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METHODS

Microvascular decompression for trigeminal neuralgia: Pearls and technique for the classic procedure that stands the test of time

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Trigeminal neuralgia (TN) is a kind of neuropathic pain that is found to be persistent and classically has sudden, excruciating pain in the facial area that is similar to electric shock or stabbing-like pain. Microvascular decompression has consistently remained the predominant procedure for TN every year since 1992 and presently constitutes over 90% of the surgical interventions carried out for neuropathic facial pain. This article describes the technical aspects of the surgical planning and the procedure for microvascular decompression, along with an operative video. In total, 75–80% of patients are known to have complete relief after the procedure, which makes this classic procedure a must-have for the neurosurgeon in the arsenal of armaments in trigeminal neuralgia management.

Keywords: Trigeminal, Neuralgia, Microvascular, Decompression, Neurovascular conflict

Introduction

Trigeminal neuralgia (TN), also known as tic douloureux, represents a condition having chronic neuropathic pain characterized by abrupt and provoked episodes of pain resembling electric shocks or stabbing sensations localized to the facial region. This pathological condition has been associated with diminished quality of life and, in extreme cases, the manifestation of suicidal ideation. Since 1992, the surgical procedure that classically and consistently emerged was microvascular decompression (MVD), currently accounting for over 90% of the surgical interventions performed for neuropathic facial pain. The inaugural MVD procedure was executed by W. James Gardner in 1959, and later this procedure was well refined and brought into light by Peter Jannetta. W. James Gardener entailed the repositioning of a vessel adjacent to the trigeminal nerve and the insertion of absorbable gelatin sponge (Gelfoam) between the two structures, executed without inflicting any deliberate harm to the nerve.

Carbamazepine, gabapentin, phenytoin, pregabalin, sodium valproate, clonazepam, and baclofen are the pharmacological agents that have efficaciously managed this condition. Initially, a substantial proportion of patients report significant alleviation of pain; however, the therapeutic efficacy diminishes over time, with approximately half of the patient population showing diminished response to the medication after a decade. Alternative surgical interventions for TN aside from MVD generally necessitate a technique to access the nerve through a needle percutaneously and with the help of a radiofrequency generator, glycerol injection, radiofrequency ablation, or balloon compression, which lead to direct lesioning of the nerve (**Figure 1**). Another technique that showed effectiveness was the stereotactic radiosurgery, which aimed at the nerve root entry zone. However, there was a delay in the onset of pain relief, typically by several months, and in comparison to other known modalities, total relief of pain was found to be less prevalent. The success of all these procedures was in direct proportion to some degree of numbness of the face. In glycerol rhizotomy the degree of numbness has a positive correlation to both pain control and complications. Post these interventions, the moment the facial sensation restores, after a few years there is always a significant recurrence rate, thus suggesting that most of these interventions are unable to address the fundamental etiology but primarily function by inhibiting triggering impulses (1–4).

Indications for MVD

(1) Patients who are unable to achieve sufficient medical management of trigeminal neuralgia and are expected to survive for at least 5 years without significant medical or surgical risk factors (although a small p-fossa exploration is generally well-tolerated, surgical complications do increase with age).

(2) May be used in patients who do not fit the above criteria but have intractable pain and fail percutaneous techniques.

(3) A patient with a tic involving V1 who faces a high risk of developing exposure keratitis due to corneal anesthesia by percutaneous techniques, which would be unacceptable (e.g., if already blind in the other eye), or a patient who prefers to avoid facial anesthesia for any reason (5).

Preoperative imaging

Prior to MVD surgery, it is essential to rule out other conditions such as a cyst, AVM, tumor, or cyst, which could also compress the trigeminal nerve and cause pain; hence, every patient needs to undergo magnetic resonance imaging (MRI). Also, MRI can rule out the presence of any structural abnormalities such as bony abnormalities or ectopic basilar artery, which can make the procedure of MVD quite challenging. High-resolution MRI (**Figure 2**) can accurately detect neurovascular compression prior to surgery. The presence of severe neurovascular compression before surgery is linked to better results following MVD, while preoperative distal trigeminal nerve atrophy is associated with less favorable outcomes (6).

