

Microsurgical Intercapsular Resection Schwannoma Without Severing Nerve Fibers: A Technique of Using Only 2 Freer Dissectors

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Background: Schwannoma is often removed by severing the nerve fascicle of origin or microsurgical enucleation, and patients may sometimes experience postoperative neurological deficits and sensory loss. An intercapsular resection technique was devised to remove only the true tumor and preserve nerve function. We report our technique and results using only 2 Freer dissectors.

Methods: Twenty cases of schwannoma of extremities and head were treated by the same surgeon from 2018 to May 2024. The schwannoma was exposed under general anesthesia. The superficial incision was performed at an area on the epineurium where there was no funiculus, followed by total removal of the tumor using only 2 Freer dissectors without cutting nerve fibers.

Results: The patients were 12 men and 8 women with a mean age at surgery of 55 years (range: 20–81 y). The preoperative mean diameter on magnetic resonance imaging averaged 24 mm (range: 10–46 mm). The average operation time for tumor removal was 39 minutes. The average postoperative follow-up was 1 year. All patients showed improved preoperative symptoms, with no muscle weakness, movement disorders, or sensory loss. None of the cases showed residual neurological deficits or tumor recurrence.

Conclusions: This method, using 2 Freer dissectors, does not require grasping the nerve with micro forceps, and it was possible to gently strip off the surrounding normal nerve fibers from the tumor, like peeling the skin of an onion. This is an extremely useful technique that can remove only the tumor safely and in a short time without damaging nerves. (*Plast Reconstr Surg Glob Open* 2025;13:e6703; doi: 10.1097/GOX.00000000000006703; Published online 16 April 2025.)

INTRODUCTION

Schwannoma and neurofibroma are tumors that originate in peripheral nerves. Although both tumors are derived from Schwann cells, they can have different histological shapes. In neurofibroma, many nerve fibers are

mixed with tumor mass comprising proliferated Schwann cells and fibroblasts.^{1–3} Conversely, in schwannomas, only Schwann cells become tumorigenic, with tumor mass characteristically enclosed within a capsule.^{1–3}

Notably, schwannomas are sometimes removed by resecting the nerve fascicles of origin or enucleated without attempting to preserve neuronal functions.^{4,5} Therefore, postoperatively, many patients may experience neurological deficits and sensory loss. Based on this background, Hashimoto^{6,7} developed the technique of intercapsular resection by focusing on the characteristic features of an encapsulated tumor mass. This technique enabled removing only tumor lesions en bloc along with their capsules while preserving neuronal functions.^{6,7} Recently, we performed intercapsular resection using only 2 Freer dissectors, and this technique enabled us to

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handle nerves atraumatically. In addition, we found that this technique caused less nerve damage and successfully produced favorable outcomes. Herein, we present the details of these cases.

PATIENTS AND METHODS

Overall, 20 patients with schwannoma in the extremities or head underwent surgery performed by the same surgeon from 2018 to May 2024. The patient's preoperative symptoms were numbness and radiating pain in the nerve distribution area caused by compression or tapping of the mass. Preoperative examination included ultrasonography and magnetic resonance imaging (MRI) in all cases. During each operation, the surgeon first incised a funicular-free site on the epineurium and then performed intercapsular resection to remove the tumor en bloc using only 2 Freer dissectors, namely Elevatorium and Raspatorium (Keisei Medical Industrial Co., Ltd., Tokyo, Japan) (Fig. 1). For each nerve of origin, pre- and postoperative neurological symptoms (numbness, pain, sensory loss,

movement disorder, and Tinel sign), pathological classification, and recurrences were evaluated.

