 1913 described a percutaneous approach making it possible to an electrode to access to the Gasserian ganglion through the oval foramen passing by the cheek, which gave birth to three different techniques of percutaneous treatment.

The aim of this surgery is the thermal or mechanical destruction of the nociceptive fibers (Aδ, C) responsible of the pain occurred in TN.

In fact, Aδ and C fibers are most sensitive compared to Aβ fibers, however, these Aβ fibers are usually affected in the process which ends up in the end with the patient having hypoesthesia.

In this study we focus mainly on two techniques: percutaneous thermo coagulation and Balloon compression of the Gasserian ganglion.

1.1. The radiofrequency thermocoagulation

1.1.1. Technique's presentation [34]

This concept behind the technique developed by SWEET [35] is to use radiofrequency stimulation to cause a thermal lesion in the retro Gasserian root or ganglion.

The patient is placed with the head extended to about 30 degrees, bipolar fluoroscopy can be used if available.

Anesthesia is induced using a short-acting, such as propofol, in order to reach a plane 1 of stage III anesthesia (classification of Guedel) with loss of eyelash reflex but without abolition of laryngeal reflexes.

Anticholinergics (usually 0,2 mg of glycoppyrolate) may be given to minimize oral secretions and blunt the vasovagal response during penetration of the needle through the foramen ovale.

The skin of the cheek and perioral region on the ipsilateral side is painted with antiseptic solution after achieving the required level of anesthesia.

A nasal cannula may assist in the maintenance of the airway.

The surgeon stands on the same side as the patient's affected side, and cannulation of the foramen proceeds under fluoroscopic guidance using the Hartel technique with the radiofrequency electrode trochar.

The needle enters the cheek through a point 2,5cm lateral to the corner of the mouth and 1 cm inferior to the occlusal plane and advances through the cheek in the sub mucosal layer, between the pterygoid bone and the angle of the mandible, guided by surgeon's index finger of the other hand within the patient's mouth (figure 34).

The needle engages the foramen ovale about 6 to 8cm from the skin surface. This can usually be evidenced by a contraction of the masseter muscle.

Lateral fluoroscopy is used thereafter, and the needle is advanced 45 degrees to a point just superior to the intersection of the petrous bone and the clivus on a true lateral view.

The patient awakened from anesthesia, the stylet of the trochar withdrawnand replaced with the radiofrequency electrode, a curved-tip electrode may be necessary to target V1 and V2, but typically a straight electrode suffices to produce a lesion in V3.

Once the patient is awake, stimulation test of the target is achieved using a square wave stimulus at 50 Hz to evoke paresthesia in the stimulated division.

When the electrode location has been confirmed, the patient is again anesthetized. Lesion creation is achieved by heating with a temperature between 60 and 70 degrees (preferably 68 degrees) for about 1 minute [36].

When neurolysis is complete, the patient is again awaked from anesthesia to test the procedure efficacy. The end point point of this procedure is slight hypoesthesia, the patient is able to feel touch in the affected area but cannot differentiate between the sharp and blunt ends of a safety pin.

The patient is observed for few hours and can be discharged in the same day.

The most common complications are severe dysesthesia, corneal hypoesthesia and transient motor weakness.

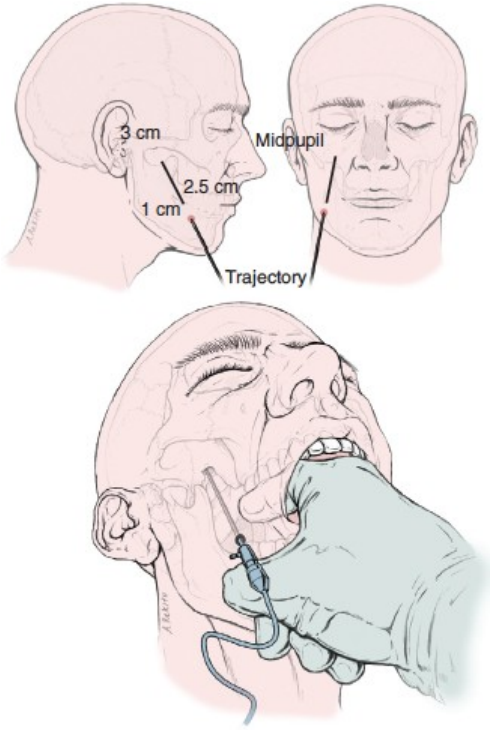

Figure 34 : Detection of the trajectory of the radiofrequency needle in the percutaneous radiofrequency thermocoagulation technique [34].

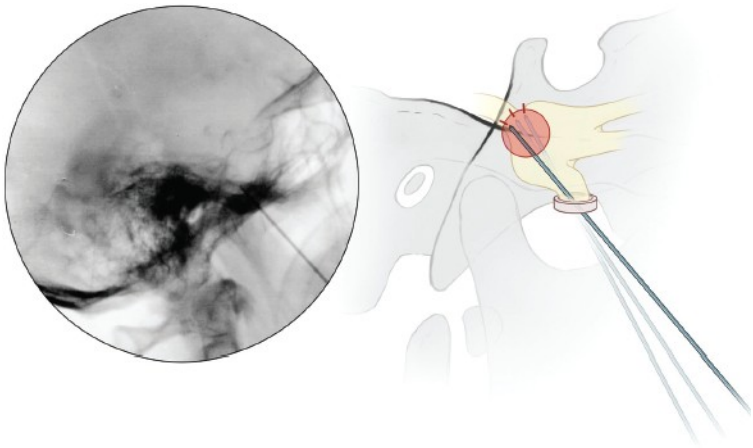

Figure 35 : On lateral fluoroscopy, the needle is seen entering the the foramen ovale toward the trigeminal ganglion [34].

1.1.2. The radiofrequency thermocoagulation in our study:

The mean age of patients benefiting from TC in this study (54,89 ± 12,664) was higher than the one found in the MVD.

In literature, the radiofrequency thermocoagulation is preferable for elderly patients and those with adverse co-morbidity or those who are not willing to undergo open surgery.

In this study, this technique was mainly used to treat resistant TN caused by branches V2 and V3 same as the study of M.Laghmari [37] (done in the neurosurgery department of « Hôpital des spécialités » in Rabat, between 1983 and 2004) and showing both the high rates of immediate pain relief compared to the other techniques.

The review of many literature series shows similar results between this study and those of the other authors.

Table XXXIV: Comparative table of short-term pain relief rate of the TC in different studies.

Authors	Number of patients	Rate of the immediate pain relief (%)
Laghmari *et al.*[37]	73	96
Meglio *et al.*[38]	33	81,8
Taha and Tew **Updated by : K.Toda [39] [40]**	500	98
W. Fouad (2011) [41]	312	100
In this study	44	97,70

Another criterion used for the judgment is the complications rates of the radiofrequency thermocoagulation.

In this study, this rate, compared to the rates of the two other surgical methods represents the highest one.

The most notable complication in our series and in literature as well, is the ipsilateral hemi facial numbness, however, that can be also considered as an efficacy criterion of this technique.

We noticed, high rates of anesthesia dolorosa, which is a constant burning painful numbness creating spontaneous pain signals without nociceptive stimuli, caused by injury of the trigeminal nerve because of this operation.

Meningitis due generally to *Streptococcus pneumoniae* is being also an important morbidity caused by the TC that can even lead to mortality, the sources of contamination are the contamination of the surgical equipment, the lack of asepsis in the operation, an inadequate preparation of the skin, and an accidental penetration of the needle into the oral cavity [42].