Operative technique

Anesthesia and positioning

Standard neuroanesthetic methodologies are utilized, integrating pharmacological paralysis and regulated ventilation to guarantee immobility of the surgical area. Routine implementation of intraoperative monitoring is not customary in our practice. A cranial fixation apparatus, which includes the Mayfield 3-pin head holder, is used. The position of the patient post fixation with the 3 pin is either right or left lateral decubitus or three-quarter prone depending on the side of compression. Next, we give flexion of the neck in such a way that the chin is positioned not less than 2 fingerbreadths from the sternum. Later, the shoulder is pulled and fixed in a caudal direction. The vertex is aligned parallel to the horizontal plane, and this is done so that the facial and vestibulocochlear cranial nerves appear to be below the trigeminal nerve, thereby facilitating an unobstructed view and a more accessible approach. Make sure to adequately cushion all the pressure points (**Figure 3**).

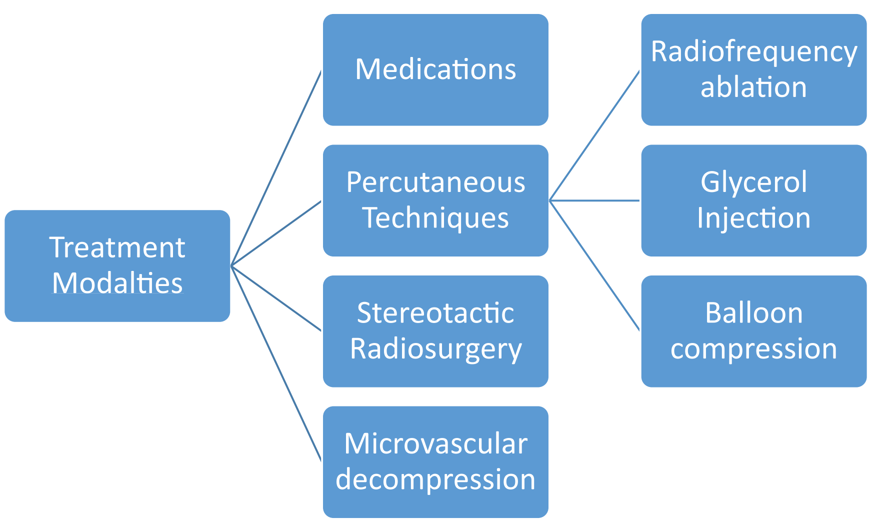

FIGURE 1 | Various treatment modalities available for trigeminal neuralgia.

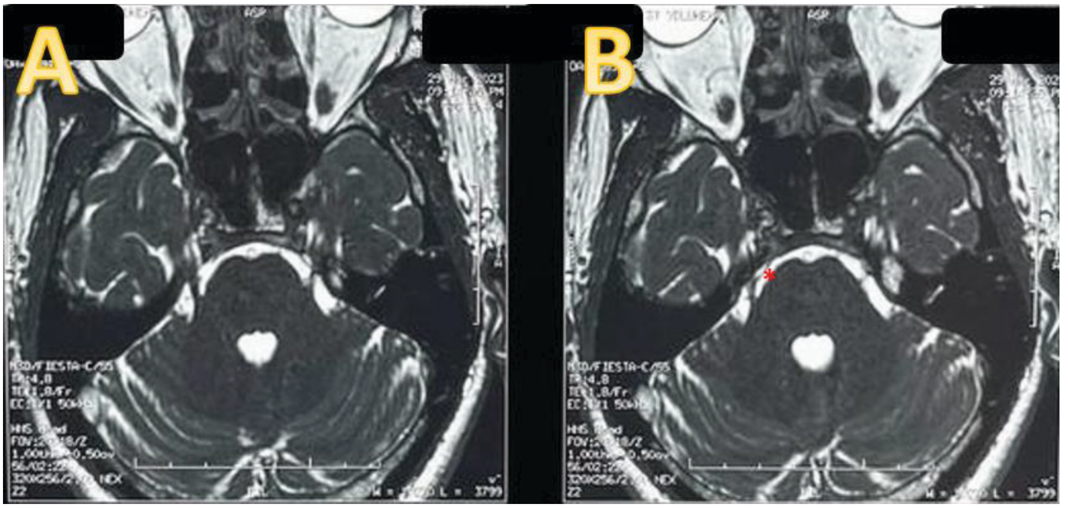

FIGURE 2 | High-resolution MRI utilizing steady-state precession images showing **(A)** bilateral trigeminal nerves and **(B)** loop of a superior cerebellar artery (asterisk) crossing trigeminal nerve.