Surgical Technique

The intercapsular resection technique is based on the concept that total removal of a tumor can be achieved without severing any nerves, as schwannoma originates from a single nerve fiber within a perineurium and is not connected to any surrounding nerve fibers or nerve fibers within other perineuria.^{6,7} The operation is performed under general anesthesia with tourniquet use. When a tourniquet is used, a rubber Esmarch bandage is not used. This is because blood remains in the tortuous nutrient vessels of the true capsule of the schwannoma, which facilitates the identification of the capsule as described later. The specific procedures performed during intercapsular resection are as follows. First, nerve fibers on the tumor are observed under a microscope; subsequently, a small incision is made in the direction of the nerve fibers. This incision of the epineurium should be made on the opposite side of the main trunk of the healthy nerve fascicles if it is visible. This is because schwannoma growth is localized in the nerve trunk, and healthy nerve fascicles are scarce on the convex side. Therefore, it is optimal to first incise the epineurium at this site.^{6,7} However, the main trunk may not always be visible, and in such cases, the surgeon should make an incision parallel to the nerve fibers at a site devoid of motor fibers while using a nerve stimulator.^{6,7}

Furthermore, the true tumor capsule should be confirmed after incising the epineurium and perineurium on the surface of the tumor. However, because it can be difficult to confirm the tumor capsule in some cases, the surgeon should use Freer dissectors to strip off thin layers one at a time at the incision site near the tumor capsule, similar to peeling an onion. In particular, this separation procedure should only be carried out with the Freer dissectors. Accordingly, the surgeon does not need to grasp the nerves with micro forceps or other instruments and can handle them atraumatically. After this procedure, the layer without fibrous tissue represents the true tumor capsule layer. However, in some cases, the surgeon may

Takeaways

Question: Schwannoma is often removed by severing the nerve of origin, which leads to postoperative neurological deficits and sensory loss, so how can we remove it without damaging the nerve?

Findings: Using only 2 Freer dissectors, we performed microsurgical intercapsular resection in 20 cases. This technique enabled us to handle nerves atraumatically. All patients showed improved preoperative symptoms, with no muscle weakness, movement disorders, or sensory loss. None of the cases showed residual neurological deficits or tumor recurrences.

Meaning: This method is a very useful technique that can remove only the tumor safely and in a short time without damaging nerves.



Fig. 1. The Freer dissectors. Elevatorium and Raspatorium (Keisei Medical Industrial Co., Ltd., Tokyo, Japan) were used for separation.

incorrectly assume that nerve fibers are continuous with the tumor when the separation is incorrectly made at a shallow layer, as well as mistakenly consider that tumor removal is impossible unless the nerves are severed.^{8,9} In other words, when the tumor is found to be continuous to the nerve fibers and does not seem to be removable without severing the nerves, the surgeon should consider the possibility that the tumor capsule may not have been reached yet.^{8,9} In such cases, it is important to strip off thin layers from the central side patiently without giving up.

Finally, the surgeon should bluntly dissect the tumor capsule using 2 Freer dissectors to achieve total removal of only the tumor. Preoperative ultrasonography and MRI scans may show cystic degeneration on the surface of the tumor. In this case, the tumor capsule is first identified at the cyst-free site, and dissection is performed gradually from that site. Once the surrounding area has been dissected, the last step is to dissect the cyst site. Because the tumor is fragile at this cystic site, the dissection is performed in an atraumatic manner without rupturing the capsule on the cyst as much as possible. After removal of the schwannoma, the nerve fiber can be observed without damage under a microscope. Under the microscope, the nerve fascicle, epineurium, and perineurium are restored to their original positions as much as possible. In this process, to prevent unnecessary damage to the nerve, the nerve is not grasped with micro forceps, and no epineural or perineural sutures are performed. The wound is closed

primarily. (See **Video 1 [online]**, which displays case 2. It demonstrates a series of intercapsular resection procedures using only 2 Freer dissectors. Specifically, this video shows procedures from an incision on the epineurium to the total removal of the tumor.)

RESULTS

Among the 20 cases, 12 were men, and 8 were women, and their mean age at the time of surgery was 55 years (range: 20–81 y) (**Table 1**). All patients exhibited a Tinel sign at the tumor site, and the mean maximum diameter of the tumor, as measured by MRI, was 24 mm (range: 10–46 mm). Preoperative MRI scan showed a target sign, fascicular sign, and split fat sign, and the diagnosis of schwannoma was made. In particular, the nerves of origin were located in the upper limbs (median, ulnar, posterior interosseous, and cutaneous nerves in 4, 2, 1, and 4 patients, respectively), lower limbs (tibial, posterior femoral cutaneous, medial sural cutaneous, superficial fibular nerves in 1 patient each), and head (great auricular, greater occipital, accessory, and cutaneous nerves in 1, 1, 1, and 2 patients, respectively). All operations were performed under general anesthesia. The mean surgery time from the start of the operation to tumor removal was 39 minutes (range: 7–114 min). The technique involving the use of only 2 Freer dissectors allowed the surgeon to remove the tumors while preserving fine nerve fibers. The pathological examination