Antibiotic prophylaxis is the warranty to prevent this complication if undergoing TC.

Cases of keratitis and corneal anesthesia were not found in our study, still, in literature, they are considered one of the important complications of the TC.

Since the appearance of the first cases of keratitis of the V1 division, induced by the TC, this technique was not used anymore for ophthalmic neuralgia and that explains why we are not finding such complications in this study results.

The cornea is innervated mainly by the V1 which plays an essential role in the production of tears and preserve the normal metabolism and function of the ocular surface,so when sensitivity is lost due to the surgical damage caused by TC, many epithelial changes happen including an epithelial keratopathy.

Table XXXV: The commonly encountered complications of the TC in several studies.

Authors	Complications
Laghmari *et al.*[37]	Ipsilateral hemi facial numbness Cheek hematoma Keratitis Meningitis
Meglio *et al.*[38]	Dysesthesia
Taha and Tew **Updated by: K.Toda [39] [40]**	Ipsilateral hemi facial numbness Dysesthesia Anesthesia dolorosa Keratitis Corneal anesthesia
W. Fouad [41]	- Ipsilateral hemi facial numbness - Dysesthesia - Corneal anesthesia - Meningitis
In this study	Ipsilateral hemi facial numbness Anesthesia dolorosa Cheek hematoma

Concerning the mid-term pain relief, the TC in this study represents the lowest rate compared to the other techniques, similar to the rate shown in the study of Laghmari, in literature there are several rates but all authors agree that in terms of mid-term outcome the TC shows mediocre results.

Table XXXVI: Comparative table of mid-term pain relief rate of TC in different studies.

Authors	Months of follow up	Rate of the pain relief (%)
Laghmari *et al.*[37]	72	70
Meglio *et al.*[38]	24	57,6
W.Fouad [41]	12	86,5
In this study	24	70,45

The high rate of recurrence of this technique found in this study (27,25%) compared to the MVD, is confirmed by the study of Taha and Tew updated by K.Toda showing a rate of 20%.

As mentioned earlier, the recurrence rate of the TC is related to the degree of ipsilateral hemi facial numbness, in other words, no hypoesthesia equals high recurrence rate, versus, mid-term efficacy equals a certain degree of hypoesthesia. This criterion is applied only for percutaneous techniques.

According to these results, it is safe to say that TC gives the best results in matter of short-term, however, the mid-term efficacy and its several complications make this technique questionable.

1.2. The percutaneous balloon compression of the Gasserian ganglion

1.2.1. Technique's presentation [34]

This technique developed by Mullan [43] is an update of the one presented by Shelden [44], which consisted of a micro compression of Gasser's ganglion using a balloon catheter, when the balloon is fully infiltrated, there is stretching of the Dura causing a Dural compression of the trigeminal ganglion and its root.

Balloon micro compression does not require the patient to be awakened during surgery and can thus be performed under general anesthesia, limiting by that anxiety and discomfort of the patient.

Premedication with an anticholinergic or an external pacemaker are administrated to deal with bradyarythmia during insertion of the needle through the foramen ovale.

The patient is positioned supine with the head extended about 15 degrees.

Using a fluoroscopic guidance and the Hartel technique as well, a 14-gauge needle with a blunt obturator is introduced into the foramen ovale of the affected side.

When the cannula has engaged the foramen ovale, the blunt obturator is removed and a straight guiding stylet is inserted. Under fluoroscopic guidance, the stylet is then directed toward the porus trigeminus, this brings the tip of the stylet between 17 and 22 mm beyond the foramen ovale, within 5 mm beyond the clival line. In this location, the tip of the stylet abuts the maxillary fibers. Manipulations of the stylet medically or laterally bring the tip closer to V1 or V3 fivers, respectively.

A No.4 Fogarty balloon catheter is test-inflated with contrast and all air excluded from the balloon. The stylet is withdrawn and the balloon with inner stylet is introduced.

The balloon is then inflated using about 1ml of contrast agent. If accurately positioned, it assumes a pear shape on lateral fluoroscopy.

Adequate compression can be verified by measuring the intraluminal pressure changes (adequately 1200 to 1500 mmHg) and is limited by lifting the Dura off the trigeminal ganglion.

A limited time of compression (less than 2 minutes) has resulted in the reduction of the incidence of masseter muscle weakness and sever numbness.

When the compression time is over, the balloon is deflated and both the catheter and the balloon are removed with a pressure of 5 minutes to prevent hematoma formation.

The patient can be discharged after about 4 hours of observation.

Permanent motor root weakness as well as dysesthesia are the major complications of this technique

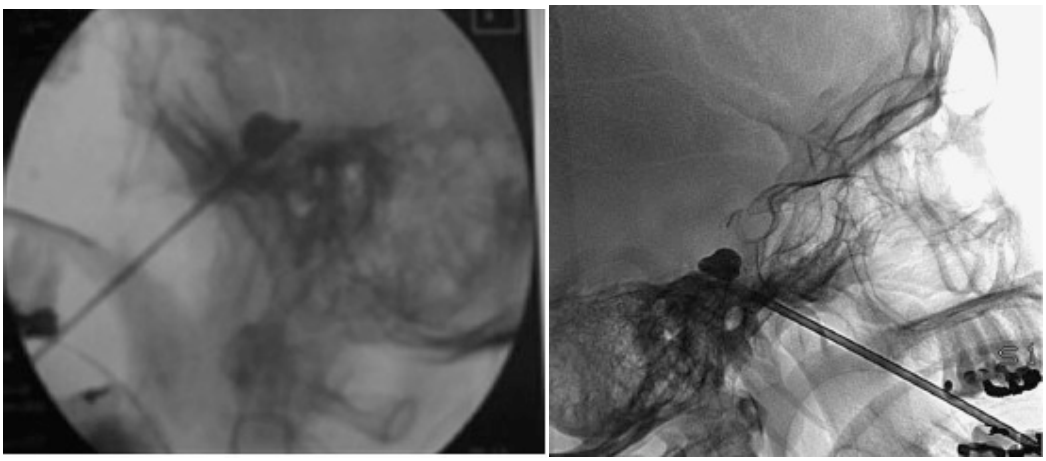

Figure 36 : Lateral Fluoroscopic images showing a Pear-shape appearance of an inflated balloon under fluoroscopic guidance during PBC [45].

1.2.2. The percutaneous balloon compression of the Gasserian ganglion in our study:

The mean age of patients in this study was higher than the ones found in all three techniques (60,48±12,575), joining literature in the idea that percutaneous techniques are to be used for elderly patients.

Concerning the pain relief at short-term, the rate was comparable to the ones in several studies.

Table XXXVII: Comparative table of short-term pain relief rate of the PBC in different studies.

Authors	Number of patients	Rate of pain relief (%)
Laghmari *et al.*[37]	41	95
Grewal *et al.* [46]	222	89
Meglio *et al.*[38]	74	93,2
M.Taha *et al.*[39]	759	93
Kostantinos *et al.*(2010) [45]	47	85
In this study	31	96.7

PBC is an operation considered in literature a less precise and a general anesthesia dependent, however, it has a low complications rate compared to the TC, shown in this study as well as the series of other authors.

Complications are the same found in the TC, with the exception of keratitis and corneal anesthesia being at low incidence compared to the TC.

Table XXXVIII: The commonly encountered complications of the PBC in several studies.