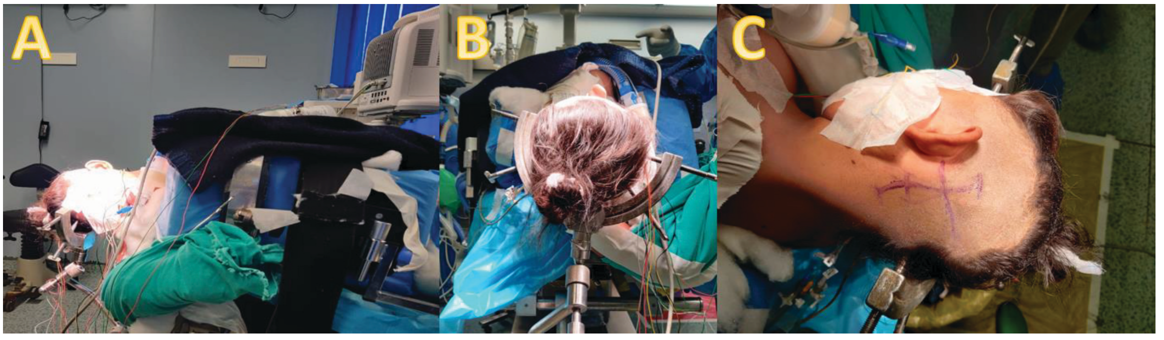

FIGURE 3 | Positioning and incision for microvascular decompression. **(A)** Three-quarter prone positioning with vertex parallel to floor. **(B)** Positioning of the head and cranial fixation device. **(C)** Lazy-S incision, which is three-fourth below the iniomeatal line.

As an alternative, a supine lateral positioning of the head may be employed.

Incision

With the help of a few bony landmarks, we can get guided for the position of the transverse and sigmoid sinuses. When a line is drawn involving the inion and external auditory meatus, just parallel aligning to this line is the trajectory of the transverse sinus, and it also runs posteriorly to the zygomatic arch. The trajectory of the sigmoid sinus usually follows the course of the digastric groove and is located just behind the mastoid eminence. Prior to the surgical intervention, hair is meticulously trimmed from the designated area, and the scalp is subjected to sterilization, subsequently receiving an injection of local anesthetic that contains epinephrine to mitigate hemorrhaging. A lazy-S incision, approximately 5 cm in length, is employed, angling inferomedially, with almost three-fourths of the incision placed inferior to the iniomeatal line.

The next step in the procedure is to expose the bony mastoid prominence and digastric groove, which is done by dissecting and excising the muscle and the soft tissue with the help of a monopolar cautery. During the muscular tissue dissection, the occipital artery is found frequently and sacrificed. At this juncture, a prominent mastoid emissary vein is usually discernible. This mastoid emissary vein overlies the junction of the transverse and the sigmoid sinus, hence serving as a significant reference point. Subsequently, more dissection is done in order to expose the bone for about 3–5 cm laterally. The self-retaining retractor is employed to keep the surgical wound adequately open.

Burr hole

A burr hole ought to be created 1 cm inferior and 1 cm medial to the asterion. But in conditions where the identification of the asterion proves challenging, making its reliability as a reference for the meeting point of the transverse and sigmoid sinuses uncertain, the position of the burr hole is made just over the mastoid emissary vein. This vein drains superolaterally into the sigmoid sinus.

