INTRODUCTION

Trigeminal neuralgia is defined by the IASP (International Association for the study of pain) as a sudden, unilateral, brief stabbing recurrent episodes of pain in the distribution of the trigeminal nerve branches, affecting the quality of life.[1]

Trigeminal neuralgia is also coined with ‘tic douloureux’: is a syndrome characterized by paroxysmal attacks of pain. Via myelinated A-fibers, it is caused by non-nociceptive stimuli such as yawning, chewing, light touch, and other transmitted stimuli.[1]

The diagnosis is usually made based on the patient’s history and the absence of neurological deficits, except for discrete hypoalgesia, thermo hypesthesia, or mechanoreceptive hypoesthesia in the trigger area.[2]

Trigeminal neuralgia may be “classical” or “symptomatic”. The term classical, refers to trigeminal neuralgia (TN) of unknown cause. While The secondary or symptomatic trigeminal neuralgia is due to other causes such as tumors or demyelinating lesions.[3]

The pathogenesis of TN and the effect of the different surgical procedures are not completely understood until now.[4] However, The neurovascular conflict theory is a cause widely accepted and can also explain other cranial rhizopathies.[5]

Facial pain is a complex issue that may originate not only from the nerves but also from other facial structures. The most important issue is the sound clinical diagnosis of the trigeminal neuralgia, as the importance of investigations is limited to reveal secondary causes or compressing vascular loop. For a better assessment of facial pain different specialties can be involved to rule out other non-neurological causes of facial pain like dentists and neurologists.

Treatment options for the trigeminal neuralgia include medical treatment[6, 7], ablative procedures (Gasserian ganglion percutaneous techniques, gamma knife surgery)[8,9]and non-ablative procedure (microvascular decompression).[10]

Aim of the Work

The study aims to evaluate the effectiveness of microvascular decompression in patients with primary trigeminal neuralgia regarding pain control, recurrence rate, and procedure- related complications.

HISTORICAL BACKGROUND

The first documentation of trigeminal neuralgia was in the first century AD as described in the Aristaeus's writings. At that time, treatments were so primitive: bloodletting and the administration of arsenic-, cobra-, hemlock-, and mercury soaked bandages.[11]

In the 11th century, in his book (Elquanun), the Avicenna (Ibn Sina), Arab physician and philosopher, described a severe facial pain condition without loss of power or sensation. The recommended treatment at that time was rest in a darkened room.[12]

Centuries later, Johannes Bausch and John Locke documented clinical descriptions of TN in 1672 and 1677, respectively. In 1765, Nicolaus Andre, a French physician, coined the term tic douloureux ("painful spasm").[11]

In the nineteenth century, susceptibility to TN was thought to be secondary to hereditary factors or insufficient diet and treatments included focusing on a nutritious diet, improved sleep, exercise, and things in moderation. Moderation was recommended because extremes in stress (including work) and toxins such as alcohol and tobacco use were thought to be an inciting factor for pain attacks.[12,13]

The first medical treatment for trigeminal neuralgia has been introduced in 1920, using trichloroethylene inhalation until its toxic effects were recognized in 1959.[13]

Early attempts at surgical treatments of TN were conducted by Mareschal (the surgeon to King Louis XIV of France) and Veillard around 1750 but were unsuccessful.[14]

The anatomical description and function of the trigeminal and facial nerve introduced by Bell and Megendie in the early 19thcentury is thought to have been the start of subsequent effective surgical treatments.[14]

There are several different surgical approaches including the middle fossa approach, demonstrated by Horsley, Taylor, and Coleman in 1981, and the subtemporal approach by Hartley and Krause in 1892. In 1925, a lateral suboccipital or cerebellar approach introduced by Dandy, he was able to observe vascular loops that were pinching on the root entry zone (REZ).[12,13]

In 1967, Peter Jannetta popularized a lateral suboccipital approach with the use of an operating microscope. the vascular loop compression of the REZ has been documented by Dandy, leading to the development of the microvascular decompression (MVD) surgery.[15]

Epidemiology

TN is a relatively rare neurological disorder with an incidence of 26 new cases per 100,000 per year.[16] Such incidence increases with age, being 1/1000 above 75years old. Onset is typically Between ages 50 and 80. Only 1.5% are below the age of 50 years.[17] If patients are younger than 40years, then suspicion should be raised for a secondary cause.[16]

The incidence of TN has consistently been found to be higher in women in most of the published series with a 1.74:1 female: male ratio.[18]

It is much more common in the second and third divisions of the trigeminal system and rare solely in the first division, unlike shingles (varicella zoster).[2]

