Surgical Technique of Microvascular Decompression Surgery for Trigeminal Neuralgia

6

Jun Zhong and Hui Sun

Abstract

As an etiological treatment of trigeminal neuralgia, the microvascular decompression (MVD) surgery has been popularized around the world for more than half a century. However, as a functional operation in the cerebellopontine angle, this process should be refined to enhance the cure rate and minimize the complication. After accomplishment of more than 6000 MVDs, we've learned something concerning the operative technique: (1) the principle of MVD is to separate the neurovascular confliction rather than isolation with prostheses; (2) identification of the conflict site is important, which relies upon a good exposure; (3) a satisfactory working space can be established by an appropriate positioning and a close-to-the-sigmoid craniectomy as well as a caudorostral approach; (4) a sharp dissection of arachnoids leads to a maximal visualization of the entire intracranial course of the nerve root; (5) all the vessels contacting the trigeminal nerve root should be treated; and (6) the dura should be closed with watertight stitches at the end. In this chapter, every single step of the procedure was detailed.

Keywords

Microvascular decompression • Surgical technique • Trigeminal neuralgia

According to the classification of *the International Headache Society*, trigeminal neuralgia can be classified as idiopathic (primary) and symptomatic (secondary) (Olesen and Steiner 2004). Whatever, the diseases are etiologically caused by cerebellovascular compression of the trigeminal root, no matter directly or indirectly pushed by neoplasms or adhesions in the cerebellopontine angle (Shulev et al. 2011; Zhong et al. 2008; de Lange et al. 1986). Therefore, separation of the nerve from the offending vessel(s) seems to be an ideal treatment. Since microvascular decompression (MVD) was first introduced by Dandy and then popularized by Jannetta in the last century, it has been thought to be the most

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reasonable technique for treatment of trigeminal neuralgia (Kellogg et al. 2010; Jannetta 2007; Haines et al. 1979; McLaughlin et al. 1999; Zhong et al. 2012). Nevertheless, this sort of surgical process is still with risk because of those delicate cerebellopontine structures, and some patients cannot totally relieve their symptoms postoperatively (Zhong et al. 2012; Sindou et al. 2002, 2007; Xia et al. 2014; Barker et al. 1996). As a result, the surgical techniques of MVD need to be further discussed (Devor et al. 2002; Hong et al. 2011; Zhong et al. 2014).

6.1 Indications

> MVD is appropriate for most of the patients with trigeminal neuralgia.

Generally, MVD is indicated for all the patients suffering from drug-resistant trigeminal neuralgia as long as their general conditions do not contraindicate general anesthesia. We would like to point out that old age is not an unconditional contraindication for MVD. Instead, it is relatively easier to operate on the aged for they have a wider subarachnoid space as a result of brain atrophy (Sekula et al. 2008, 2011). Only those with decompensated dysfunction of vital organs should be evaluated cautiously. Hence, we suggest performing the surgery in the early stage before the patient's quality of life is awfully influenced. Especially, for those undernourished because of less eating to avoid an attack of severe pain induced by oral movement, a prompt surgery is encouraged (Lemos et al. 2011; El-Ghandour 2010). In addition, MVD is indicated in patients with coexistent trigeminal neuralgia and hemifacial spasm (Zhong et al. 2011; Cook and Jannetta 1984), glossopharyngeal neuralgia, (Wang et al. 2014) or Bell palsy (Jiao et al. 2013).

6.2 Anesthesia

> Intracranial pressure and brain pulsation should be well controlled.

