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Original Article

Posterior Fossa Microsurgical Approach to the Trigeminal Nerve for Tic Douloureux: An Operative Technique and Immediate Results

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Background: There are several methods for treating tic douloureux including Gamma Knife stereotactic radiosurgery (GKSR), gasserian ganglion percutaneous technique and microvascular decompression (MVD). MVD via the posterior fossa has become the standard treatment for trigeminal neuralgia (TN). This microsurgical procedure has been proven safe in experienced hands and its effectiveness rate is as high as 98%. The aim of this paper is to share the authors' personal experience, from the standpoint of operative technique, with those who are contemplating performing or who are already performing this kind of surgery.

Materials and Methods: Over the past two decades, among 349 patients (including three with failed GKSR) with typical TN, 288 received MVD, 39 received partial sensory rhizotomy and 22 received MVD combined with partial sensory rhizotomy. With the patient in a lateral position, a small retrosigmoid craniectomy was used to approach the cerebellopontine angle (CPA) via the lateral supracerebellar route. Exploration and identification of the offending artery (arteries) in contact with the whole nerve, at any point, not merely the root entry zone (REZ), were carefully carried out. Transposition of the offending vessel (vessels) away from the nerve was the main decompression method, followed by Teflon felts interpositioned between the two structures.

Results: All patients were evaluated within 1 week of operation. Excellent (90.9%) and good (4.6%) clinical outcomes were achieved in 333 patients; partial pain relief was achieved in 10 patients; and little or no pain relief was achieved in 6 patients. All 6 patients who failed to respond positively to the initial surgery underwent partial sensory rhizotomy within 1 week of evaluation to relieve the pain.

Conclusion: MVD is generally accepted as the gold standard for first line treatment of TN, especially in younger patients who are refractory to medication. The anatomical approach that we have adopted is described in detail.

Key words: microvascular decompression, tic douloureux, trigeminal nerve, root entry zone

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Introduction

Tic douloureux or trigeminal neuralgia (TN) is characterized by an abrupt intense paroxysm of brief, stabbing and recurrent pain, lasting from a few seconds to several minutes in duration, usually provoked by non-noxious stimuli and confined to

the trigeminal nerve distribution on one side of the face. Untreated patients live in fear of the next painful attack and attempt to do whatever they can to prevent it. Patient quality of life is severely affected and suicide is not uncommon.

There are several methods for treating TN including Gamma Knife stereotactic radiosurgery (GKSR), gasserian ganglion percutaneous technique and microvascular decompression (MVD). MVD via the posterior fossa has become the standard treatment for TN. This microsurgical decompression procedure has been proven safe in experienced hands and its effectiveness rate is as high as 98%. Generally, MVD is the first choice of treatment in younger patients with TN[1].

Materials and Methods

Patient population

Three hundred and forty-nine patients (212 men and 137 women) with typical TN underwent MVD via the posterior fossa microsurgical approach from March 1994 through February 2014 (Table 1). Their ages at operation ranged from 16 to 77 years (mean, 56.1 years). The duration of the disease varied from 1 month to 30 years, with an average of 4.7 years. The right side (63.3%) was affected more often than the left side (36.7%). There were no patients with bilateral involvement. The preoperative diagnostic evaluation consisted of neurological examinations and neuroradiological studies.

Surgical indications and preoperative workup

Patients who experienced typical idiopathic TN, were refractory to medication, and failed GKSR or other percutaneous treatment, underwent MVD. Pre-operative evaluation consisted of a thorough pain history, medication history and neurological examination to rule out other facial pain disorders. All patients received enhanced magnetic resonance imaging (MRI) of the brain focused on the ipsilateral posterior fossa to exclude any gross anatomic pathology, such as tumor or vascular lesion.

Table 1. Summary of clinical data of 349 patients with TN

Characteristics	Number	Percent or mean
Sex (male/female)	212/137	60.7/39.3
Age at operation	16-77 years	56.1
Duration of symptoms	1 mon- 30 yrs	4.7 years
Laterality of TN	Right, 221	63.3
	Left, 128	36.7

Operative technique

Patient positioning

Each of the patients was placed in the lateral decubitus position with the neck slightly flexed and laterally tilted away from the affected side using the Mayfield three-point fixator, under general anesthesia with endotracheal intubation (Fig.1-A). Each patient was taped securely onto the table to allow for further rotation or tilting during the procedure when necessary. In some cases (especially in overweight or obese patients), the shoulder was taped and gently pulled caudally to give an adequate working corridor. The main anatomical landmarks are shown in Figure 1-B.