Authors	Complications
Laghmari *et al.*[37]	- Ipsilateral hemi facial numbness - Meningitis - Cheek hematoma - Hypoacousia - Facial nerve palsy
M.Taha *et al.*[39]	- Facial numbness - Dysesthesia - Anesthesia dolorosa
In our study	- Ipsilateral hemifacial numbness

Concerning the pain relief at mid-term, results in this study show that the PBC is less effective than MVD and has a relief rate slightly higher than the TC. These results are confirmed by those found in literature.

Table XXXIX: Comparative table of mid-term pain relief and recurrence rates of PBC in different studies.

Authors	Rate of pain relief (%)	Recurrence rate (%)
Laghmari *et al.*[37]	72	12,19
Grewal *et al.*[46]	87	18,50
Meglio *et al.*[38]	57,2	No data available
M.Taha *et al.*[39]	73	21
In our study	74,19	22,51

The Postoperative management in percutaneous procedures:

After all percutaneous procedures, the entry point must be cleaned.

Corneal sensation must be tested, in case of a substantial loss or corneal irritation, for that artificial tears may be advised for use every 2 to 4 hours with an ophthalmologic control.

Jaw opening exercises may be necessary, especially for patients who underwent balloon compression procedure.

Some patients may develop a maceration of the buccal mucosa, requiring irrigation of the mouth with warm saline solution every 4 hours.

Some patients may develop herpes simplex type 1 lesions few days after surgery, treated simply by Acyclovir.

In cases of headache, it is important to eliminate a probable meningitis.

2. The Microvascular decompression (MVD)

The MVD is considered in literature the Gold standard surgical intervention of TN.

The conservative technique of Gardner-Janneta consists on liberating the root of trigeminal nerve from the vascular compression and keeping distance between the vessel and the nerve using a special prosthesis.

The MVD differs from the other treatments in that it treats the primary cause of TN so that mid-term pain relief is possible, it can also be safely performed after a lesioning procedure.

If life expectancy is very short or general anesthesia cannot be tolerated, a less invasive destructive procedure may be more appropriate replacing the MVD.

All patients should undergo MRI before MVD.

2.1. Technique's presentation: [47]

General anesthesia is essential in this intervention of approximatively 2 hours.

Intraoperative monitoring is helpful to prevent injury to the brainstem and cranial nerves.

A cranial fixation device such as the three-pin Mayfield® head holder is applied before positioning. There are several options for patient positioning for MVD, the simplest option is to place the patient in a flat supine position with head rotated and flexed to the side opposite the affected side, this position requires a flexible neck and may not work for obese or short-necked patients.

Another option is the lateral decubitus position with the shoulder taped caudally and the neck flexed, ensuring the chin is at least two fingerbreadths from the sternum. The sitting

position can also be used, but it is associated with complications such as air embolism and subdural hematoma.

Hair is clipped from the surgical site, the scalp is sterilized and then infiltrated with local anesthetic with epinephrine to reduce bleeding.

The linear incision runs longitudinally two fingerbreadths behind the ear (5mm behind the hairline) and extends 3 to 5cm.

Monopolar electro cautery is used to dissect and clear muscle and soft tissue until the bone of the mastoid eminence and digastric groove is seen.

The wound is held open with a self-retaining retractor or with sutures.

Bone removal is performed with a high-speed drill or perforator, starting at the mastoid emissary vein.

With a drill and a periosteal elevator to carefully elevate the Dura, the craniotomy is expanded until the junction of the transverse and sigmoid sinuses can be seen.

The Dura is opened in an inverted L shape, parallel to and 3 to 5 mm from the transverse and sigmoid sinuses.

Cerebrospinal fluid is then allowed to drain through gentle retraction on the cerebellum with a cotton neurosurgical patty.

Any adhesions or bridging veins along the superior margin of the cerebellum along the transverse sinus are coagulated and sharply divided.

The microscope is brought into the field, and the self-retaining retractor system is set up to gently retract the cerebellum up and medially and slightly elevated toward the surgeon. It allows for penetration of the trigeminal cistern and further drainage of cerebrospinal fluid, reducing the need for medial cerebellar retraction for exposure of the trigeminal nerve.

Some surgeons recommend preserving all or at least the superior part of the petrosal venous complex if the veins do not obstruct the nerve or are easily mobilizable, but their presence usually prevents full exploration of the nerve.

The arachnoid membrane over the nerve is carefully removed to allow complete inspection and allow decompression of the nerve.

Vascular compression is usually seen close to the brainstem, often anterior to the nerve.

The artery that most frequently produces compression is the SCA, decompression requires elevation of the artery in a horizontal rather than the vertical orientation, displacing it away from the nerve.

The AICA may compress the nerve from below, requiring displacement more inferiorly away from the nerve.

A Teflon® pad is placed between the vessel and nerve in a proximal-to-distal manner; it is held in place by the the tension between the artery and nerve root and reinforced if necessary with absorbable gelatin sponge or fibrin glue.

Small veins may be coagulated, but arteries should always be preserved. The nerve must be explored along its entire length, because the REZ may extend many millimeters from the brainstem and even very small vessels may cause compression.

If venous compression is identified, the vein is carefully dissected from the nerve and coagulated with low-voltage small bipolar forceps.

After decompression, the vessels are carefully observed, the operative field is liberally irrigated, retractors are removed and a Valsalva-like maneuver is performed with the ventilator by the anesthesiologist to ensure there is no bleeding.

The Dura is closed in a watertight manner with continuous or interrupted braided 4-0 sutures to prevent subsequent leakage of the cerebrospinal fluid.

After the operation, the patient must be observed in the intensive care unit and blood pressure is monitored.

Patients are generally discharged by the third postoperative day and can be back to work within 2 to 4 weeks.

Complications from MVD are rare, however, some patients suffer from hearing loss, vertigo, facial nerve palsy, cerebrospinal fluid rhinorrhea, aseptic meningitis with headache, wound infection, cerebellar hemorrhagic infraction or posterior fossa hemorrhage.

