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ORIGINAL ARTICLE - FUNCTIONAL NEUROSURGERY - PAIN

Resection of the suprameatal tubercle in microvascular decompression for trigeminal neuralgia

Takuro Inoue[1] · Yukihiro Goto[2] · Mustaqim Prasetya[3] · Takanori Fukushima[4]

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Abstract

Background The suprameatal tubercle (SMT) may obscure the neurovascular compression (NVC) in microvascular decompression (MVD) for trigeminal neuralgia (TGN). The aim of this study is to address the necessity of resecting SMT in MVD for TGN.

Methods We retrospectively analyzed radiological findings of 461 MVDs in patients with TGN, focusing on the relation between SMT and the NVC site. Three-dimensional (3D) images were used for preoperative evaluation. The NVC sites were obscured by SMT in 48 patients (10.4%) via the retrosigmoid approach. This study was conducted to review the management of SMT among these patients. Resection of SMT was performed in 8 patients (resected group) for direct visualization of the NVC site. On the other hand, nerve decompression was achieved without resecting SMT for the rest of the 40 patients (non-resected group). Biographical data, radiological findings, intraoperative findings, and surgical outcomes were retrospectively evaluated.

Results The mean height of SMT obscuring NVC was 5.0 mm (2.8–13.9 mm) above the petrous surface. The NVC was located at a mean of 1.9 mm (0–5.9 mm) from the porous trigeminus. The most common offending vessel was the superior cerebellar artery (SCA, 56.3%), followed by the transverse pontine vein (TPV, 29.2%). In the resected group, the transposing culprit vessels were feasibly performed after direct visualization of the NVC site, whereas in the non-resected group, the SCA was successfully transposed using curved instruments after thorough dissection around the nerve. TPV having contact with the nerve was coagulated and divided. Immediate pain relief was obtained in all patients except one who experienced delayed pain relief 1 month after surgery. Facial numbness at discharge was noted in 9 patients (18.8%); thereafter, numbness diminished over time. Numbness at the final visit was observed in 5 patients (10.4%) at mean of 49 months after MVD. Recurrent pain occurred in 4 patients (8.3%) in total. Statistical analysis showed no significant differences in surgical outcomes between both groups.

Conclusions Direct visualization of the NVC site by resecting the SMT does not affect surgical outcomes in the immediate and long term. Resecting the SMT is not always necessary to accomplish nerve decompression in most cases by use of suitable instruments and techniques.

Keywords Microvascular decompression · Petrous endostosis · Suprameatal tubercle · Surgical technique · Trigeminal neuralgia

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✉ Takuro Inoue
takuro39@gmail.com

[1] Department of Neurosurgery, Subarukai Koto Kinen Hospital, 2-1 Hiramatsu-cho, Higashiomi-shi, Shiga 527-0134, Japan

[2] Department of Neurosurgery, Saiseikai Shiga Hospital, Ritto, Shiga, Japan

[3] Department of Neurosurgery, National Brain Center Hospital, Jakarta, Indonesia

[4] Division of Neurosurgery, Duke University Medical Center, Durham, NC, USA

Introduction

The bony prominence above the internal auditory meatus called the suprameatal tubercle (SMT) is frequently observed during posterior fossa surgery [5, 10, 13]. A large SMT obscures the distal portion of trigeminal nerve root at the juxtaporous trigeminus. In microvascular decompression (MVD) for trigeminal neuralgia (TGN), decompression of entire length of the nerve is necessary as neurovascular compression (NVC) anywhere along the root may cause neuralgia [9, 14]. In the cases with large SMT, the NVC may not be exposed or even recognized, resulting in insufficient decompression or negative exploration [13], whereas, resecting the SMT in the narrow operative field may have potential risks of vascular or

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nerve injury and postoperative cerebrospinal fluid leakage. The incidence of large SMT obscuring NVC has not been fully elucidated yet. We evaluated our surgical management and outcomes of MVD for TGN in relation to SMT.