General anesthesia is used for the process. Besides imperceptions and relaxations, decrease of intracranial pressure (ICP) should not be neglected. The dura should not be opened until a satisfactory ICP is ready. Otherwise, the brain tissue might be squeezed out and lead to cerebellar contusions. Hyperventilation can be used temporarily to reduce brain volume and decrease ICP when necessary. Meanwhile, the brain pulsation should be well controlled as it may generate a terrible cerebrospinal fluid (CSF) tide. The microscopic imagings of the trigeminal root and offending artery as well as petrosal veins will be transferred ceaselessly due to the changing optic refraction arose by CSF fluctuation. Hence, it will be a challenge to dissect the trigeminal root in such an SCF rapid – not to mention the deep and narrow operation field. As brain pulsation is generated by the heartbeat via the transmission of the arterial pulse, ventricular tachyarrhythmia should be avoided. Therefore, β-adrenergic blockers will be helpful. Basically, small doses of esmolol can be used repeatedly to control the perioperative tachycardia or hypertension.

6.3 Positioning

> A proper positioning contributes to a satisfactory exposure.

We place the patient in a park bench position (3/4 lateral prone decubitus). This position is superior to supine or full prone position because it obviates the need to turn the patient's head into an uncomfortable position and therefore decreases the risk of postoperative neck pain, especially for

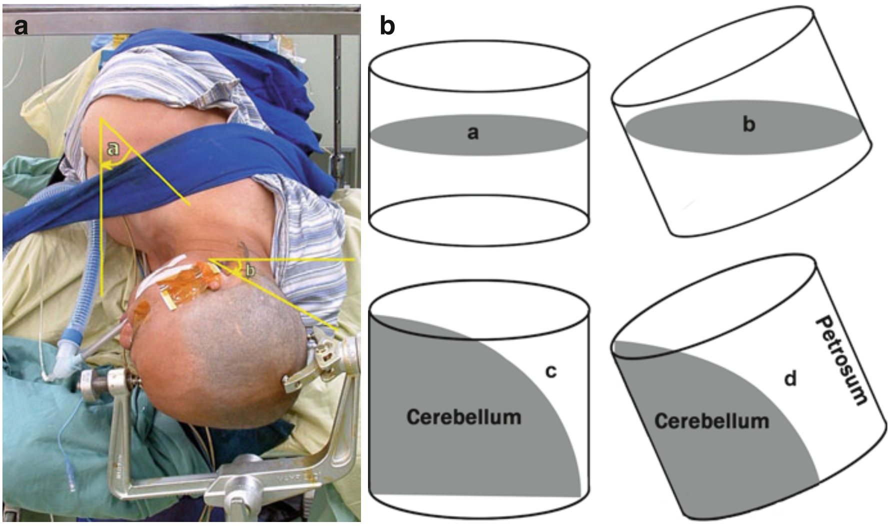

Fig. 6.1 Positioning. (**a**) The patient is placed in a 3/4 lateral prone decubitus position with the ipsilateral shoulder being slanted forward (∠*a*) and pulled away from the head. The patient's head is turned back 15° from the horizontal plane (∠*b*). (**b**) The diagrammatic drawing exhibits the benefit of the head-inclined position. It offers a bigger visualizable area (*B*) than a flat position (*A*) does. Because of its own gravity, the cerebellum falls away from the petrosal bone and provides more working space (*D*) than a flat position (*C*) does

obese patients with generous supraclavicular fat pads. It is necessary to point out that the contralateral shoulder should be close to the edge of the bed so that the surgeon can easily reach the surgical site. Meanwhile, the ipsilateral shoulder should be pulled away from the head by a shoulder belt so as to create a satisfactory working space, which facilitates the instruments getting in and out of the surgical field. A fixation frame is used to hold the patient's head stable and make it possible to apply retractor system when necessary. However, we no longer use retractors even in cases of secondary trigeminal neuralgia resulting from CPA masses since we have chosen an oblique position of the patients' head. This inclined position with the patient's head turning back 15° from the level surface facilitates the cerebellum to fall away under its own gravity from the petrosal bone and obviates the need of retractors. Therefore, a good exposure is achieved by rational positioning of the patient's head rather than retracting of cerebellum (Fig. 6.1) (Zhong et al. 2012, 2014).

6.4 Incision

An extra-large incision may not be good for exposure.