Identifying the course of the transverse sinus and sigmoid sinus

The course of the transverse sinus (TS) was identified by marking a line connecting the inion with the zygomatic arch at the level of the supramastoid crest passing through the asterion. A second line behind the mastoid body and tip was then drawn to locate the sigmoid sinus (SS). The junction between the TS and the SS was identified and marked (Fig. 2-A). These important initial

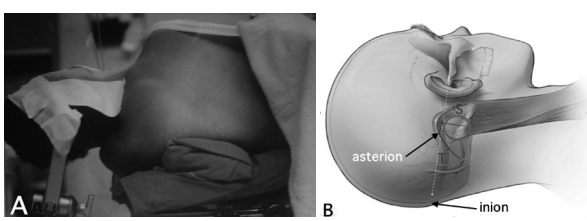


Fig. 1. **A:** A patient in lateral decubitus position with the neck flexed and tilted away from the side operated on. The ipsilateral shoulder (especially in overweight or obese patients) should be taped and gently pulled caudally to increase the view or the working corridor. **B:** Identification of key landmarks. The main anatomical landmarks are drawn. The red circle indicates the site of craniectomy.

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landmarks were used to conduct the craniectomy as close to the junction of the TS and SS as possible.

Skin incision and soft tissue dissection

An S-shaped incision 5-6 cm long on the right (with a reverse S on the left) was made behind the hairline with the lower end not exceeding the mastoid tip (Fig. 2-A). The subcutaneous and muscular tissues were dissected to the bone in two layers. The mastoid emissary vein (MEV) connects the suboccipital venous plexus to the SS. Thus, this landmark is helpful for localizing the SS. Once the MEV was identified, its bone orifice(s) were sealed with bone wax. A bony window of 1.5 to 2.0 cm was made at the superior and anterior parts of the wound to give access to the posterior margin of the SS and the inferior margin of the TS. The craniectomy was conducted superiorly and anteriorly to the wound. In this way, the retractor or the operating route under microscope was not hindered by the wound edge (Fig. 2-B).

Craniectomy

The junction of the TS and SS was located prior to bone drilling. The asterion is the junction of the lamdoid, parietomastoid and occipitomastoid sutures. In most cases, it is over the transverse-sigmoid junction. Another important landmark is the mastoid foramen, which conveys the MEV and indicates the posterior margin of the middle portion of the SS. A burr hole (1x1 cm) was made below the asterion. The edge of the bone opening was then progressively enlarged, thinned and removed by a punch until the junction of the TS and SS was reached. In many cases, posterior mastoid air cells were opened to obtain adequate exposure. These were sealed with bone wax and glue to avoid postoperative cerebrospinal fluid (CSF) rhinorrhea.

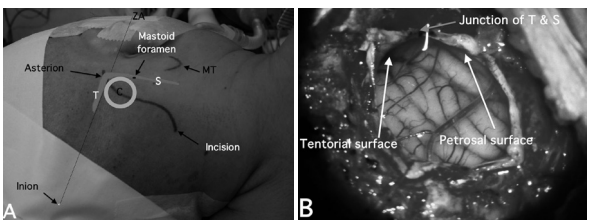


Fig. 2. **A:** Anatomical landmarks on the skin. The mastoid foramen, which conveys the mastoid emissary vein, indicates the posterior margin of the middle portion of the sigmoid sinus. **B:** The angle formed by the tentorial and petrosal surfaces of the cerebellum is shown.

T = transverse sinus, S = sigmoid sinus, ZA = zygomatic arch, MT=mastoid tip, c = craniectomy

Drainage of the CSF

The dura was opened by cruciate incision and tented. Under operating microscope, the cerebellum was pressed lightly downward at the upper petrosal surface. CSF spontaneously emerged allowing the cerebellum to slacken. We seldom used manitol or any other osmotic agent during surgery as it has proven to be unnecessary. The retractor was moved upward until the superior petrosal vein (SPV) came into view. The cerebellopontine cistern was opened by cutting the arachnoid to facilitate further CSF drainage and subsequent cerebellum slack.

Division of superior petrosal veins (SPV)

The SPV are formed by the terminal segment of a single vein or by the common stem of the union of tributaries draining the antero-lateral margin of the cerebellum and the brain stem surface. Attention should be paid to the positions of these tributaries, as in some cases, they are the offending vessels causing TN. In most instances, the SPV or its tributaries are coagulated and divided to expose the trigeminal nerve and its root entry zone (REZ).

Exposure of the trigeminal nerve and the REZ

The retractor or spatula was advanced along the antero-lateral margin to the anterior angle, i.e., the anterior-most part of the anterolateral margin. The arachnoid holding or fixing the artery (arteries) to the fifth nerve was exposed and opened to mobilize the vessel or to free the nerve. The whole nerve root and its REZ were inspected for evidence of arterial or venous contact and the presence or absence of distortion or indentation by such structures.