MICROSURGICAL ANATOMY

Since the aim of trigeminal neuralgia surgery is the vascular decompression so the microsurgical anatomy of the posterior fossa and the cerebellopontine angle is mandatory. Trigeminal nerve-related neurovascular complex includes the SCA, AICA, PICA, basilar artery, midbrain, cerebellomesencephalic fissure, superior cerebellar peduncle, the tentorial surface of the cerebellum, and CNs III–V. This anatomical knowledge not only important for a causal relationship with the trigeminal nerve but also for operative nuances associated with the possibility that major vessels may be encountered and injured during rhizotomy and other posterior fossa operations on the trigeminal nerve. Thus, comprehensive knowledge of the anatomy of the trigeminal nerve is crucial for performing surgical procedures without significant complications.[19]

Anatomy of the trigeminal nerve:

It is the principal nerve of the first brachial arch.[20]The trigeminal nerve is the largest of the CNs. the trigeminal nerve has been divided along its course into[21]:

- Brainstem nuclei,
- Cisternal segment,
- Meckel's cave segment,
- Trigeminal ganglion,

- Peripheral divisions (ophthalmic, maxillary, and mandibular divisions).

The trigeminal nerve is a mixed sensory and motor nerve, serving facial sensation (V1, ophthalmic; V2, maxillary; and V3, mandibular) as well as the muscles of mastication via the V3 segment.[22]

- **Brainstem nuclei:** The four central nuclei of the trigeminal nerve are within the brainstem[21]:

1. *<u>The mesencephalic nucleus:</u>* This nucleus is concerned with mechanisms that control the force of the bite. It is located within the lower midbrain and upper pons lateral to the Sylvian aqueduct along the lateral margin of the periaqueductal gray matter and anterolateral to the fourth ventricle, medial to the sensory nucleus.[22]

2. *<u>The principal sensory nucleus</u>* conveys impulses for tactile and pressure sensors. It is arranged in a dorso ventral organization (ophthalmic, maxillary, mandibular). This nucleus lies lateral to the entering trigeminal root fibers in the upper pons. Trigeminal fibers from the principal sensory nucleus are both crossed and uncrossed to terminate the ventral posteromedial (VPM) nucleus of the thalamus. Crossed fibers originated from the ventral part of the nucleus ascend in association with the contralateral medial

lemniscus to form ventral trigeminothalamic tract. Uncrossed fibers originated from the dorsomedial part of the nucleus ascend close to the central gray of the midbrain to form dorsal trigeminothalamic tract.[20, 22]

3. *The motor nucleus* is medial to the principal sensory nucleus. Fibers from this nucleus exit from the brain stem medial to the entering sensory root, pass underneath the trigeminal ganglion without synapse and become incorporated in the mandibular division. Axons from the mesencephalic nucleus project to the motor nucleus, completing a reflex arc in modulating the degree of bite.[20]

4. *The spinal trigeminal tract and nucleus* relay the sensory modalities of pain and temperature. It extends from the mid-pons to the cervical cord at the level C2- C4 and lies anterolateral to the fourth ventricle[20, 22]. Root fibers entering the spinal trigeminal tract and nucleus have a definite topographical organization caused by medial rotation of the sensory root as it enters the pons. Fibers of the ophthalmic division are most ventral, fibers of the mandibular division are most dorsal, and those of the maxillary division are intermediate and descend less far caudally than the other divisions. The spinal trigeminal nucleus consists of three parts.[20]

(1) A pars-oralis: receives impulses predominantly from internal structures of the nose and mouth.

(2) A pars inter-Polaris: is related mainly to cutaneous facial regions.

(3) A pars-caudalis: has a large receptive field over the forehead, cheek, and jaw. This topographic anatomy of the spinotrigeminal pathway may explain the onion peel representation of the face in the descending spinotrigeminal tract.

- **Trigeminal Root (Cisternal Segment):**

The trigeminal nerve arises from one motor nucleus and three sensory nuclei, which extend throughout most of the length of the brain stem. The trigeminal root is composed of the large sensory root and the small motor root.[22]

The sensory root receives somatosensory sensation from the entire face (except the angle of the jaw innervated by the cervical plexus, C2), temple, external acoustic meatus, and the anterior scalp as far posterior as the vertex of the skull.[22] Although most cell bodies of the somatosensory neurons are located in the trigeminal ganglion, the cell bodies for proprioception and stretch receptors in the muscles of mastication are located in the mesencephalic nucleus in the dorsal pons. The proprioceptive impulses from the masticatory muscle run through the motor root to enter the mesencephalic nucleus. The large sensory rootlets of the trigeminal nerve exit the lateral aspect of the mid pons medial to middle cerebellar peduncle.[22]

The orientation of the trigeminal nerve fibers includes: the ophthalmic division being most inferior, the maxillary in the middle, and the mandibular division is in the superior position.[21]

As the roots pass anteriorly through the prepontine cistern and Meckel’s cave to the trigeminal ganglion in the middle fossa, they rotate approximately lateral 180-degree rotation.[23] However, the topographic distribution of the fibers within the trigeminal nerve is that the fibers from the mandibular division remain in a caudolateral position in the trigeminal root throughout the interval from the ganglion to the pons, the ophthalmic division rostro medial, with maxillary division fibers in an intermediate position.[24]