Table 1. Patient Data for Microsurgical Intercapsular Resection of Schwannoma Without Severing of Nerve Fibers

Age, y/sex	Nerve	Tumor Size (mm) MRI	Pathological Classification	Postoperative Neurological Symptoms (Duration of Symptoms)	Operative Time From Skin Incision to Tumor Removal, min
1. 81/M	Median nerve	29	Mixed	None	74
2. 45/F	Median nerve	29	Mixed	None	55
3. 73/M	Median nerve	25	Mixed	None	56
4. 73/M	Median nerve	10	Antoni A	None (numbness of the thumb, index, and middle fingers, 5 mo.)	52
5. 52/M	Ulnar nerve	21	Antoni A	None (numbness of the ring and little finger, 45 d)	57
6. 61/F	Superficial branch of ulnar nerve	25	Antoni A	None (numbness in finger pad of the little finger, 1 y)	19
7. 24/F	Posterior interosseous nerve	34	Antoni A	None	41
8. 67/M	Tibial nerve	35	Mixed	None (numbness of the fifth toe, 3 mo)	114
9. 66/M	Posterior femoral cutaneous nerve	19	Antoni A	None	56
10. 45/M	Medial sural cutaneous nerve	17	Mixed	None	14
11. 33/M	Superficial fibular nerve	18	Antoni A	None (numbness of the first toe, 1 mo)	17
12. 43/M	Great auricular nerve	31	Mixed	None	13
13. 61/F	Greater occipital nerve	46	Mixed	None (sensory loss in a 5 cm scalp area, 3 mo)	49
14. 20/M	Accessory nerve	27	Mixed	None	65
15. 72/F	Cutaneous nerve	30	Antoni A	None	16
16. 47/M	Cutaneous nerve	12	Antoni A	None	7
17. 59/F	Cutaneous nerve	26	Mixed	None	22
18. 60/F	Cutaneous nerve	15	Mixed	None	14
19. 57/F	Cutaneous nerve	15	Antoni A	None	11
20. 73/M	Cutaneous nerve	13	Antoni A	None	20