Microvascular decompression (MVD)

The anatomic relationship between the fifth cranial nerve and the offending artery (arteries) should be clearly visible. In the majority of cases, the superior cerebellar artery (SCA) is the vessel compressing the trigeminal nerve or its REZ. The offending artery (arteries) were gently dissected

from the nerve root. Every effort was made to transpose the vessel away from the nerve, with or without Teflon felt interposition between the nerve and the vessel (Fig. 3).

Wound closure

Watertight dural closure in such a small opening is usually hampered by its retraction. Therefore, a piece of Neuro-patch (B=Braun, Aesculap, Tuttlingen, Germany) was sutured around the dural edges, which were then soaked with Histoacryl (B=Braun, Aesculap,Tuttlingen, Germany). A thick piece of Gelfoam (Pharmacia & Upjohn Company, Kalamazoo, MI) was used to cover the craniectomy defect before the tissue glue dried. The fascia were sutured in a watertight fashion to avoid CSF leak from the wound. The bony defect was covered with an MR-compatible titanium plate (Bioplate, Bioplate Inc., Los Angeles, CA, USA) to avoid skin depression.

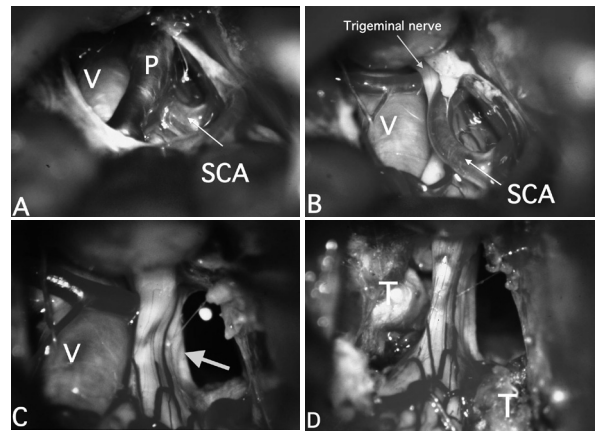


Fig. 3. AIntraoperative film of a left maxillar and mandibular branch TN patient. (A) The trigeminal nerve is covered by the petrosal vein and the superior cerebellar artery. Note that the nerve is almost completely covered by these vascular structures. (B) After coagulation and division of the petrosal vein, the superior cerebellar artery is found compressing the nerve. (C): Transposition of the superior cerebellar artery away from the nerve is accomplished. Note the indentation of the nerve created by the vessel compression (yellow arrow). (D) Teflon felts are interpositioned between the nerve and the vessels; the 5th nerve is totally free from any vascular contact.

V=vertebral artery, P=petrosal vein, SCA=superior cerebellar artery, T=Teflon felts

Results

The operative procedures and findings are summarized in Table 2. Two hundred and eighty-two patients with distortion of the fifth nerve root caused by extrinsic vascular compression underwent MVD, 39 patients with no offending vessels underwent partial sensory rhizotomy (PSR), 15 patients with vascular contact but no distortion of the nerve root underwent MVD and PSR. Seven patients with distortion of the fifth nerve root underwent MVD and PSR due to vessel transposition failure. Six patients in the early part of this series with vascular contact but no distortion of the nerve root underwent MVD only. All six of these patients experienced little or no pain relief, necessitating PSR within one week to

Table 2. Operative findings of and procedures in 349 patients with TN

Findings (Procedure)	No. of cases (%)	Age at onset (yrs) (range)	Duration of symptoms (yrs) (range)	Age at operation (range)
Nerve root compression or distortion (MVD)	282(80.8)	51.6(18-74)	6.8(0.25-30)	58.7(28-77)
Nerve root compression or distortion (MVD+PSR)	7 (2.0)	63.7(55-71)	4.1 (0.30-10)	67.9(59-71)
Vascular contact without distortion (MVD only)	6 (1.7)	43.4 (34-51)	13.8 (4.0-30)	57.2 (42-71)
Vascular contact without distortion (MVD+PSR)	15 (4.3)	57.5 (33-4)	3.2 (0.08-11)	58.6 (38-76)
No extrinsic compression (PSR)	39 (11.2)	51.5(16-76)	4.6 (1.60-20)	56.3(26-77)
Total or mean	349	56.1	4.7	60.4

Table 3. Offending vessels in 310 patients undergoing MVD

Findings	No. of Patients	(%)
SCA	139	(44.7)
AICA	72	(23.3)
SCA+AICA	62	(20.1)
BA	15	(4.7)
BA+SCA	6	(2.0)
BA+AICA	9	(2.8)
Vein	7	(2.4)

SCA: superior cerebellar artery; AICA: anterior inferior cerebellar artery; BA: basilar artery

Table 5. Surgical complications after posterior fossa exploration for the treatment of TN in 349 patients

Complications	No. of patients
Aseptic meningitis	4
CSF rhinorrhoea	4
CSF leakage (wound)	3
Cerebellar edema	1
Hearing impairment	1
Facial palsy (partial)	1
Death *	1

* a hypertensive patient developed CVA with massive putaminal hemorrhage on the second postoperative day.

control the pain. Of the 39 patients who underwent PSR only, all had a tolerable degree of dysaesthesia with a preservation of light touch sensation at the corresponding branch section.