Although transversal, arc, or reverse 'U' shape incisions have been reported (Cohen-Gadol 2011), we choose a vertical linear incision. It is laterally parallel to the hairline and crosses the inion-zygomatic line with 1/3 above and 2/3 below. Nowadays, we have adopted a mastoid retractor to hold the incision and no scalp clip is needed. Owing to the limitation of the retractor's open angle, an incision longer than 7 cm is not really necessary. To save a good blood supply, undue coagulation should be avoided during the incision making and a quick retraction of the incision is recommended. As the operator is sitting behind the patient, a more medial peeling will provide a good sight (Fig. 6.2).

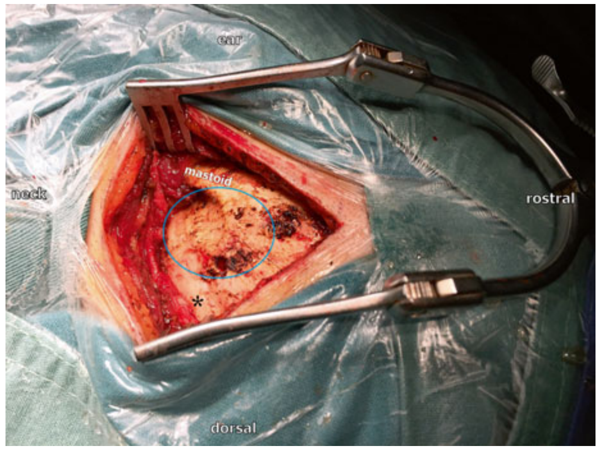

Fig. 6.2 Incision and craniectomy. A vertical linear incision is suggested, which parallels laterally to the hairline. The incision is held by a mastoid retractor without scalp clip. Owing to the limitation of the retractor's open angle, an incision longer than 7 cm is not really necessary. As the operator is sitting behind the patient, a more medial peeling (*) will provide a good sight. A *circle* marks the location of craniectomy, which should be very close to the mastoid and lateral enough to the sigmoid sinus

6.5 Craniectomy

> A much lateral craniectomy close to the sigmoid sinus is recommended.

Basically, a craniectomy of <3 cm in diameter is enough for most cases. The edge of the sigmoidal sinus should be exposed to ensure an ideal surgical corridor. To avoid dural sinus injury, we prefer craniectomy with pneumatic drill and Kerrison rongeur to craniotomy with milling cutters. Bone dust and chips were preserved for the later cranioplasty. The bone over the sigmoid sinus should be removed in small pieces. Bone wax is effective for homeostasis at the edge of dural sinuses. To obtain a good working angle, the mastoid antrum could be opened if necessary, but it should be immediately waxed to prevent infection and CSF leak (Fig. 6.2).

6.6 Durotomy

> A good durotomy provides a maximal surgical corridor toward the conflict site.

Before dural opening, a thorough irrigation is necessary. It is not merely for bone scraps cleaning but mainly for double checks of bleeding. Even a little oozing of blood may flow in your surgical field continuously, which may interfere with your vision and mood terribly. In spite of a variety of dural tailoring, we now prefer an arc-shaped cutting with its chord paralleling to the lateral rim of the craniectomy. After the dural mater is sutured back with double knotting, the suture thread remains in place (without cutting off), which facilitates tightening when necessary during the procedure. This pattern of dural opening leaves the majority of the dura on the cerebellum, which avails the protection of the cerebellar hemisphere during the process (Fig. 6.3). To avoid shrinkage of the dura due to the heat generated by the operating microscope's lamp aimed at the surgical field during the intradural portion of the operation, pieces of wet Gelfoams are placed over the dura.

6.7 Exposure

> A satisfactory exposure is obtained by sharp microdissection as well as proper position and craniectomy rather than harsh retraction.