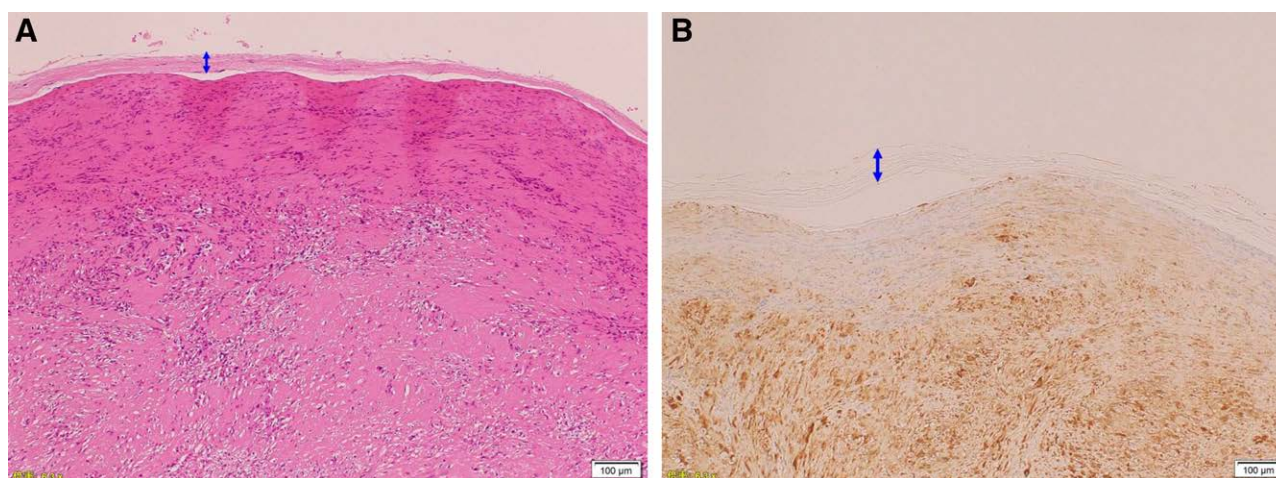


Fig. 2. Pathological image of the excised specimen in case 12. The tumor was composed of Antoni A and Antoni B areas of schwannoma. The blue arrow indicates the tumor capsule. A, Hematoxylin–eosin staining, $\times 10$. B, Immunohistochemical staining for S100 protein, $\times 10$.

also revealed positive immunostaining for S100 protein, and all cases were schwannoma. Ten cases were Antoni A, and the other 10 cases were a mixed pattern of Antoni A and Antoni B areas. The pathological examination confirmed the presence of tumor capsules, although some were ruptured (Fig. 2). On average, postoperative follow-up was conducted for up to 1 year. Postoperatively, all patients exhibited improvement in preoperative symptoms, and none had signs of muscle weakness or movement disorders. When motor nerves were included, it was confirmed with the patient that there was no loss of mobility or muscle strength in the fingers or other extremities. Further, although 30% of the patients experienced slight numbness postoperatively (3, 2, and 1 in the upper limbs, lower limbs, and head, respectively), all patients, except one, showed improvement 1–3 months after surgery. In 1 patient with schwannoma originating from the ulnar nerve, slight numbness persisted for 1 year after surgery. Nevertheless, it resolved eventually. Furthermore, none of the patients exhibited persistent neurological deficits or tumor recurrences during follow-up.

CASE REPORTS

Case 2

A 45-year-old woman noticed a swelling on the left upper arm 6 years before presentation. Notably, numbness in her first and second fingers worsened each year, hindering her work of assembling precision machinery. Thus, she decided to visit our hospital. Based on a preoperative MRI scan, a schwannoma within the median nerve was suspected. Furthermore, surgery was performed under general anesthesia, and the schwannoma (size: 2.5×2 cm) was microsurgically removed (Fig. 3) (see Video 1 [online]). The surgery time from the start of the operation to tumor removal was 55 minutes. Postoperatively, she exhibited improvement in preoperative symptoms and had no signs of muscle weakness or movement disorders.

Case 7

A 24-year-old woman noticed a swelling on the right forearm 2 years before presentation. As pressure pain at the site of swelling worsened, she decided to visit our hospital. Based on a preoperative MRI scan, a schwannoma within the posterior interosseous nerve was suspected. Further, surgery was performed under general anesthesia, and the schwannoma (3.5×2 cm) was microsurgically removed (Fig. 4). (See Video 2 [online], which displays Case 7. It shows a blunt separation of the tumor capsule by the surgeon using only 2 Freer dissectors to achieve total resection without holding the nerve fascicles with micro forceps.) The surgery time from the start of the operation to tumor removal was 41 minutes. Postoperatively, no drop finger was noted (Fig. 5). One year after surgery, there has been no recurrence, and the surgical wound is not noticeable (Fig. 6).

DISCUSSION

Overview of Schwannoma and Neurofibroma Characteristics

Schwannoma and neurofibroma are tumors originating in peripheral nerves.^{1,10} Although both are Schwann cell-derived tumors, in schwannoma, only Schwann cells become tumorigenic, with tumor mass characteristically enclosed in a capsule.^{1–3,10} It has been reported that the peak age of the onset of schwannoma is 20–60 years, with no differences in this age in terms of sex.¹⁰ The annual incidence of this tumor has been reported to be 2.1 in 100,000 individuals.¹¹

Notably, schwannoma can occur in both motor and sensory nerves, leading to numbness and radiating pain on pressing or hitting the swelling site. Although this tumor grows gradually, some reports have indicated that it expands by 2–4 mm annually.^{12,13} These findings suggest that surgical options should be considered in the treatment of patients experiencing tumor-related neurological symptoms, such as pain, numbness, and muscle weakness.