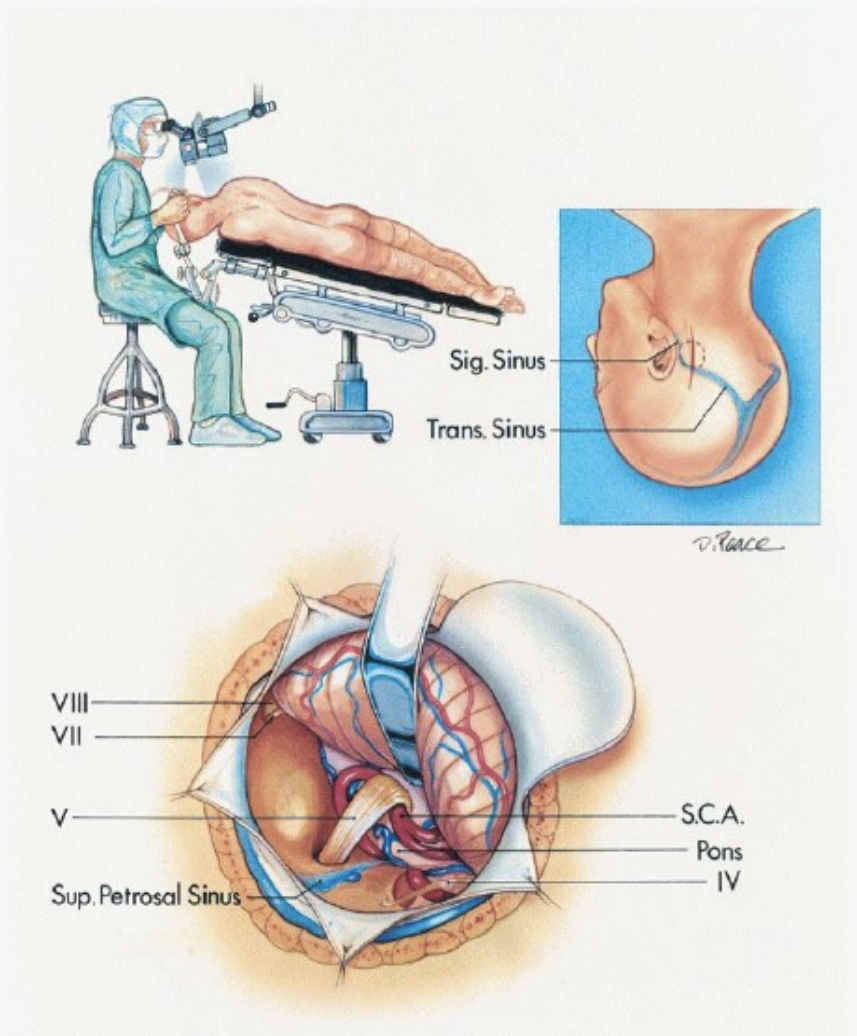

Figure 37 : Retro sigmoid approach to the trigeminal nerve for a microvascular decompression. [7]

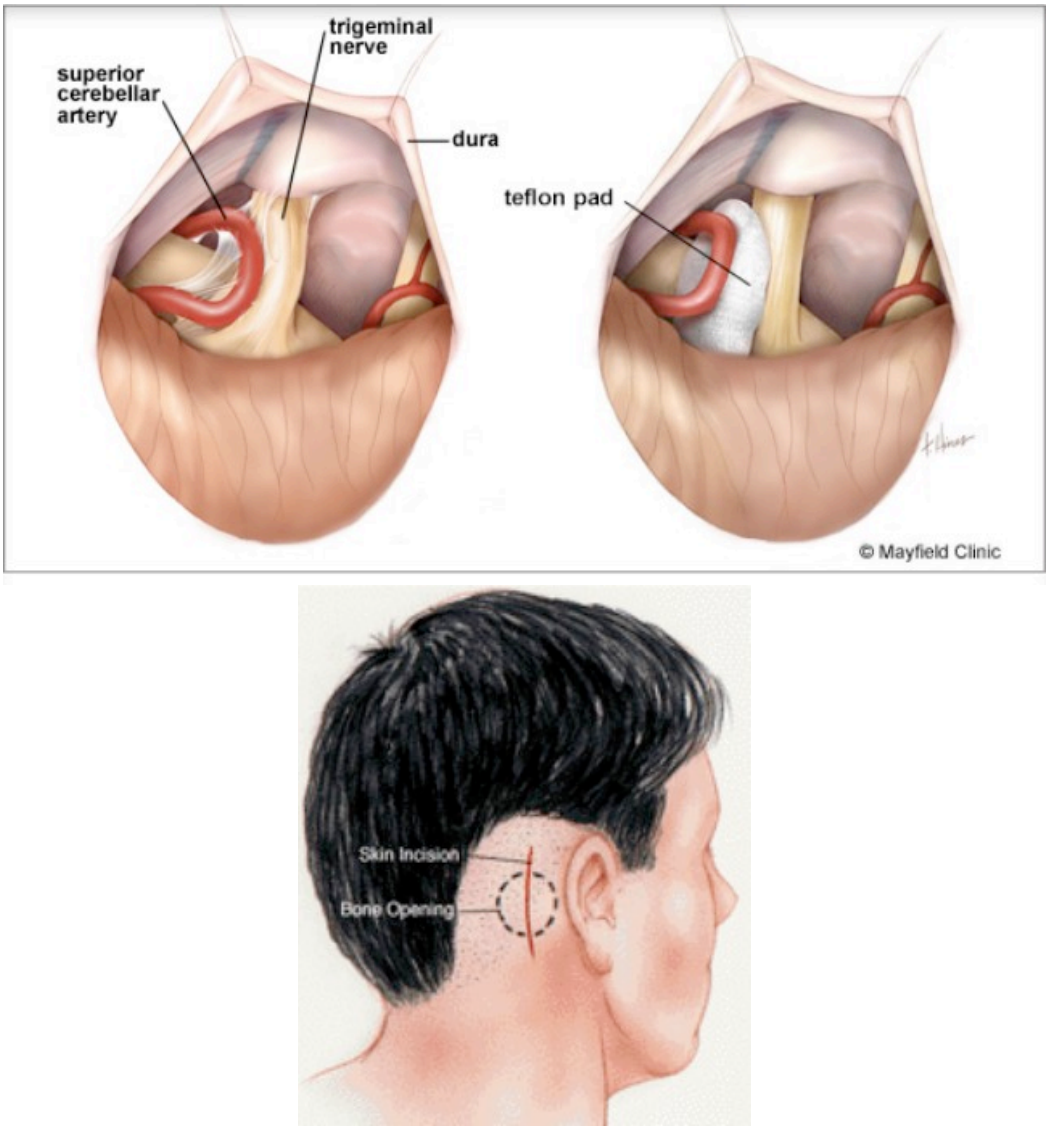

Figure 38 : Schematic view of the MVD technique. [48]