In our series of 6000 MVDs, the main reason of a failed surgery was that the exact offending vessel(s) were not recognized or the neurovascular conflict site was inaccessible intraoperatively. So we believe a full exposure of the entire trigeminal nerve root course is the key to obtain a good result. Advancing toward the target starts with a Cottonoid placed over the cerebellum and draining CSF slowly. Usually, an unhurried suction drainage of CSF and an ample adhesiolysis are effective enough to achieve brain relaxation, and no mannitol or lumbar puncture is needed for most of the cases. We do not use retracting blades because a narrow suction tube allows more mobility and can actually afford more working space than a wider spatula does during the procedure at a moment when a specific area is dissected. As a matter of fact, with a good knowledge of the regional anatomy, one does not have to visualize the whole area of CPA while operating at a particular site (but those surrounding structures should always be in mind). Basically, a Fukushima teardrop suction tube, a pair of microscissors, a microdissector, and a pair of bipolar coagulation forceps are enough to complete all the intracranial manipulation. Instead of the ordinary gun-shape forceps, a self-irrigating bipolar forceps can keep the Cottonoid over the cerebellum moist all the time and avoid cerebellar contusion. The action of clamping an artery should be avoided, which may cause vasospasm (Fig. 6.4).

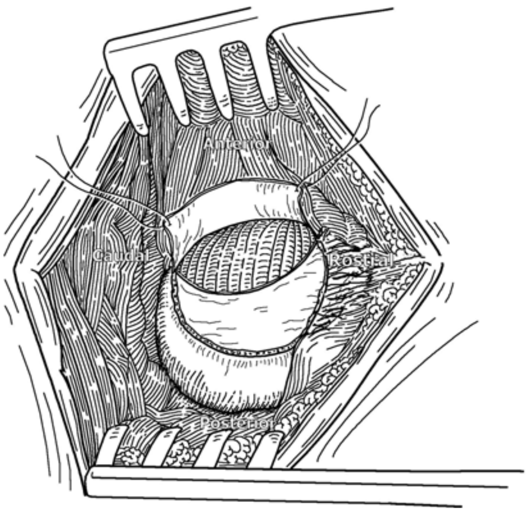

Fig. 6.3 Durotomy. The dural membrane is cut in an arc shape with its chord paralleling to the lateral rim of the craniectomy. This pattern of dural opening leaves the majority of the dura on the cerebellum, which avails the protection of the cerebellar hemisphere during the process. After the dural mater is sutured back with double knotting, the suture thread remains in place (without cutting off), which facilitates tightening when necessary during the procedure

6.8 Approach

> A caudorostral (via cerebellar fissures) approach is suggested.

The protection and management of petrosal veins poses the main challenges and risks during the process. In early cases, we approached the

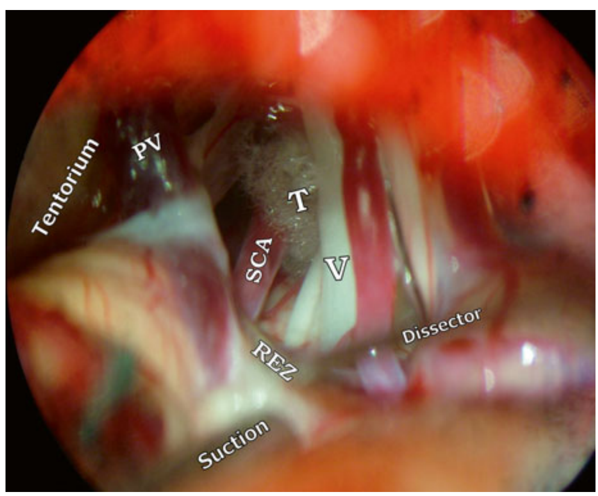

Fig. 6.4 Exposure. A satisfactory exposure can be achieved without using retracting blades. With a slow drainage of CSF and an ample adhesiolysis, a surgical corridor can be established. Actually, a narrow suction tube affords more working space than a wider spatula does at a moment when a specific area is dissected. *V* trigeminal nerve, *PV* petrosal vein, *SCA* superior cerebellar artery, *T* Teflon waddings, *REZ* root entrance zone