Table 3 shows the offending vessels responsible for TN in 310 patients. SCA was most frequently responsible for the compression of the fifth nerve or its REZ (44.7 %) followed by the anterior inferior cerebellar artery (AICA) (23.3 %). Patient outcomes were assessed immediately after the first procedure, regardless of the response to any subsequent operations, and are shown in Table 4.

Discussion

Success rate and complications

The right side (62.8%) was affected more often than the left side (37.2%) and the maxillary and mandibular branches were the most commonly involved. This correlates with the results of previous studies. The overall complication rate was as low as 4.3%. None of the complications were disabling (Table 5). CVA attack in 1 patient was not regarded as a surgical complication. This procedure can be applied to most patients (even the aged) who are candidates for general anesthesia or who have failed previous ablative procedures[2]. It is a safe operation in experienced hands and the immediate effectiveness rate is as high as 95% in the present study.

Instructions to the patients

Patients were given all necessary information about concurrent treatment methods, including the gasserian ganglion percutaneous technique and Gamma Knife radiosurgery. MVD has been shown to yield the highest rate of pain relief and the lowest rate of recurrence on long-term follow-up; however, there are risks of early and late pain recurrence. When compared with other treatment modalities, MVD carries risks of GA and surgery-related complications. However, these are rather rare in experienced hands.

Postoperative care

The patients were monitored overnight in the neurosurgical intensive care unit. Blood pressure was maintained in the normal range if a patient presented with hypertension. No osmotic agent was used. Postoperative checks of cranial nerve function were carried out. In the case of profound headache or dizziness, steroids were administered for 2 days. Patients were usually discharged after 5 days.

Table 4. Clinical outcome after the first procedure in 349 patients with TN

Outcome	Definition	No. of Patients	(%)
Excellent	Pain-free without medication	317	(90.9)
Good	Mild pain not requiring medication	16	(4.6)
Fair	Moderate pain requiring medication	10	(2.8)
Poor	Minimal or no pain relief	6	(1.7)

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Avoiding complications

The small bony opening does not usually exceed 2 cm in diameter, but in a large, muscular, and/or dolichocephalic patient, a longer skin incision and a larger craniectomy are required and placed more posteriorly to provide an appropriate angle for viewing and draining of the CSF via the cerebello-pontine cistern under operating microscope.

Making exact identification of the main anatomical landmarks and the courses of the TS and SS were critical before the start of drilling for the craniectomy. The margins of the TS and the SS and their junction were reached to view the angle formed by the tentorioum and the petrous bone once the dura was opened and the CSF was drained. The tentorial surface of the cerebellum was not explored because bleeding in this surgical field is difficult to manage and should be strictly avoided.

If the tributaries of the SPV were in the way or hindered nerve dissection, they were coagulated and divided. If not, traction on the cerebellum could tear the SPV at the base of the petrosal sinus causing massive bleeding. Total disruption of the common stem of the SPV can cause peduncular phenomenon, venous infarction and subsequent cerebellar edema. Once the trigeminal nerve was exposed along its entire length and the neurovascular conflict was found, the vessel was carefully mobilized to avoid damage, arterial spasm, ischaemia or small perforating arterial rupture.

CSF rhinorrhoea is probably the most frightening complication for both the patients and the surgeons. If mastoid air cells are opened during craniectomy, they must be sealed with bone wax and/or glue.

Conclusions

Generally, in younger patients with TN, the first choice of treatment is MVD. In fact, this procedure can be applied to most patients (even the aged) who are candidates for general anesthesia or who have failed a previous ablative procedure or Gamma Knife radiosurgery. It is a safe operation in experienced hands and the immediate effectiveness rate is as high as 95% in our series[3-5].

The aim of this paper was to share the authors' personal experience, from the standpoint of operative technique, with those who are contemplating performing or who are already performing this kind of surgery. Unlike hemifacial spasm (HFS) surgery in which one has to wait from 2 weeks to 1 year for a postoperative result[6], the successful outcome of TN surgery is dramatic and prompt. If the patient does not respond positively, the initial surgery is considered a complete failure and a second exploration within 1 week is required.

Remarks

All patients shown in Figs. 1, 2, and 3 gave their permission to use these photographs at the time of surgical consent.

Conflicts of interest: None

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