Materials and methods

To collect the cases with SMT obscuring NVC, preoperative three-dimensional (3D) images and recorded operative videos were reviewed. 3D images were created using GammaPlan (Elekta, Stockholm, Sweden) based on magnetic resonance imaging (MRI) as previously described [4]. Among the consecutive 461 MVDs for TGN, 48 patients (10.4%) were identified having such SMTs (Fig. 1). SMT resection was applied in 8 patients (resected group). An ultrasonic bone shaver was used to remove the SMT through retrosigmoid approach in 7 patients (Fig. 2). A great care was taken not to injure the petrosal vein and the vestibulocochlear nerve by covering with cottonoids. The dura mater over the SMT was peeled off with a small dissector, and then the SMT was shaved with an ultrasonic bone shaver. There were no complications regarding this maneuver, whereas the rest of one patient with an enormous SMT was operated via the anterior trans-petrosal approach. In this approach, the trochlear nerve was found coursing in the middle of the operative corridor. The trochlear nerve was securely preserved, and no postoperative complication was noted. There was one patient with pneumatized SMT in this group, in whom the resection was limited not to open the air cells. After direct exposure of the NVC, transposition of the compressing arteries and/or division of the compromising veins was performed. For the remaining 40 patients, who were mostly later cases of our experience, SMT resection was not attempted (non-resected group) due to precise evaluation with 3D images and changes of our surgical techniques (Fig. 3). Transposition of the culprit artery was successfully accomplished after sufficient drainage of the cerebrospinal fluid (CSF) and thorough dissection around the trigeminal nerve. Several kinds of curved dissector and micro-scissors were used to dissect the area behind the SMT. Extensive dissection of the superior surface of the cerebellum allowed for access to manipulate the proximal portion of the superior cerebellar artery (SCA). The small veins were coagulated and divided near the SMT. Biographical data of the patients and radiological and surgical findings and outcomes including pain relief, facial numbness, and other complications were assessed by reviewing the medical records. All patients were followed up in our clinic or by questionnaire survey to evaluate long-term pain control and recurrences.

Results

Patient characteristics, measurement of SMT, and postoperative results are summarized in Table 1. SMT height was measured higher in the resected group (mean 6.0 mm, range 2.9–13.9 mm) than in the non-resected group (mean 4.8 mm, range 2.8–8.9 mm). The NVC was located at a mean length of 1.5 mm (range 0–5.8 mm) from the porous trigeminus in the resected group and at a mean of 2.0 mm (range 0–5.9 mm) in the non-resected group. The anatomical data showed no significant difference between the groups. The most frequent compromising vessel was the SCA in both groups (6 patients (75%) in the resected group, 21 patients (52.5%) in the non-resected group), followed by the transverse pontine vein (TPV) (2 patients (25%), 12 patients (30%), respectively). Four cases with other compressing vessels, such as the anterior inferior cerebellar artery, the vertebral artery, the trigeminocerebellar artery, and the pontotrigeminal vein, were found in the non-resected group. The variety of responsible vessels did not show statistically significant differences in either groups.

All patients were followed up for the mean period of 49 months (range 2–129 months). The resected group had longer follow-up periods as SMT removal was mainly performed in our earlier experience. Immediate

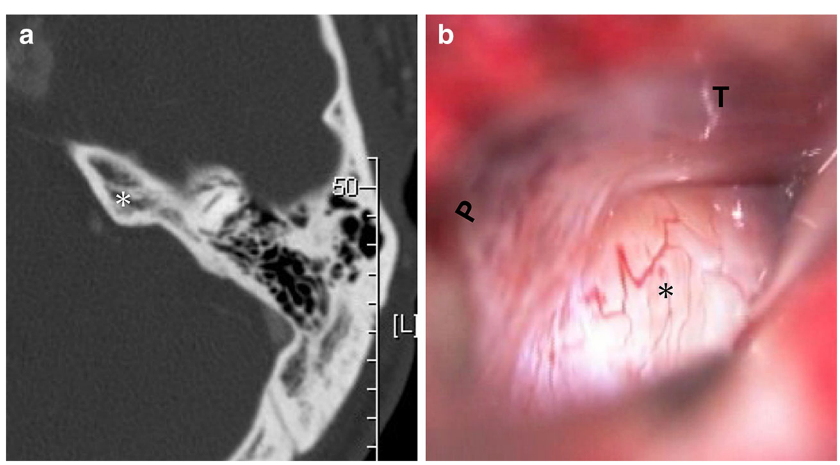

Fig. 1 **a** An axial slice of computer tomography shows a suprameatal tubercle (SMT, asterisk) on the left. **b** The SMT located on the petro-tentorial junction, obscuring the deeper surgical corridor. P, petrous dura mater; T, tentorium