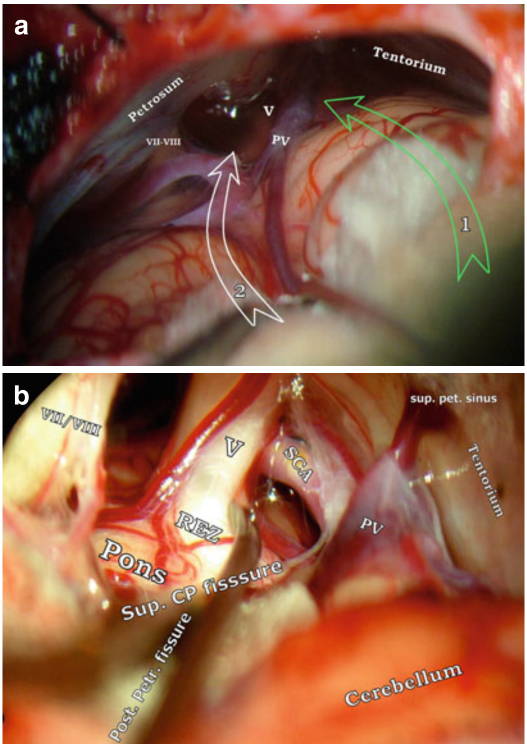

Fig. 6.5 A caudorostral approach. (**a**) To yield petrosal veins (*PV*), we choose the via-cerebellar-fissure approach (*2*) instead of the infratentorial superior-lateral cerebellar approach (*1*). (**b**) After dissection of the arachnoid membranes around the posterior petrous and the superior cerebellopontine fissures, usually the REZ of the trigeminal nerve (*V*) could be turned up in your sight directly. *VII-VIII* facial and vestibulocochlear nerves

trigeminal nerve from the superolateral aspect of the cerebellum, and petrosal veins were often obstructing the access path. We used to sacrifice these veins to prevent unintentionally tearing at its entry to the superior petrosal sinus, which was tough to manage. In that case, compression with Gelfoam was the only way for homeostasis, while coagulation could only make things worse. However, when a Gelfoam was used to cover the bleeding point, working space became much narrower and the following procedures could be very difficult. To detour off those petrosal veins, we now dissect the arachnoid membranes around the petrous and the superior cerebellopontine fissures. Basically, the REZ of the V nerve will be directly in your sight with the cerebellar fissures opened thoroughly (Fig. 6.5) (Zhu et al. 2014).

6.9 Decompression

> Identification of the neurovascular confliction: a full-way inspection of the nerve root increases the chance.

The trigeminal nerve is then circumferentially inspected along its entire intracranial course from its REZ at the brainstem laterally to its entrance into the Meckel's cave. The neurovascular relationship is carefully studied, and any vessel related to the V nerve is moved away, followed by placement of soft Teflon wadding between them. Those venules adhered to or even go through the trigeminal nerve can be coagulated and cut. Due to structural difference, the central portion of trigeminal nerve is more vulnerable to compression. A study found that the average length of the central portion of the trigeminal nerve is 2.6 mm, while for facial nerve, it is only 1.7 mm (De Ridder et al. 2002). Accordingly, the patients with trigeminal neuralgia have more chances of lateral confliction than those with hemifacial spasm (Katusic et al. 1990; Auger and Whisnant 1990). Nevertheless, to achieve a high cure rate, a thorough exposure of the whole intracranial nerve course is recommended. Comparing to hemifacial spasm, the neurovascular confliction in trigeminal cases is more complicated (Sindou et al. 2002). A superior cerebellar artery along the shoulder of the root entry zone is commonly seen compressing the caudal side of the trigeminal nerve ventromedially. Mobilization of the arterial loop often discloses a site of discoloration (or even an indent) along the nerve, which confirms that the intended pathology is found and is predictive of a good outcome after surgery. The possibility of multiple offending vessels (arterial and/or venous loops) should be excluded with careful inspection.