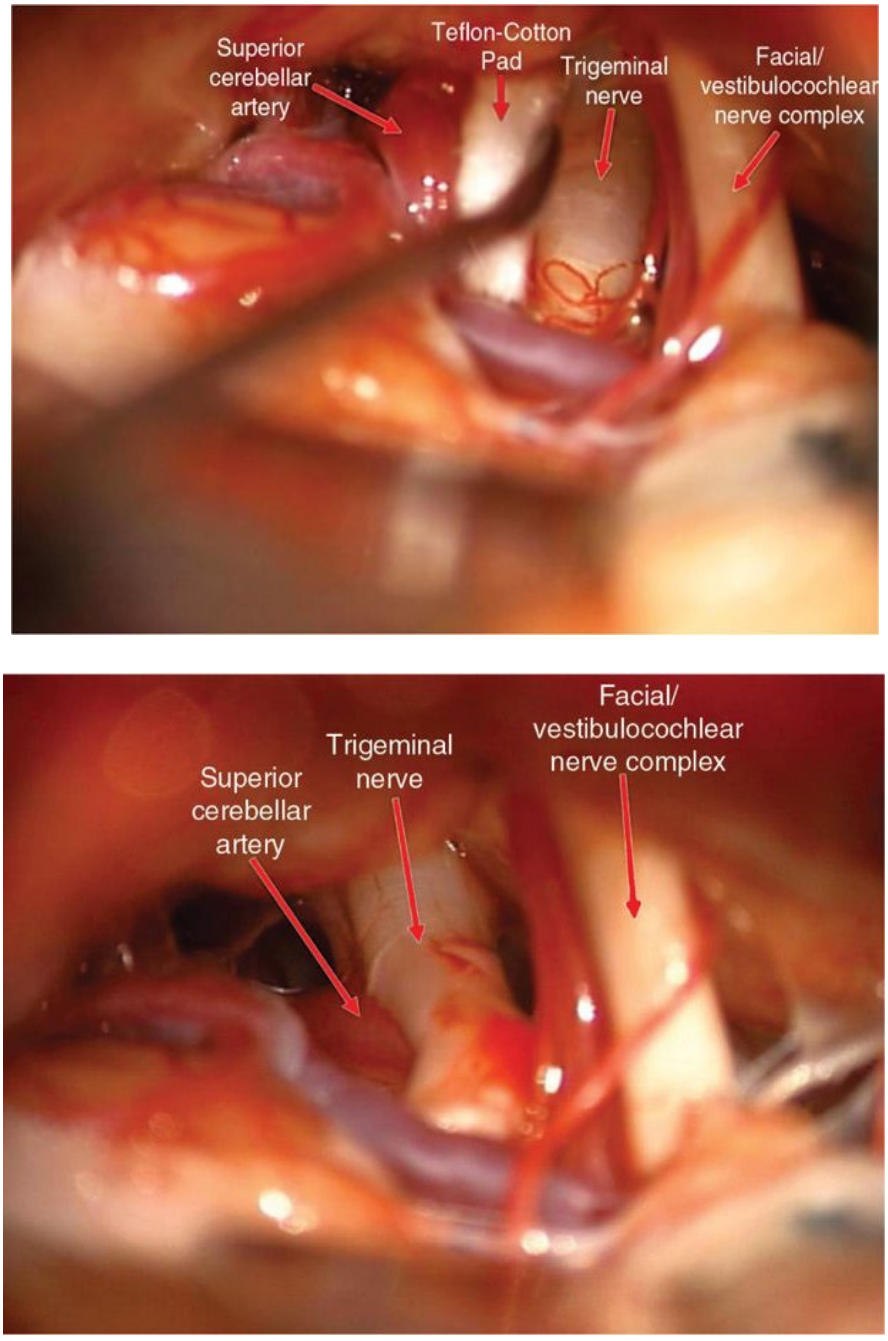

Figure 39 : Intraoperative findings in the MVD showing a NVC and the use of a Teflon pad. [48]

2.2. The microvascular decompression in our study

The mean age of patients in this study was nearly the same found in other techniques (51,77± 9,905), however, in literature, the consensus is that the microvascular decompression represents the ideal technique for young and healthy patients.

Several studies in literature conclude that microvascular decompression is the technique less exposed to failure based on many criteria justifying the satisfactory outcomes.

In our study, this technique was used mainly to treat resistant TN of V2 branches same as the study of M.Laghmari *et al.*[37] and showing a high rate of immediate pain relief but less than the ones found in the percutaneous techniques.

The review of the many literature series shows similar results between this study and those of the other authors.

Table XL: Comparative table of short-term pain relief rate of the MVD in different studies.

Authors	Number of patients	Rate of immediate pain relief (%)
Laghmari *et al.*(2007) [37]	51	94
Meglio *et al.*(1990) [38]	20	85
Chen *et al.*(2003) [49]	114	94,7
Taha and Tew Updated by : K.Toda (2008) [39] [40]	1417	98
P.J.Janneta *et al.*(1996) [50]	1185	98
Serdar K. *et al.*(2009) [51]	62	87,20
In this study	26	92,30

Another criterion used for judgment is the complications rate of the microvascular decompression.

In our study, this rate compared to the rates of the two other surgical methods studied represents the lowest rate.

We can justify the existence of several cases of Hypoacousia in this study with the fact of the proximity of the CNV to cranial nerve VIII. The Same theory can be applied justifying facial nerve palsy.

Two major morbidities reported in literature but not found in our series are: Aseptic meningitis that can be caused by Teflon® implantation and the hemorrhagic complications such as cerebellar hematomas and strokes caused by cerebellar infraction.

Called a conservative technique, MVD can be responsible of a low rate of ipsilateral hemi facial numbness and dysesthesia unlike the percutaneous techniques.

Table XLI: The commonly encountered complications of MVD in several studies.

Authors	Complications of MVD
Laghmari *and al* [37]	Hearing loss Meningitis Cranial nerve palsy
Meglio *and al* [38]	Hypoacousia CN IV palsy
Chen *and al* [49]	Cerebellar hematoma Headaches Hearing loss
Taha and Tew Updated by : K.Toda [39] [40]	- Ipsilateral hemi facial numbness - Dysesthesia - Anesthesia dolorosa - Cranial anesthesia
P.J.Janneta *et al.*[50]	Death Cerebrospinal fluid leakage Ipsilateral hemi facial numbness Cerebral hematoma Dysesthesia Hearing loss IV cranial nerve palsy
In this study	Ipsilateral hemi facial numbness Hearing loss Severe headache

Concerning the mid-term pain relief, the MVD in this study has the highest rate compared to the other techniques, similar to the rates shown in literature.

Table XLII: Comparative table of MVD mid-term pain relief rate in different studies.

Authors	Rate of pain relief (%)
Laghmari *et al.*[37]	77
Meglio *et al.*[38]	75
Chen *et al.*[49]	81,50
Taha and Tew **Updated by : K.Toda [39] [40]**	83
P.J.Janneta *et al.*[50]	75
M.Tronnier *et al.*[52]	64
In this study	76,92

Many studies : Meglio *and al*., Tronnier *and al*., Parmar *et al.*[32], conclude that the MVD is the best choice for mid-term, but in association with the following factors : Typical neuralgia, neurovascular conflict, short time between first episode and surgery and finally absence of anterior surgery.

The low rate of recurrence of this technique (15,38%) found in this study compared to the percutaneous techniques, is confirmed by the study of Laghmari having nearly the exact rate.

However, it is not the case with other studies reporting different rates.

The disparity between the results can be explained by the difference in the choices of the mid-term follow up periods.

Table XLIII: Comparative table of the MVD recurrence rate in different studies.

Authors	Recurrence rate (%)
Laghmari *et al.*[37]	15,60
P.J.Janneta *et al.*[50]	30
M.Tronnier *et al.*[52]	23
In this study	15,38

3. Gamma knife radiosurgery

3.1. Technique's presentation

Gamma Knife radiosurgery was developed more than 50 years ago by a Swedish neurosurgeon, Professor Lars Leksell, at Karolinska University Hospital in Stockholm. His idea was to treat areas of the brain deep down using gamma rays like a scalpel (origin of the connotation "Gamma Knife").

Usually, the root entry-zone of the CNV is used as a target, alternative targets are the trigeminal nuclei in the brainstem or the Centro median nucleus of the thalamus with doses ranging between 70 to 100 Gy.

The target is localized thanks to its stereotaxic coordinates obtained by the imaging carried out with the stereotactic frame of Leksell.

The mean maximal dose is approximately 80 Gy, with complications starts to appear at a dose of 90 Gy.

The slow chemical reaction inducing the final blockage of sodium chains would be the origin of the mechanism involved in this process. In other words, blocking nerve stimuli is the result of indirect destruction of ion channels, mainly sodium.

The most significant complication resulting from this technique is numbness, which has been reported to occur in up to 21% of cases and is considered as bothersome or painful in 5% to 10% of patients [53] [54].

Significant dysesthesia has been reported in about 3,2% of patients after this operation [55].

3.2. The Gamma knife radiosurgery in a previous study done in the national center of rehabilitation and neuroscience in Rabat

In comparison, we are going to refer to the study of Ibn Seddik Touaiba, done inthe national center of rehabilitation and neuroscience *(a reference center that the Hassan II Foundation for the Prevention and Control of Nervous System Diseases, the Ministry of Health and the Ibn Sina Hospital of Rabat have created, on the High Directives of His Majesty King Mohammed VI)*, over a period of 10 years (from 2008 to 2018) assembling 10 patients suffering from idiopathic trigeminal neuralgia and treated using the gamma Knife radiosurgery.