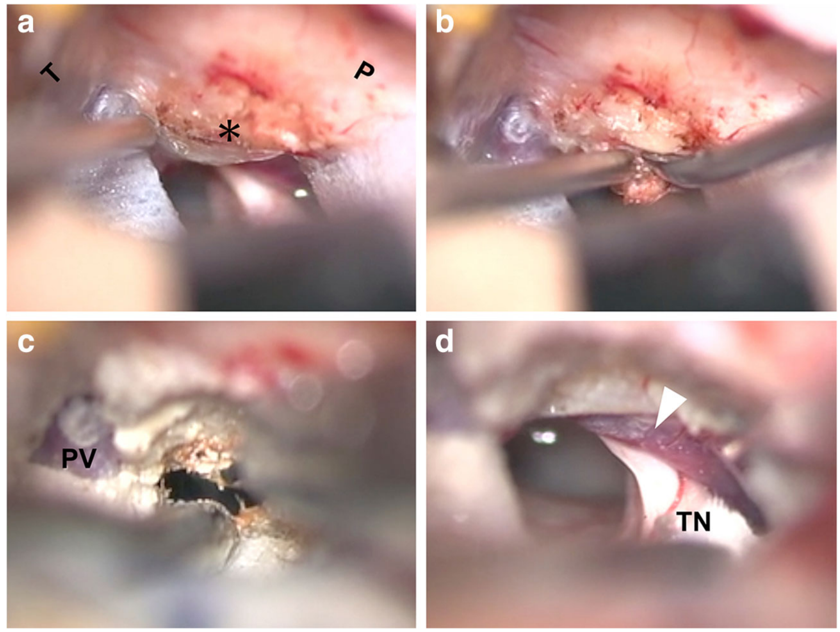

Fig. 2 **a** A SMT (asterisk) is obscuring the distal part of the trigeminal nerve and the neurovascular compression (NVC). **b** The dura mater overlying the SMT is peeled off using a sharp dissector. **c** The exposed SMT was resected with an ultrasonic bone shaver. **d** The NVC with a transverse pontine vein (white arrowhead) was exposed. P, petrous dura mater; PV, petrosal vein; T, tentorium; TN, trigeminal nerve

postoperative pain relief was obtained in all patients except one in whom the patient reached delayed pain free 1 month after surgery. Facial numbness was noted in 2 patients (25%) in the resected group and 7 patients (17.5%) in the non-resected group, which diminished gradually over time. Remaining numbness at the final follow-up was observed in 1 patient (12.5%) in the resected group and 4 patients (10%) in the non-resected group. Post-operative wound infection was noted in one patient, in whom bone removal and debridement were required. Other complications, such as dry eye, hearing impairment, and CSF leakage, were not observed. The surgical outcomes and follow-up results showed no significant difference between the two groups.