> The Principle of Decompression: separation of the neurovascular conflict rather than insertion of prosthesis between them

As a matter of fact, a skillful driving of a microdissector in assistance with a fine suction tube by the operator's two hands is enough to complete the decompression process, including removal of the offending vessel(s) and placement of Teflon wadding piece by piece, and no other instruments controlled by a third hand are needed in such a small room. Moving the vessel with forceps is not recommended. The substance of decompression should be separation of the neurovascular confliction rather than insertion of prosthesis between the nerve and the vessel. Actually, the role of the Teflon is to keep the offending vessel from rebounding; therefore, it is unnecessary to be always put at conflict site (Fig. 6.6). Furthermore, those offending arteries are supposed to be positioned anatomically. As the SCA or AICA is the most common culprit, they should be transposed rostrally or caudally though they may occur any way in the nerve root (Jannetta 2007). We advocate simple and safe techniques in MVD surgeries (Zhong 2012). As the ordinary decompression process is usually not so complicated, we merely discuss some extreme cases here.

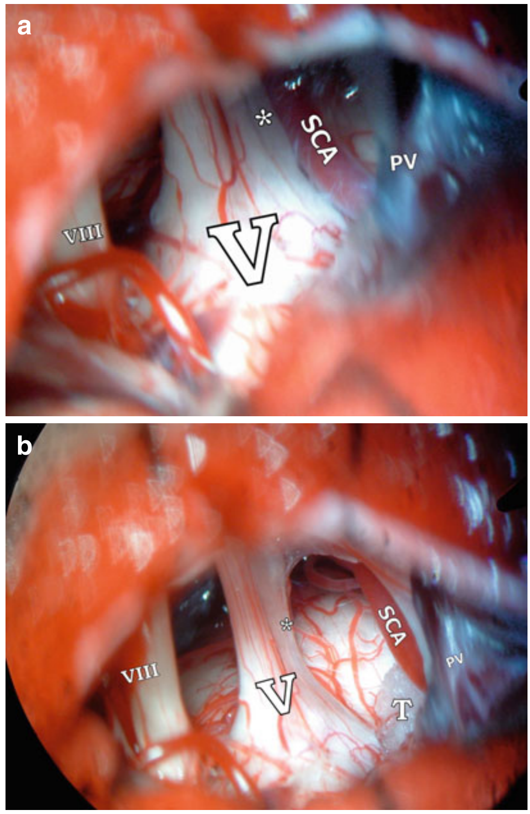

Fig. 6.6 The decompression process. The principle of decompression is separation of the neurovascular conflict rather than insertion of prosthesis between them. The Teflon may be placed anyway as long as it could keep the vessel from rebounding. (**a**) In this case, the superior cerebellar artery (*SCA*) was identified as the culprit, which contacted with trigeminal nerve (*V*) rostrally. (**b**) After the offending artery was separated from the nerve, a Teflon wadding (*T*) was not placed at the original conflict site (*). VIII the vestibulocochlear nerve, PV petrosal vein

6.9.1 Ectatic Vertebrobasilar Artery Complex

It will be tough when the surgeon encounters an incompliant and ecstatic vertebrobasilar artery complex (VBA) during the MVD (Linskey et al. 1994; Mittal and Mittal 2011; Ma et al. 2013). In that case, the point of the surgery is to move the VBA proximally. Basically, a tortuous vertebral artery is usually found ventrally to the caudal cranial nerves in these cases. Through the interstices between the caudal nerves, the proximal segment of VBA is mobilized caudolaterally, and then small pieces of shredded Teflon are gradually placed between the VBA and the medulla oblongata to keep the artery free from the brainstem. With the arachnoid membrane around the nerves opened thoroughly, the cerebellum is gradually raised until the pontomedullary sulcus is visualized. Then, ventrally to the facial nerve, more pieces of Teflon wadding are added between the VBA and the pons in order to further remove the VBA caudolaterally. By that time, the neurovascular confliction can be distinguished without difficulty – sometimes, the offending artery may have left from the trigeminal nerve root spontaneously (Yang et al. 2012). This lateroinferior cerebellar approach has the advantage of evading veins that may block the surgical corridor when the infratentorial approach was adapted (Fig. 6.7) (Sekula et al. 2011; Lemos et al. 2011).