Craniotomy/craniectomy

Our preference is for craniotomy, with the apex of the craniotomy being positioned as proximally to the transverse sinus as feasible. Due to the thin and slender osseous wall and the curved groove into which the sigmoid sinus sits make the sigmoid sinus more susceptible to damage. Steps are to be taken in order to separate the lateral wall of the sinus from the mastoid bone just prior to the craniotomy in order to prevent injury to the sinus, especially in geriatric patients, as it may be found adherent in them. If there occurs minor damage to the sinus, it can be dealt with by applying oxidized cellulose or absorbable gelatin sponge along with tack-up sutures; however, more extensive lacerations of the sinus can be managed first by exposing the bone wider and then by applying a dural patch graft, and in such situations, if excessive hemostatic agent packing is done, it could cause venous occlusion. Just at the lateral border of the osseous window made, the mastoid air cells become visible, and bone wax needs to be applied cautiously over it if exposed in order to prevent cerebrospinal fluid (CSF) rhinorrhea as a postoperative complication. Achieving hemostasis at this juncture is imperative in order to forestall the subarachnoid spaces from getting filled by the ingress of blood. There is no requirement to incise the rim of the foramen magnum.

Dural opening

The dural opening may assume a curvilinear configuration, with each terminus aligned with a sinus and the convexity oriented away from the junction (Jannetta approach), or it may take on an inverted "T" shape, featuring one incision directed toward each sinus and the third toward the junction of the sinuses, thus facilitating maximal adjacency to the sinuses. If necessary, in order to rotate the sigmoid sinus gently for more exposure to the outer surface of the cerebellum, we have to secure the dura just adjacent to the sigmoid sinus laterally (**Video 1**).

Release of CSF

After the opening of the dura, like explained above, now we introduce the optical microscope, and the surgical field is exposed with ease and maintained with the help of a self-retaining retractor. The cerebellum is gently retracted in an upward-medial direction with a bit of slight elevation, and this can be easily achieved by applying a self-retaining brain retractor, which is flexible enough, and this can be strategically kept in position over a neurosurgical cotton patty. Nonetheless, in the majority of patients, gravitational retraction of the cerebellum is typically sufficient, as it subsequently helps to enter the trigeminal cistern and also in the drainage of CSF. Efforts are made to conserve the integrity of the petrosal vein complex; however, its coagulation and division may be necessitated in some situations in order to explore and expose the nerve.

Identification of the offending vessel and decompression of the nerve

The portio minor, which is the smaller motor root, and the portio major, which is the larger sensory root of the trigeminal nerve, must be accurately identified. The arachnoid membrane overlaying the trigeminal nerve is to be meticulously peeled or dissected and sharply incised to avert any potential injury to the 5th (trigeminal) cranial nerve, alongside the 4th (trochlear) cranial nerve that resides superiorly to the trigeminal nerve within the subarachnoid space. The neurovascular conflict is most commonly due to compression of the nerve by the superior cerebellar artery (SCA), typically exerting pressure on the nerve from the anterior aspect, within the axilla, resulting in indentation of the nerve. This compression can be alleviated by repositioning the artery to a horizontal orientation instead of a vertical one, thereby elevating it away from the nerve. On the contrary, if the neurovascular conflict is due to compression of the nerve by the anterior–inferior cerebellar artery (AICA), the compression can be alleviated by repositioning the artery to a downward displacement away from the nerve. A soft substance analogous to a cotton ball is made by fragmented and shredded Teflon and is placed in a proximal-to-distal arrangement between the nerve and the artery, compressing it, and with the help of the tension created between the nerve and the artery, the substance is further maintained in position and stabilized further, and if at all necessary, in a few situations we can use either fibrin glue or absorbable gelatin sponge. The artery is subsequently turned onto the posterior aspect of the nerve, with the polytetrafluoroethylene serving as a protective barrier between the nerve and the vessel (**Video 2**).