We summarize the results found in Ibn Seddiq study and those in other studies in the table bellow:

Table XLIV: Comparison of efficacy of gamma knife radiosurgery in different studies.

Author	Number of patients	Follow up period (months)	Mean age of the patients	Success rate (%)	Recurrence rate (%)	Mid and long term Complications rates (%)
Ibn Seddik (2018) [19]	9	24	64,44	80	0	22,20
Young *et al.* (1997) [56]	110	19,8	64,70	80	37	2,70
Rogers *et al.* (2000) [57]	54	18	67	85	21	09
Arkha *et al.* (2008) [58]	262	37,5	68	88,90	21-34%	12,90
Chen et al. (2017) [59]	56	29,3	63,1	89,30	17	14,30

- Compared to this study, Gamma Knife radiosurgery showed the highest mid-term relief rate, slightly close to the one found in MVD.
- We note also a low complication rate compared to the other techniques, with the only complication being found is post operative paresthesia (22,20%).
- This technique in the study of Ibn Seddik, shows no recurrence at all, a questionable result for confirming the efficacy of this technique, especially when other studies in literature point out a recurrence rate usually ranging between 20 to 40%. It can be explained by the small sample size in the study.
- Having a mean age around 60 to 70 years, with a high rate of mid-term success and low complications rate, we consider this technique to be the ideal replacement to MVD for elderly patients or patients with comorbidities.

Table XLV : Different results of techniques used in this study compared to the GKRS results in Ibn Seddiq's study.

Technique (%)	*Number of patients (n)*	*Follow up period (months)*	*Mean age (n)*	*Success rate at mid-term(%)*	*Recurre -nce(%)*	*Complication rates (%)*	*Type of complications**
MVD	26	24	51,77	76,92	15,38	34,61	IHN (15,38%) HL (7,69%) SH (11,53%)
TC	44	24	54,89	70,45	27,25	50	IHN (29.24%) AD (11,36%) CH (6,81%) FP (2,27%)
PBC	31	24	60,48	74,19	22,51	38,70	IHN (38,7%)
GKRS	09	24	64.44	80	0	22.2	Paresthesia

**Abbreviations: IHN : Ipsilateral hemi facial numbness. / HL : Hearing loss/ SH : Severe headache/AD : Anesthesia Dolorosa/ CH : Cheek Hematoma/ FP : Facial palsy.*

III. Limits of the study

Our study, despite its comprehensiveness, which embraces a large number of aspects of the subject, has been biased at several levels by the :

- **Small sample size** (explained by the rarity of the disease and also because of the loss or the incomplete data of the medical files)
- **Short period of follow-up** compared to the different series in literature.

A long term follow up couldn't be done in our case because of absence of the "over 2 years follow up" data in patients' files highlighting the need of computerization of medical data.

Conclusion

Trigeminal neuralgia, often called Fothergill disease or tic douleureux of Trousseau is a serious neurological condition with an incidence between 10 and 25 new cases for 100.000 inhabitants per year, affecting more the elderly population and especially more common among women, although it may occur in younger patients secondary to multiple sclerosis, tumors, or vascular abnormalities.

It is described by a paroxysmal shock-like facial pain attacks located in the distribution of the trigeminal nerve. The intensity of the pain can lead the patient to suicide.

Early diagnosis helps initiate an appropriate therapy. The mechanisms of classical trigeminal neuralgia haven´t been fully proved yet, neurovascular compression is the main etiology described today.

The first step of the treatment of trigeminal neuralgia is based on the use of antiepileptic drugs with Carbamazepine considered the drug of reference. Other pharmacological classes may be employed, such as muscle relaxants, psychotropic drugs, anti-migraine drugs etc.. However, many drugs would require studies of high level of evidence regarding their effectiveness on trigeminal neuralgia.

In case of failure of medical treatment or occurrence of side effects, a neurosurgical treatment is to be considered.

The choice of the surgical treatment must take into consideration the disease and the patient, his age, his medical condition, any prior surgery as well as his opinion and his participation.

A large spectrum of surgical techniques has been used to treat patients, mainly: the microvascular decompression, the percutaneous radiofrequency thermocoagulation, the percutaneous balloon compression of the Gasserian ganglion and the Gamma-Knife radiosurgery.

In our study, these procedures are highly effective either at the short or the mid-terms.

TC shows the highest rate of immediate pain relief, however, it seems to have the highest postoperative complications rate due to its destructive characteristics.

The other percutaneous technique, PBC, technically more simple and totally painless for the patient, shows nearly similar results as the TC and less complications.

In the other hand, MVD and GKRS, present the highest rates of mid-term relief with lower complications and recurrence rates, making them suitable as first choice for younger patients with no comorbidities.

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Abstracts

ABSTRACT

Title: Trigeminal neuralgia: Treatment modalities and clinical results, a retrospective study of 101 cases.

Author : CHAHBAR Abdelaziz

Key words: Follow-up, Gamma Knife radiosurgery, Microvascular decompression, Percutaneous balloon compression, Radiofrequency thermocoagulation, Trigeminal neuralgia.

Over a period of 25 years, from 1993 to 2018, 101 patients of a mean age of 55,93 years, suffering from classical trigeminal neuralgia, underwent different types of surgical treatments at the neurosurgery department of Hôpital des spécialités ONO in Rabat, the aim of this study is to evaluate and compare the efficacy of these surgical treatments in both short-term (3 months) and mid-term (1 to 2 years).

The choice of a certain technique depends on many factors: the age of the patient and its general condition (ASA score), the consent of the patient and the decision of the medical staff.

The efficacy of each technique is evaluated at short-term by existence of an immediate pain relief as well as the complications rate, the mid-term outcome is evaluated using the complete pain relief and the recurrence rate criteria.

In our study, all surgical techniques are highly effective either at the short or the mid-terms, leading to good pain control, however, there are slight differences in terms of safety, simplicity and efficacy between this spectrum of surgical techniques.

Concerning the immediate pain relief, percutaneous techniques, mainly, the radiofrequency thermocoagulation, presents the highest rate of immediate pain relief (97,7%).

Microvascular decompression, considered in literature as the gold standard operation, presented the lowest complications rate (34,61%), the best mid-term pain control (76,92%) and the lowest recurrence rate (15,38%) versus the percutaneous techniques, making it the ideal technique to be applied if patient meets the operability criteria.

It is necessary to continue studies on a larger patients' selection and a longer period to improve outcomes reliability on defining the best choice of surgical treatment.

RESUME

Titre: Névralgie du nerf trijumeau : modalités thérapeutiques et résultats cliniques : Une étude rétrospective à propos de 101 cas.

Auteur: CHAHBAR Abdelaziz

Mots clés : Compression par ballonnet, décompression micro vasculaire, névralgie faciale, radiochirurgie Gamma Knife, Surveillance, thermorhizothomie retrogassériennne.

Sur une période de 25 ans, de 1993 à 2018, 101 patients d'un âge moyen de 55,93 ans, souffrant de névralgie trigéminale classique ont subi différents traitements chirurgicaux au service de neurochirurgie de l'Hôpital des Spécialités de Rabat, le but de cette étude est de comparer l'efficacité de ces différentes techniques à court terme (3 mois) et au moyen terme (1-2 ans).

Le choix d'une technique dépend de nombreux facteurs : l'âge du patient et son état général (score ASA), le consentement du patient et la décision du staff multidisciplinaire.

L'efficacité de chaque technique est évaluée à court terme par l'existence d'un soulagement immédiat de la douleur et le taux de complications. L'efficacité au moyen terme est évaluée par le soulagement complet de la douleur et le taux de récidive.