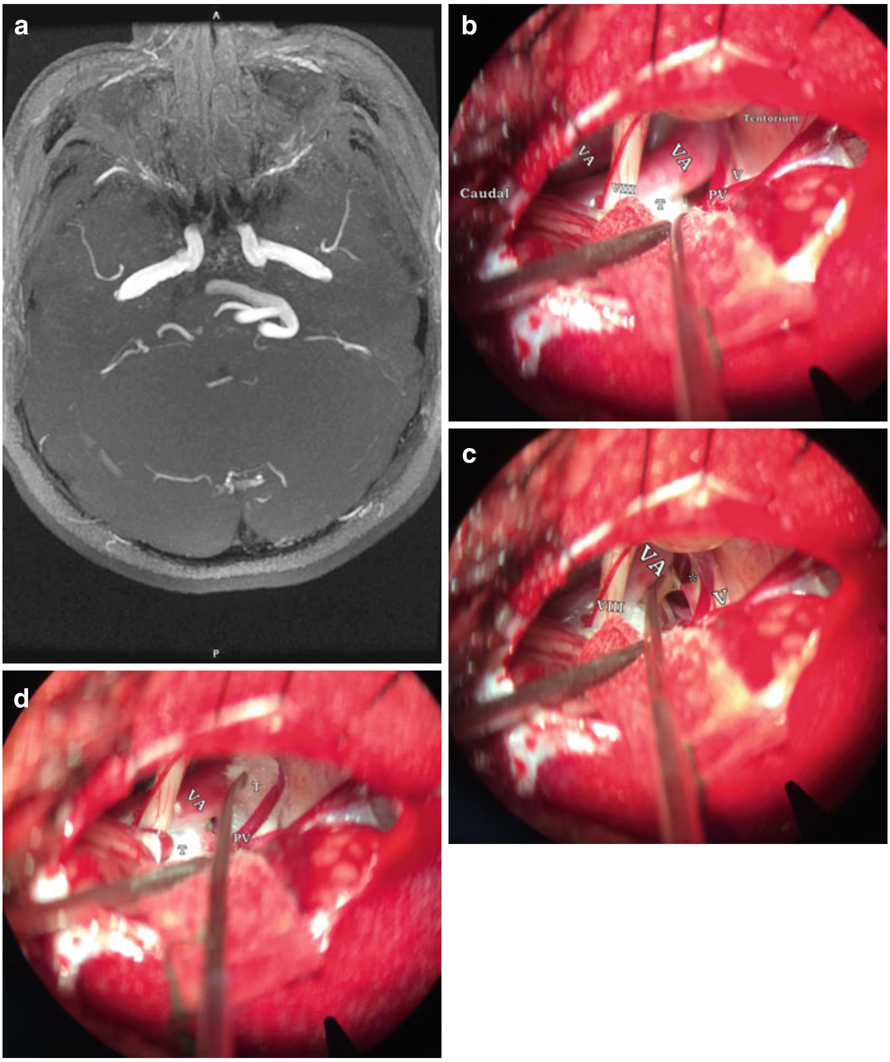

Fig. 6.7 Decompression of an ectatic vertebrobasilar artery. (**a**) The MRI delineated an ectatic vertebrobasilar artery that shifted to the ipsilateral side. (**b**) As the cerebellum being raised, both the vertebral arteries (*VA*) were visualized in the surgical field and the trigeminal nerve (*V*) was covered by a tortuous VA. Before dissection of the trigeminal root, the covering VA should be freed beginning from the proximal segment. In this photo, the proximal VA had been mobilized caudolaterally and held by Teflon waddings. Without spatula, these waddings had been buried by the cerebellar hemisphere while the section tuber moved rostrally, but only those Teflon (*T*) in the level of acoustic nerve (*VIII*) were visible. (**c**) With the VA being moved caudally, a dent (*) was found in the caudal V nerve. (**d**) Teflon waddings were inserted between the nerve and VA and the dorsal petrosal vein (*PV*) as well as a small artery