The small motor roots emerge from the pons anterosuperomedial to the entry point of the large sensory root and pass through the Meckel’s cave on the medial side of the sensory root and ganglion to join the mandibular division.[21]

Evaluation of the cisternal segment of the trigeminal nerve represents the keystone for both diagnosis and treatment.[20]

The cisternal portion of the trigeminal nerves measured 12.3 mm (range 8–15 mm).[25] The root exit zone (REZ) of the trigeminal nerve (the precise nerve-pons junction) and the central-peripheral myelin transition zone (TZ).[25]

The interchangeable use of the terms root entry zone (REZ) and transitional zone (TZ) is so common. However, REZ is used to define the portion of the nerve that includes the TZ, the central myelin root portion, and the adjacent brain stem surface.[26]

The cisternal segment spans the prepontine cistern with portions, including:

- <u>Dorsal root entry zone:</u> Immediately anterior to the apparent nerve origin at the ventrolateral pons.
- <u>Transitional Zone (TZ)</u>: The TZ between central and peripheral myelination is believed particularly vulnerable to the mechanical irritation caused by neurovascular compression. TZ of trigeminal sensory fibers measures approximately 2 mm in length[27], rarely occurs within the ventral 50% of the cisternal segment.
- <u>Plexus triangularis or retrogasserian segment</u>: immediately dorsal to the porus trigeminus.[27]

➢ Meckel's Cave Segment

The cisternal segment of the trigeminal nerve in the posterior fossa passes forward below the tentorial edge and superior petrosal sinus between the periosteal and meningeal (dura propria) layers of middle fossa dura to enter Meckel's cave. The cave is situated at the trigeminal impression between the meningeal layer (dura propria) and the periosteal layer of dura which appears to be tightly attached to the petrous apex.[28]

The arachnoid membrane from the posterior fossa extends to Meckel's cave, forming a pocket within the cave, and continues along the rootlets of the trigeminal nerve as far as the trigeminal ganglion.[28]

The contents of the Meckel's cave are the sensory and motor roots of the trigeminal nerve, trigeminal ganglion, and arachnoid layer. The anterior portion of the trigeminal ganglion tightly adheres to the overlying arachnoid and dura propria of Meckel's cave without any potential subarachnoid space. The subarachnoid space within Meckel's cave is behind the trigeminal ganglion and is actual space that constitutes the trigeminal cistern.[29]

The trigeminal ganglion and trigeminal roots have two layers of dura propria on their superolateral aspect. The inner layer, the dura propria, constitutes the superolateral wall of Meckel's cave. The outer layer is the meningeal layer (dura propria) of the middle fossa. The cleavage plane is formed laterally between the epineural sheaths of the trigeminal nerves (inner layer) and dura propria of the middle fossa (outer layer). This cleavage plane serves as the anatomic basis for the interdural exposure of the contents of Meckel’s cave. However, the limits of the Meckel’s cave decided by its meningeal architecture remain controversial. The meningeal pouch (Meckel’s cave) extension beyond the trigeminal ganglion along the three divisions is variable.[28]

The horizontal segment of the petrous ICA is situated just below the Meckel’s cave. The horizontal segment begins at the distal end of the posterior genu, courses anteromedially along the long axis of the petrous part of the temporal bone, largely below the GSPN, posterior to the tensor tympani muscle and Eustachian tube, and posterior to the foramen spinosum and ovale, and ends below the trigeminal nerve and ganglion at the anterior genu, where the artery turns upward above the fibrocartilage-filled foramen lacerum.[30]

Four parasympathetic ganglia are associated with the trigeminal nerve: the ciliary, pterygopalatine, otic, and submandibular ganglia.[20]

- **Peripheral divisions (ophthalmic, maxillary, and mandibular divisions**

V1 is the smallest division and is formed through coalescence of V1 branches posterior to the orbital apex.[22]

V2 is formed by the coalescence of V2 branches in the infraorbital canal and pterygopalatine fossa. It traverses the foramen rotundum to enter the cavernous sinus[22]. Both V1 and V2 travel within the lateral wall of the cavernous sinus and enter Meckel's cave posteriorly, where they join V3.[22]

The sensory branches of V3, the largest division of TGN, merge in the parapharyngeal space below the skull base to form the V3 trunk, which then enters Meckel's cave through the foramen ovale Within Meckel's cave.

The three divisions coalesce to form the trigeminal or semilunar ganglion. The ganglion houses the cell bodies of first-order sensory neurons of all three divisions with the exception of proprioceptive fibers.[22]from V3, the first-order neurons of which are located in the mesencephalic nucleus itself. The trigeminal ganglion then divides into multiple individual rootlets, which course through the prepontine cistern posteriorly to reach the brainstem.[21]