Dans notre étude, toutes les techniques chirurgicales sont efficaces au court et au moyen termes, conduisant à un bon contrôle de la douleur mais ils gardent quelques différences en termes de sécurité, de simplicité et d'efficacité.

Concernant le soulagement immédiat de la douleur, la thermorhizothomie retrogassériennne, présente le taux le plus élevé de soulagement immédiat de la douleur (97,7%). La décompression microvasculaire, considérée dans la littérature comme l'opération de référence, présentait le taux de complications le plus faible (34,61%), le meilleur contrôle de la douleur au moyen terme (76,92%) et le taux de récidive le plus faible (15,38%) par rapport aux techniques percutanées, ce qui la rend idéale à appliquer si le patient répond aux critères d'opérabilité.

Il est nécessaire de poursuivre les études sur un échantillon plus large et une période plus longue pour améliorer la fiabilité des résultats orientant vers le meilleur choix du traitement chirurgical.

ملخص

عنوان الأطروحة: آلم العصب الثلاثي التوأم، الطرق العلاجية و النتائج السريرية ، دراسة باثر رجعي تضم 101مريضا.

المؤلف : شهبر عبد العزيز

كلمات البحث : مراقبة الحالة، ألم العصب الثلاثي التوأم، تخفيف الإنضغاط الوعائي المجهري، التخثير الحراري، الضغط المجهري بواسطة البالون، غاما نايف.

على مدى 25 سنة، منذ سنة 1993 إلى غاية سنة 2018، خضع 101 مريض يبلغ متوسط أعمارهم 55.93عاما ويعانون من ألم العصب الثلاثي التوأم الكلاسيكي، لأنواع مختلفة من العلاجات الجراحية في قسم جراحة الأعصاب بمستشفى الاختصاصات بالرباط.

الهدف من هذه الدراسة يتمثل في اختبار ومراجعة نجاعة هذه الأساليب الجراحية على المدى القصير (3 أشهر) والمتوسط (سنة-سنتين).

يعتمد اختيار تقنية معينة على عدة عوامل: عمر المريض، حالته العامة و الحالة الصحية قبل العملية وموافقة المريض إضافة إلى قرار الطاقم الطبي.

تم تقييم نجاعة كل تقنية على المدى القصير من خلال وجود أو عدم وجود تخفيف فوري للآلام وكذلك معدل المضاعفات، أما تقييم النتيجة على المدى الطويل فقد تم بالنظر إلى بلوغ تخفيف كامل للألم من عدمه وحصول انتكاس للحلات من عدمها.

في هذه الدراسة، جميع التقنيات الجراحية فعالة للغاية سواء على المدى القصير أو المتوسط، مما يؤدي إلى السيطرة الجيدة على الألم، ومع ذلك، هناك اختلافات طفيفة من حيث السلامة والبساطة والمردودية بين هذه التقنيات الجراحية.

فيما يتعلق بتخفيف الآلام الفوري، فإن تقنيات التخثير الحراري والضغط المجهري بواسطة البالون، تقدمان نسبة أعلى من تخفيف الآلام الفوري (٪97.7).

إن تقنية تخفيف الانضغاط الوعائي المجهري والتي تعتبر في الأدبيات العملية العلاج الجراحي الأساسي لآلم العصب الثلاثي التوأم تقدم أقل معدل للمضاعفات (٪34.61) أفضل معدل تخفيف للألم (٪76,92) وأدنى معدل انتكاس (٪15,38) ، مما يجعلها تقنية مثالية ليتم تطبيقها إذا كان المريض مؤهلا للخضوع لعملية جراحية.

من الضروري مواصلة الدراسات لفترة أطول وحول مجموعة أكبر من المرضى للحصول على أكبر عدد من النتائج للحكم بشكل أوثق عن نوع العلاج الأكثر نجاعة.

Appendix

Appendix 1:

Investigation Sheet : Surgical treatment of trigeminal neuralgia

1) Identity :

- Name :
- Entry number :
- Year :
- Origin :
- Age :
- Gender :
    - Male
    - Female

2) History :

- Medical History :
    - No medical History
    - Cardiovascular abnormalities (HBP, Atherosclerosis …)
    - Neurological abnormalities (Multiple sclerosis …)
    - Other
- Drug intake :
    - Yes
    - No
- Surgical history:
    - No
    - Neurosurgery
    - Other

- Dental care:
    - Yes
    - No
- Familial history of TN :
    - Yes
    - No

3) Pain characteristics and topography :

- Type :
    - Electric charge
    - Burning
    - Pressure
    - Other
- Intensity : BNI score :
    - I
    - II
    - IIIa
    - IIIb
    - IV
    - V
- Number of attacks per day :
    - None
    - 1
    - 2 or more

- Triggering factor :
    - Direct
    - Indirect
- Duration of attacks:
    - Between 1 minute and 30 minutes
    - Between 30 minutes and 1 hour
    - More than 1 hour
- Affected side :
    - Left
    - Right
- Division involved :
    - V1
    - V2
    - V3
    - V1V2
    - V2V3
    - V1V2V3

4) N***otable pathology at clinical examination :***

- None
- Neurological
- Otorhinolaryngological
- Ophthalmic
- Other

5) Imaging :

- Technique used :
    - CT
    - MRI
- Results :
    - Normal
    - Neurovascular conflict
    - Tumor
    - Malformation
    - Inflammation

6) Name of Medical treatment taken and posology :

……..

7) Surgical treatment :

- Type :
    - MVD
    - Percutaneous Radiofrequency thermocoagulation
    - Percutaneous Balloon compression of the Gasserian ganglion.
- Short-term follow up :
    - Relief
    - Relief with medical treatment included
    - No Relief

- Mid-term term follow up:
    - Relief
    - Relief with medical treatment included
    - No Relief

8) Complications:

- None
- Ipsilateral hemi facial numbness
- Anesthesia dolorosa
- Keratitis
- Meningitis
- Cheek hematoma
- Hypoacousia
- Facial palsy
- III nerve palsy

9) Recurrence:

- Yes
- No

10) If yes, what is the technique used in the re-operation :

……..

11) Mortality :