6.9.2 Venous Compression

As a high recurrence rate has been reported, the venous compression is worth addressing here (Hong et al. 2011; Helbig et al. 2009; Kimura et al. 1999; Sato et al. 1979; Lee et al. 2000; Li et al. 2014; Matsushima et al. 2004). A thorough understanding of the venous anatomy around the trigeminal nerve is crucial to identify the culprit veins accurately. The veins that commonly compress the trigeminal nerve are tributaries of the superior petrosal vein, namely, the transverse pontine vein, the pontotrigeminal vein and the vein of cerebellopontine fissure, and the vein of middle cerebellar peduncle (Choudhari 2007). The transverse pontine vein is usually attached to the superior-medial or inferior surface of the trigeminal nerve just in front of the Meckel's cave. When the culprit vein adheres firmly to the brain stem and cranial nerve, coagulating and cutting techniques are preferred in the decompressing process. However, large veins ($\Phi > 2$ mm) should avoid sacrificing unless they are surely not related to deep venous drainage of the brain stem (Zhong et al. 2008; Hong et al. 2011; Masuoka et al. 2009).

6.9.3 Intraneural Vessels

In very rare instances, a vessel may cross through the trigeminal nerve (Helbig et al. 2009; Kimura et al. 1999; Tashiro et al. 1991). For those very small arteries (arterioles) or veins (venules), coagulation and cutoff could be used. For those that situate very laterally to the edge, some nerve fibers of the trigeminal nerve root could be cut off to release the offending vessel. However, improper management of big middle intraneural vessels may lead to trigeminal nerve injury and result in uncomfortable neuropathy and numbness (including corneal hypoesthesia). In that case, we suggest fully dissecting to mobilize the artery or vein, followed by wrapping with tiny Teflon wadding (Zheng et al. 2012).

6.10 Closure

> The dura should be closed in a watertight pattern.

At the end of the operation, the surgical field should be well irrigated with 37 °C normal saline to vent air as well as to assure that there is no bleeding. Meanwhile, attention should be paid to make sure the implanted Teflon is stable under the flow of CSF. Before dural closure, it is suggested to place a piece of wet Gelfoam over the cerebellum, which prevents not only epidural hemorrhage from flowing into the subdural space but also accidental injury to the brain tissue while suturing. In order to prevent CSF leakage, the dura should be closed tightly. The surgeon should begin the stitch process from the lowest level to prevent blood inflow from outside. Sometimes, it is difficult to complete a watertight closure due to dura defect. In that case, a muscle patch can be used to repair the defect (Fig. 6.8). Then, the dura is sealed with glue and covered by an artificial dura plus bone chips to reconstruct the normal anatomy. Finally, the muscles, subcutaneous tissues, and the scalp are sutured layer by layer, and no drainage is required.

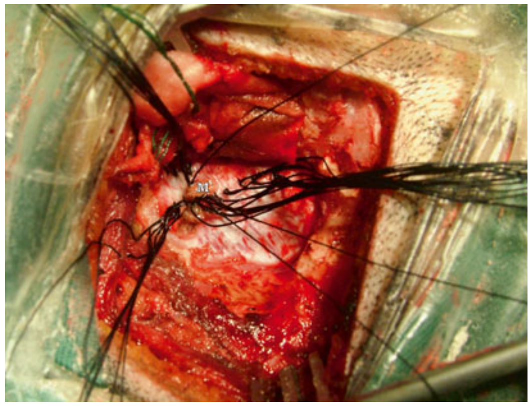

Fig. 6.8 Closure. The dural membrane should be always stitched in a watertight pattern as far as possible. In case of dura defect, a muscle patch (*M*) is the first choice to be used to repair the defect. Artificial materials are not suggested

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