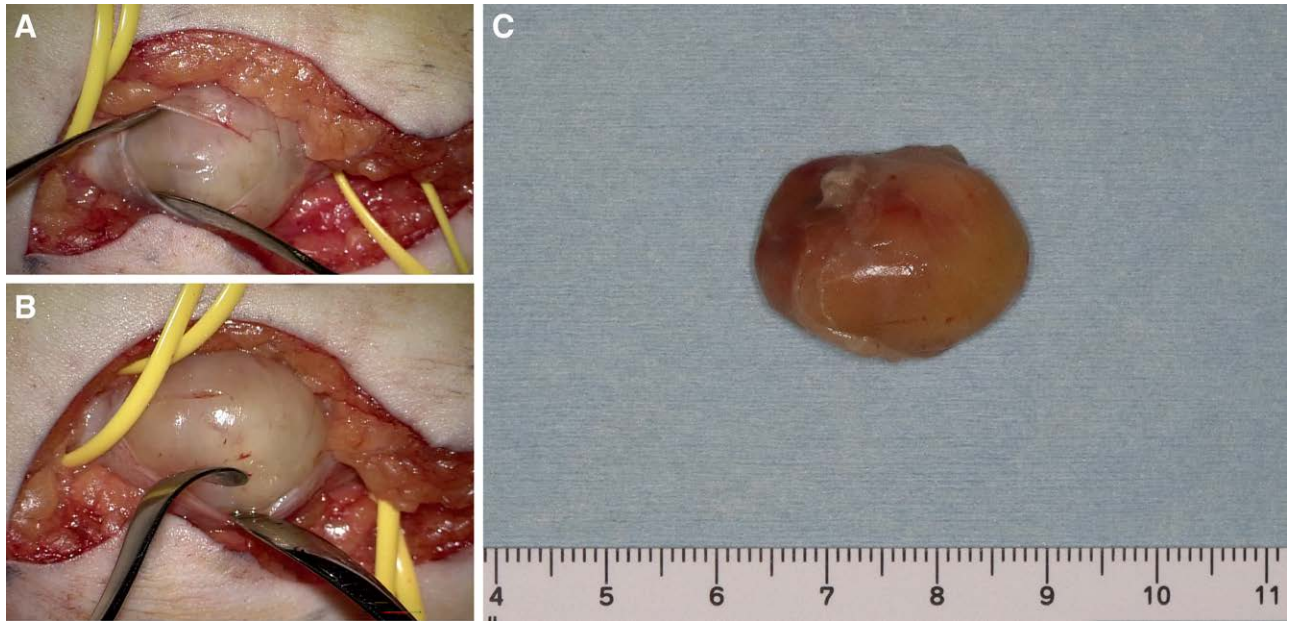


Fig. 3. Case 2. Intraoperative images. A, The upper part of the tumor was dissected with 2 Freer dissectors. B, The lateral aspect of the tumor was dissected. C, Excised schwannoma (size: 2.5 × 2 cm).