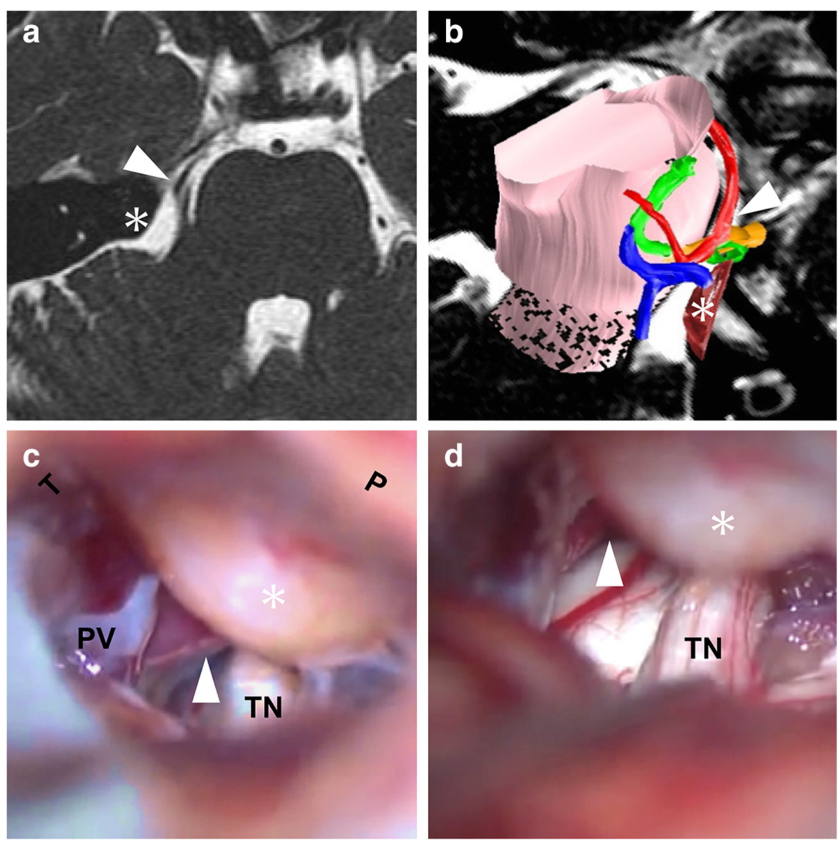

Fig. 3 **a** An axial slice of magnetic resonance imaging (MRI) shows SMT (asterisk) and the NVC by the superior cerebellar artery (SCA, white arrowhead) on the right. **b** A three-dimensional image demonstrates the anatomical relations around the trigeminal nerve (TN). SCA (white arrowhead) is compressing TN (yellow) anterior to the SMT (asterisk). (blue, the petrosal vein; brown, SMT (asterisk); green, the transverse pontine vein; pink, the brainstem; red, SCA; yellow, trigeminal nerve). **c** NVC site of the right TN by SCA (white arrowhead) is obscured by SMT (asterisk). **d** Nerve decompression was accomplished without resecting SMT (asterisk). P, petrous dura mater; PV, petrosal vein; T, tentorium; TN, trigeminal nerve

Table 1 Patient characteristics, radiological and surgical findings, and surgical outcomes

	Total	Resected group	Non-resected group	*p* value
Patient characteristics				
n	48	8	40	
Age at MVD	17–87 (55)	19–67 (52)	17–87 (55)	0.67
Sex (M/F)	17/31	2/6	11/29	> 0.99
Affected side (R/L)	29/19	7/1	22/18	0.12
Distribution (V1/V2 / V3/ V1,2 / V2,3/V1,2,3)	4/17/12/2/12/1	2/4/1/0/1/0	2/13/11/2/11/1	0.16
Duration before MVD (years)	0.4–25 (5.3)	0.5–25 (5.4)	0.4–23 (5.2)	0.9
Radiological and surgical findings				
SMT height from petrous surface (mm)	2.8–13.9 (5.0)	2.9–13.9 (6.0)	2.8–8.9 (4.8)	0.08
NVC location from porous trigeminus (mm)	0–5.9 (1.9)	0–5.8 (1.5)	0–5.9 (2.0)	0.47
Most lateral vessel hidden by SMT				0.84
SCA	27 (56.3%)	6 (75%)	21 (52.5%)	
AICA	4 (8.3%)	0	4 (10%)	
VA	1 (2.1%)	0	1 (2.5%)	
TCA	1 (2.1%)	0	1 (2.5%)	
TPV	14 (29.2%)	2 (25%)	12 (30%)	
PTV	1 (2.1%)	0	1 (2.5%)	
Outcome				
Follow-up (months)	2–129 (49)	53–129 (85)	2–113 (42)	0.003*
Pain relief (immediate / delayed > one month)	47 (97.9%) /1 (2.1%)	8 (100%) /0 (0%)	39 (97.5%) / 1 (2.5%)	> 0.99
Recurrence	4 (8.3%)	1 (12.5%)	3 (7.5%)	0.54
Numbness at discharge	9 (18.8%)	2 (25%)	7 (17.5%)	0.64
Numbness at final visit	5 (10.4%)	1 (12.5%)	4 (10%)	> 0.99
Other complications	1 (2.1%)	0	1 (2.5%)	> 0.99
Dry eye		0	0	
Hearing disturbance		0	0	
CSF leakage		0	0	

M, male; *F*, female; *R*, right; *L*, left; *V1*, the first division of the trigeminal nerve; *V2*, the second division of the trigeminal nerve; *V3*, the third division of the trigeminal nerve; *MVD*, microvascular decompression; *SMT*, suprameatal tubercle; *NVC*, neurovascular compression; *SCA*, superior cerebellar artery; *AICA*, anterior inferior cerebellar artery; *VA*, vertebral artery; *TCA*, trigeminocerebellar artery; *TPV*, transverse pontine vein; *PTV*, pontotrigeminal vein; *CSF*, cerebrospinal fluid

* Significant difference

Representative cases

Case 1: nerve decompression without SMT resection (Fig. 4a) A 39-year-old man was suffering from trigeminal neuralgia (V2 division) on the left for 3 years. MRI revealed NVC on the nerve by the SCA, which was obscured by a large SMT occupying the cistern (6.9 mm high from the petrous surface). An MVD was done through the retrosigmoid approach. Nerve decompression was performed using a curved dissector and scissors after sufficient CSF drainage without resecting the SMT. The patient became pain free immediately after surgery with temporary numbness for 3 months.