 Yes

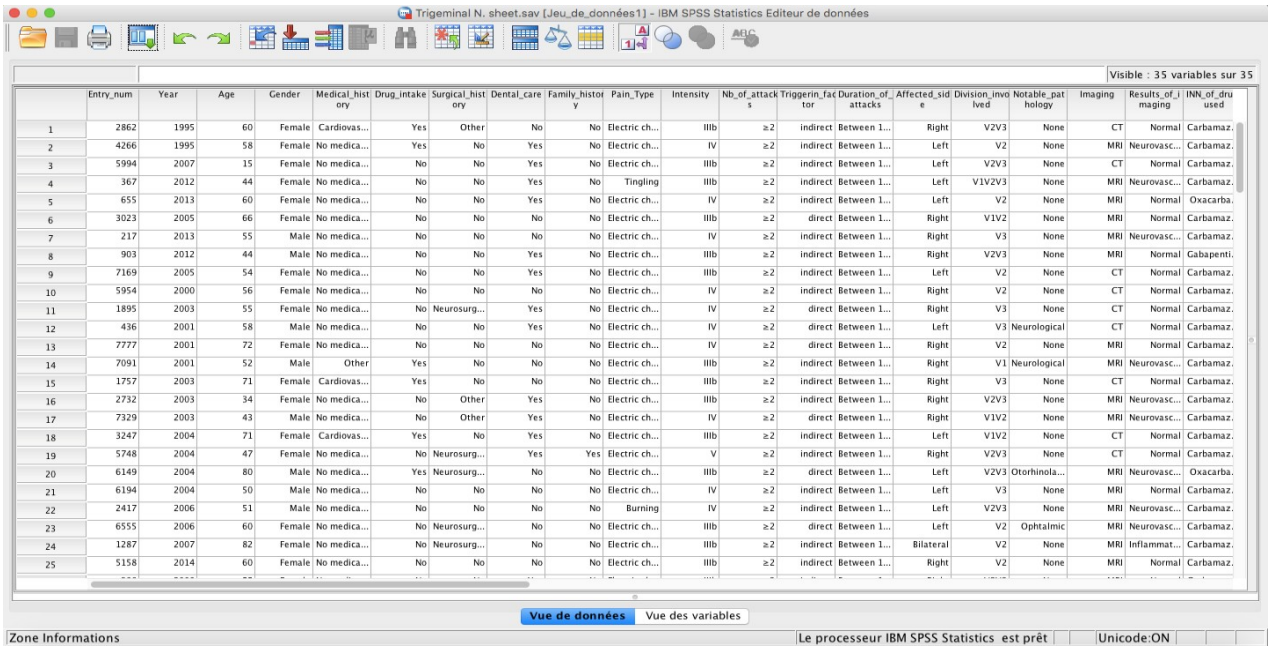
 No

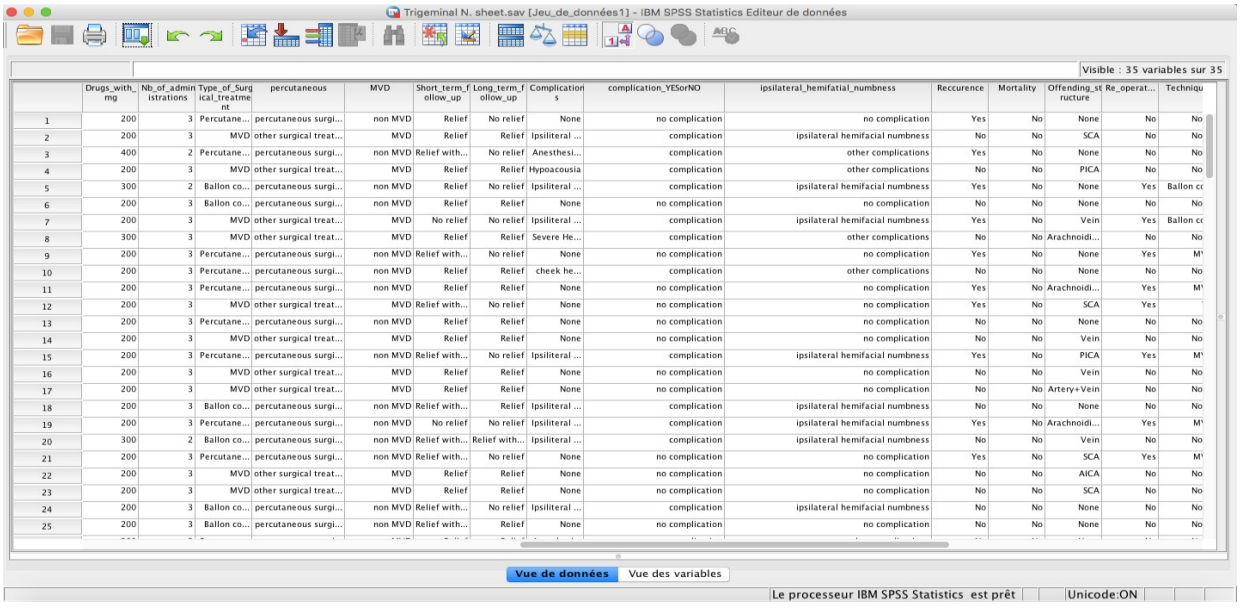
12) Type of offending structure :

- SCA
- AICA
- PICA
- VEIN
- ARTERY + VEIN
- Arachnoiditis
- Temporal bone spur
- Angulation of the entry of Meckel's cave

Appendix 2 :

Screen captures of the SPSS version 20 workbook with the data collected by the investigation sheets





Serment d'Hippocrate

Au moment d'être admis à devenir membre de la profession médicale, je m'engage solennellement à consacrer ma vie au service de l'humanité.

- *Je traiterai mes maîtres avec le respect et la reconnaissance qui leur sont dus.*
- *Je pratiquerai ma profession avec conscience et dignité. La santé de mes malades sera mon premier but.*
- *Je ne trahirai pas les secrets qui me seront confiés.*
- *Je maintiendrai par tous les moyens en mon pouvoir l'honneur et les nobles traditions de la profession médicale.*
- *Les médecins seront mes frères.*
- *Aucune considération de religion, de nationalité, de race, aucune considération politique et sociale ne s'interposera entre mon devoir et mon patient.*
- *Je maintiendrai le respect de la vie humaine dès la conception.*
- *Même sous la menace, je n'userai pas de mes connaissances médicales d'une façon contraire aux lois de l'humanité.*
- *Je m'y engage librement et sur mon honneur.*

قسم أبقراط

بسم الله الرحمان الرحيم

أقسم بالله العظيم

في هذه اللحظة التي يتم فيها قبولي عضوا في المهنة الطبية أتعهد علانية :

- بأن أكرس حياتي لخدمة الانسانية.
- وأن أحترم أساتذتي وأعترف لهم بالجميل الذي يستحقونه.
- وأن أمارس مهنتي بوازع من ضميري وشرفي جاعلا صحة مريضي هدفي الأول.
- وألا أفشي الأسرار المعهودة إلي.
- وأن أحافظ بكل ما لدي من وسائل على الشرف والتقاليد النبيلة لمهنة الطب.
- وأن أعتبر سائر الأطباء إخوة لي.
- وأن أقوم بواجبي نحو مرضاي بدون أي اعتبار ديني أو وطني أو عرقي أو سياسي اجتماعي.
- وأن أحافظ بكل حزم على احترام الحياة الإنسانية منذ نشأتها.
- وألا أستعمل معلوماتي الطبية بطريق يضر بحقوق الانسان مهما لاقيت من تهديد.
- بكل هذا أتعهد عن كامل اختيار ومقسما بشرفي.

والله على ما أقول شهيد.

المملكة المغربية
جامعة محمد الخامس بالرباط
كلية الطب والصيدلة
الرباط

سنة: 2020

أطروحة رقم: 53

آلام العصب الثلاثي التوأم، الطرق العلاجية و النتائج السريرية، دراسة بأثر رجعي تضم 101 مريضا

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المزداد في 09 ماي 1994 بتطوان

لنيل شهادة

دكتور في الطب

الكلمات الأساسية مراقبة الحالة ؛ آلام العصب الثلاثي التوأم ؛ تخفيف الإنضغاط الوعائي المجهري ؛ التخثير الحراري؛ الضغط المجهري بواسطة البالون ؛ غاما نايف

أعضاء لجنة التحكيم :

السيد: يونس بجيجو أستاذ في علم التشريح	**رئيس**
السيدة: محجوبة بوطربوش أستاذة في علم التشريح	**مشرفة**
السيد: عادل الملحاوي أستاذ في جراحة الدماغ و الأعصاب	**عضو**
السيد: علي الأيوبي أستاذ في علم التشريح	**عضو**
السيد: شريف العسري عباد أستاذ في جراحة الدماغ و الأعصاب	**عضو**