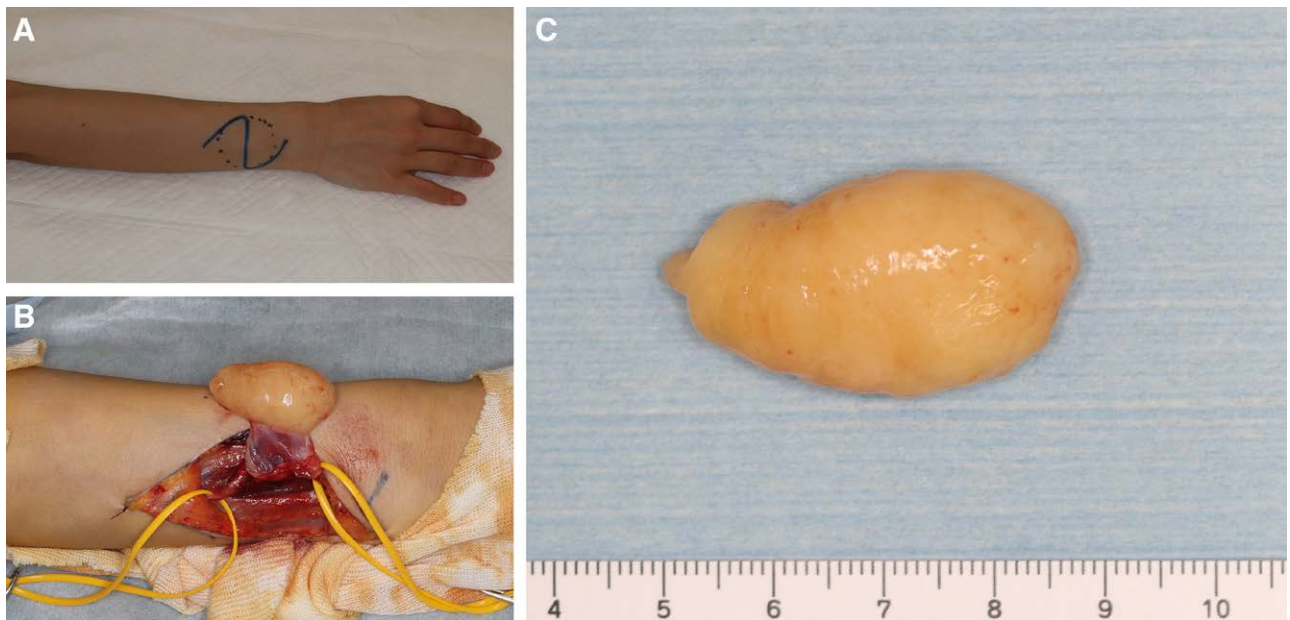


Fig. 4. Case 7. Preoperative and intraoperative images. A, The black dotted line on the forearm was the extent of the tumor, and the blue line was the location of the planned skin incision before performing surgery. B, Only the tumor capsule was bluntly dissected to achieve total removal of the tumor. C, Excised schwannoma (size: 3.5 × 2 cm).

Surgical Techniques for Schwannoma Removal

The surgical methods available are as follows: (1) total removal with healthy nerve fascicles, (2) enucleation or subcapsular removal, and (3) intercapsular resection (ie, total removal of the tumor between the healthy nerve capsule and the true tumor capsule).^{7,13,14} When the nerve of origin is fully removed, it can result in loss of neuronal functions as both ends are dissected and removed. Further, enucleation is similar to subtotal resection because, in this

procedure, only the tumor mass is within the tumor capsule, leaving the capsule of the tumor body. Conversely, intercapsular resection enables total tumor removal while preserving neuronal functions.^{6-9,13}

The intercapsular resection technique is established because schwannomas originate from Schwann cells and, thus, from only a single nerve fiber within the perineurium.^{6,7} Therefore, the tumor is not connected to the surrounding nerve fibers or nerve fibers within other

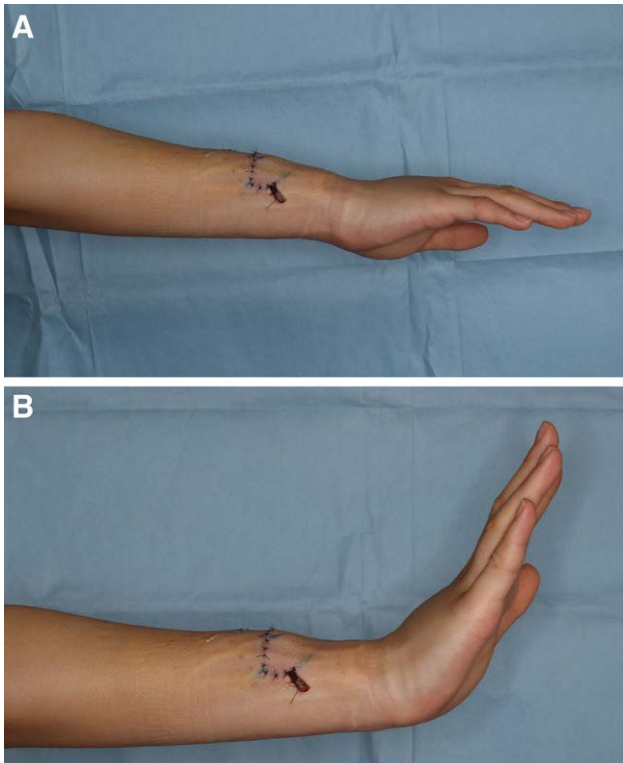


Fig. 5. Case 7. Finger movement on postoperative day 3 after removal of the schwannoma within the posterior interosseous nerve. A, No paralysis of the radial nerve. B, No drop finger noted.