Case 2: SMT resection via anterior trans-petrosal approach (Fig. 4b) A 49-year-old man was suffering from trigeminal neuralgia (V1 division) on the left for 25 years. His pain became severe even after an increased dosage of carbamazepine more than 1000 mg. A large SMT (13.9 mm in height) was found on MRI. MVD was planned through the anterior trans-petrosal approach after evaluating the surgical view with 3D images. The anterior part of the SMT was resected extradurally, and then the posterior fossa dura was incised to expose the trigeminal nerve. A transverse pontine vein was found and divided near the porous trigeminalis. His pain was relieved immediately after the surgery without any complication. The histology

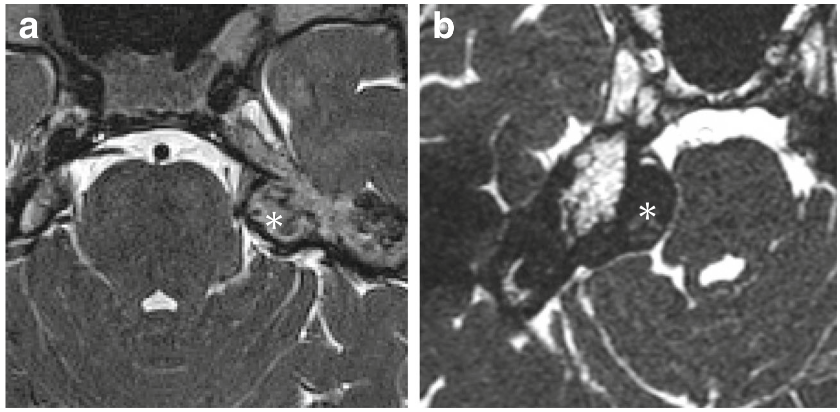

Fig. 4 **a** An example case without resecting SMT. An axial slice of MRI shows a SMT (asterisk) occupying the cistern on the left. **b** An axial slice of MRI of the case with the largest SMT resected via an anterior trans-petrosal approach. The SMT (asterisk) is compressing the brainstem

of the resected SMT revealed no pathological finding and was confirmed as normal bone tissue.

Discussion

Vascular compression at the root entry zone (REZ) was originally considered to be the pathology of TGN since Jannetta popularized MVD for the treatment of TGN [6, 7]. However, previous clinical studies showed that NVC anywhere along the entire length of the trigeminal nerve root may cause TGN [9, 14]. Therefore, it is recommended to expose and decompress the entire length of the trigeminal nerve from the pons to the porous trigeminus in MVD [9, 14]. Seoane and Rhoton [12] described anatomical characteristics of SMT in 15 cadaveric heads with the height ranging from 2.8 to 6.0 mm (mean, 4.1 mm) above the petrous surface. Our clinical observation of 461 cases confirmed that SMTs are not rare findings and have a variety of heights ranging from 2.8 to 14.5 mm (mean, 5.0 mm). In patients with large SMTs, the distally located NVC site could be obscured by SMTs. Therefore, attention must be paid to the region behind the SMT to avoid negative explorations. In the literature, little is reported regarding SMT in MVD. Shenouda et al. [13] demonstrated 15 cases (3.4%) with SMT resection among their 440 MVDs. They mentioned that the rate of SMT obscuring NVC may be underestimated because they did not recognize this entity or its significance early in their experience. We demonstrated higher incidence of such SMTs (10.4%), suggesting that the region behind SMT should be paid more attention to avoid failed decompression.

For tumor removal, resection of SMT via a retrosigmoid approach was proposed to provide a corridor to Meckel's cave [1–3, 8, 11]. Most reports are regarding cadaveric consideration for this technique [1–3, 8]. Reports of clinical cases in MVD for TGN are limited [10, 13]. Resecting SMT itself is not technically difficult by use of an ultrasonic bone shaver. Although SMT resection allows direct exposure of NVC site, this technique carries risks, such as nerve or vascular injury and opening of the petrous air cells, resulting in postoperative sequelae. In our later experience, nerve decompression was accomplished without resecting SMT in most cases by alteration of surgical technique. These patients were successfully treated for TGN with no significant difference in surgical outcomes from those who had SMTs resected. Even in the case with a large SMT occupying the cistern, nerve decompression was possible without resection by thorough dissection around the nerve and SMT (Fig. 4a). SMT resection should be limited unless exceptionally large with mass effect to the brainstem (Fig. 4b). In such a case, however, nerve decompression should be considered via an anterior trans-petrosal approach rather than via a retrosigmoid approach.

Conclusion

SMT resection is not necessary in most cases in MVD surgery. Preoperative recognition of the culprit vessel and the exact NVC location with 3D images is crucial to avoid unnecessary surgical procedures.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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