VIDEO 1 | Microvascular Decompression of Trigeminal Nerve Part 1
https://youtu.be/RS4jwnUvQe8

VIDEO 2 | Microvascular Decompression of Trigeminal Nerve Part 2
https://youtu.be/Hfq90bkYwqs

During surgical procedures, it is imperative to recognize that along with arterial compression we can also frequently observe venous contact. Just at the Meckels cave entrance, the trigeminal vein can be found distally. Another vein called the transverse pontine vein can be found anteriorly, and a petrosal vein can be located posteriorly. Upon detection of venous compression, with the help of bipolar cautery at a lower voltage, the vein is separated meticulously from the nerve, and this step is quite critical; hence, utilizing low-voltage bipolar forceps ensures that the current does not adversely affect the adjacent nerve prior to coagulation and division of the vein. In situations where the distance between the nerve root entry zone and the brainstem is just a few millimeters, a comprehensive exploration of the nerve throughout its length is essential, as even minor vessels may induce compression. Once the vessels have been decompressed, careful observations are made, and if any indication of the vasospasm is identified we can topically apply papaverine-soaked absorbable gelatin sponge (7).

Closure

The dura mater is securely sealed utilizing sutures that are braided and of size 4–0 in an interrupted or continuous fashion in order to avert any future CSF leakage. Ordinarily, the dura can be directly closed; however, in instances where direct closure is not feasible, a dural substitute may become necessary. Subsequently, the bone is reinstated. Following this, at first the fascia is sutured with absorbable sutures, followed by the subcutaneous tissue with the same suture material as the fascia, and lastly, the skin is sutured in a conventional manner, either by sutures or staplers.

Postoperative care

Postoperative management involves observation of patients in the neurosurgery intensive care unit for a duration of one night. Mild analgesics may be administered to mitigate headaches, which may endure for several weeks. In instances of pronounced bifrontal headache, a computed tomography scan is warranted to exclude the possibility of hemorrhage in the posterior fossa, although any imaging modality in the postoperative period is generally not a requisite. Nausea frequently manifests as a common postoperative symptom and typically exhibits favorable responses to antiemetic medications. The administration of corticosteroids is not considered advantageous in this specific context. Patients are transitioned to the general medical/surgical ward on postoperative day 1, with a gradual increment in both dietary intake and activity levels. Generally, at the end of the postoperative day 3, the patients are usually discharged.

Complications

Damage to cranial nerves is a rare occurrence, in comparison to other lesioning procedures, complications such as facial dysesthesia and anesthesia dolorosa are significantly lesser. Due to migration of the fluid into the middle ear from the mastoid bone, a small subset of patients can develop temporary conductive hearing loss, which generally resolves in a few weeks. While sensorineural hearing loss is typically irreversible, it can be mitigated through meticulous retraction, precise surgical technique, and the management of any AICA vasospasm that may develop. Reports suggest that approximately 2% of patients may encounter prolonged postoperative vertigo or tinnitus, with up to 5% experiencing facial nerve palsy. Nevertheless, these complications frequently demonstrate spontaneous improvement within a few weeks. Additionally, injury to the fourth cranial nerve may result in trochlear palsy, which typically resolves after several months.

In approximately 1.5% of cases, CSF rhinorrhea can occur, and the exact mechanism behind this is attributable to CSF leakage, which occurs from the dural opening following into the mastoid air cells and subsequently paves its way into the pharyngotympanic tube, followed by leaking into the nasopharynx. Furthermore, aseptic meningitis, characterized by headache and sterile CSF pleocytosis, may arise as a reaction to the materials employed, like the polytetrafluoroethylene pledget or dural graft material. Although this CSF leak is self-limiting, it often exhibits a favorable response to corticosteroids or lumbar puncture to facilitate CSF removal. Cerebellar contusions and cerebellar hemorrhagic infarctions are recognized complications.

Outcome

The primary determinant influencing the outcome following MVD surgery appears to be the classification of TN pain. Patients exhibiting type 1 trigeminal neuralgic pain (characterized predominantly by intermittent, sharp pain) typically experience outcomes that are immediate and long-term compared to those with type 2 trigeminal neuralgic pain (primarily characterized by persistent pain). Approximately 75–80% of patients attain complete relief after the procedure. And, in situations where TN is due to venous compression, due to the regrowth of venous structures, the prognosis is less favorable.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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