Fig. 6. Case 7. Postoperative photograph 1 year after surgery. No recurrence, and the surgical wound is not noticeable.

perineuriums, allowing total removal without severing the nerves. In intercapsular resection, the true tumor capsule is confirmed, and only the tumor is removed en bloc outside of the capsule. However, nerves that are stretched within the tumor capsule by tumor compression may be damaged even by minor surgical techniques. Consequently, there is still a possibility of nerve stress and dysfunction with this method.⁹ Notably, in the present study, we removed only the tumor from the nerve of origin using only 2 Freer dissectors. This technique had 2 advantages. First, it allowed the surgeon to strip off the area surrounding the tumor, much like peeling the thin

skins of an onion, without having to hold the nerve fibers with micro forceps or other instruments during separation. Second, the wide tips of the Freer dissectors allowed the surgeon to efficiently strip off the tumor while applying a consistent surface force, even in a narrow surgical field. Briefly, this technique allows the surgeon to separate the tumor from the normal nerve atraumatically.

During the separation procedure, it is particularly critical to confirm the tumor capsule and separation layer. If the surgeon inaccurately selects the layer to be separated, other nerve fascicles may be seen in the separated layers, leading to the incorrect belief that nerve fibers are integrated into the tumor.^{9,13} In such cases, multiple layers before the tumor capsule should be reconfirmed, and the layer to be separated should be changed as needed.^{7,9}

Postoperative Neurological Outcomes and Surgical Considerations

According to some reports, the persistence rate of neurological symptoms after schwannoma surgery (at the final observation) is 6%–56%.^{14,15} However, none of our patients exhibited symptoms persisting for more than 1 year after surgery. The factors related to the incidence of postoperative neurological symptoms include the pathological tissue type (Antoni A), the presence of Tinel sign preoperatively, nerves of origin (close to the proximal part of the body trunk), and tumor size (≥ 25 mm, as measured by MRI).^{16–18} In particular, one of the major factors related to the occurrence of postoperative neurological symptoms is reported to be pressure and pulling forces applied to healthy nerve fascicles during tumor excision.^{16,19,20} Specifically, the separation procedure during surgery is crucial. By protecting healthy nerve fascicles as much as possible, the surgeon can minimize the occurrence of neurological damage.^{6–9,14} In our patients, during the operation, the surgeon ensured that healthy nerve fascicles were accurately identified and was always careful not to pull or press these nerves when using the Freer dissectors strongly. Furthermore, by protecting the healthy nerve fascicles as much as possible using the 2 Freer dissectors, the surgeon minimized the incidence of neurological damage, thereby contributing to favorable postoperative outcomes. Because schwannoma is a benign tumor, the primary objective of treatment is to improve preoperative symptoms such as pain and numbness. Therefore, one must be extremely cautious about the occurrence of postoperative neurological deficits and sensory loss. Our technique was proven extremely useful for safely and quickly removing only the tumor without damaging the nerves.

Plexiform schwannomas, which grow in bundles or beads on a single nerve, are likely to be difficult to dissect using our method because they involve normal nerve fascicles in the nerve trunk. Because a preoperative MRI scan can determine whether a tumor is a plexiform schwannoma or not, if dissection is difficult, it is necessary to switch to enucleation, in which the capsule of the tumor is incised and only the tumor parenchyma is removed as a single mass. However, we have no experience with plexiform schwannoma, so we cannot describe it in detail here.

CONCLUSIONS

Depending on the surgical technique used for the removal of schwannoma, some patients may experience neurological deficits and significantly reduced quality of life postoperatively. We performed intercapsular resection using only 2 Freer dissectors. This technique allowed the surgeon to perform operations in a more atraumatic manner, resulting in no neurological deficits. Our technique contributed to a postoperative improvement in the quality of life by relieving pain and numbness in the patients.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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