



## Case Report

# Clavicular window for brachial plexus schwannoma removal

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## ABSTRACT

**Background:** Schwannomas are benign nerve sheath tumors that can either be sporadic or part of neurofibromatosis type 2 (NF2). Tumors of the brachial plexus (BP) with both supra- and infraclavicular components are uncommon and represent a challenge to complete surgical resection. There are few reports on single clavicular osteotomies for BP exposure; however, there are currently no reports of utilization of a clavicular window for a large schwannoma resection.

**Case Description:** We report a case of a patient with a schwannoma spanning the BP roots to the cords, with the majority involving the retro clavicular inferior trunk in the setting of NF2. The patient underwent previous subtotal resection and had postoperative enlargement of the residual mass. A gross total resection was made possible by the creation of a clavicular window to expose the BP. A 2 cm segment piece of the mid-clavicle was removed, allowing for roughly 6 cm of mediolateral exposure through clavicular distraction. This clavicular window facilitated complete exposure of the BP schwannoma underneath the clavicle as well as unobstructed exposure of supraclavicular and infraclavicular tumor. The segment was then refixed with a plate after resection of the tumor.

**Conclusion:** The use of a clavicular window allowed for extensive exposure of the trunks and divisions of the BP to achieve a gross total resection in this case. The clavicular window approach may provide a benefit for optimizing exposure in the setting of lesions involving the trunks and divisions that the clavicle would traditionally obstruct.

**Keywords:** Brachial plexus, Clavicle window, Neurilemmoma, Neurofibromatosis, Schwannoma

## INTRODUCTION

Schwannomas, or neurilemmomas, are the most common tumors of nerves. They arise from Schwann cells, which form myelin and aid in axonal recovery and regeneration in the event of damage. Schwannomas are benign tumors that are painless and slowly growing, often presenting as a palpable mass with minimal sensory or motor symptoms.<sup>[7]</sup> Roughly 19% of all schwannomas are found in the upper extremities<sup>[11]</sup>, and of those, 5% occur in the brachial plexus (BP).<sup>[9]</sup> The mainstay treatment of a symptomatic schwannoma is surgical excision; however, surgical access to certain anatomical locations may be difficult or limited. Retroclavicular access is particularly difficult due to the obstruction of the clavicular bone. Previous surgical approaches to expose the BP to manage traumatic injury or tumor resection have been described involving the creation of a supraclavicular window to expose the plexus roots and trunks and an infraclavicular window that runs parallel to the inferior border of the clavicle to expose the cords and terminal branches.<sup>[13,14]</sup>

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Typically, clavicular osteotomy without block resection is used to access the plexus divisions that run retroclavicularly.<sup>[13,14]</sup> In pediatric literature, the clavicular suspension has been described to provide exposure of the retroclavicular plexus from superior traction and elevation of the clavicle with umbilical tape wrapped around the clavicular bone.<sup>[12]</sup>

## CASE DESCRIPTION

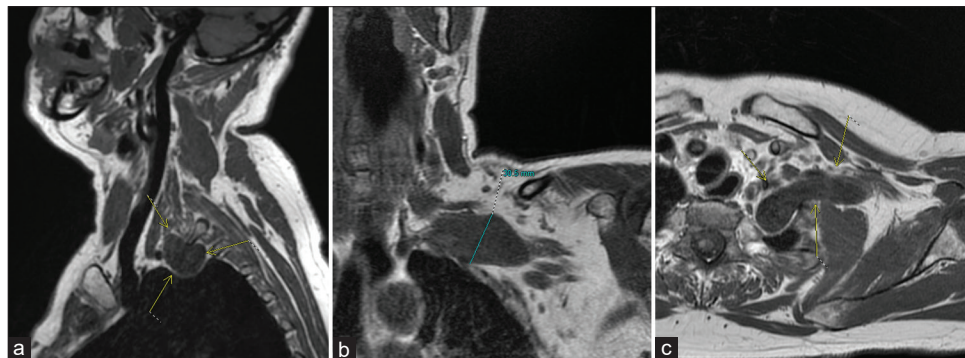
### Background

A 48-year-old female presented with recurrent schwannoma to the left BP. She has a history of neurofibromatosis type 2 (NF2) with vestibular schwannomas, multiple intracranial meningiomas, and spinal foraminal schwannomas. She underwent multiple schwannoma excisions, meningioma resections, and radiation therapy to her vestibular schwannomas. She established care with our team at 42 years old and presented with a left supraclavicular mass associated with neck pain that radiated down her lateral arm. Other symptoms included numbness, tingling, and coldness in her fingers. Physical examination was significant for positive Tinel's sign at the mass and decreased sensation in the C8 distribution. Magnetic resonance imaging (MRI) confirmed a left lower trunk contrast-enhancing mass. She underwent subtotal resection one year after establishing care, and surgical pathology confirmed a schwannoma (the World Health Organization grade 1). The mass located underneath the clavicle was left due to limited visualization in the operative field despite supra and infraclavicular approaches. She had a slow postoperative recovery, which ultimately resulted in nearly full grip strength and functionality but continued decreased sensation at her middle finger. Nearly five years after her initial surgery, she noticed the slow recurrence of radiating pain by her left clavicle throughout her left upper extremity. Follow-up MRI revealed an interval increase in the size of the residual tumor to 65 cm × 31 cm × 27 cm [Figures 1a-c] spanning the C7–T1 nerve roots to the inferior trunk of the

BP. Due to the location of the schwannoma and recurrence, it was decided to do a joint case with orthopedic surgery for clavicular block osteotomy with plate and screw fixation at the end for improved exposure.

### Surgery

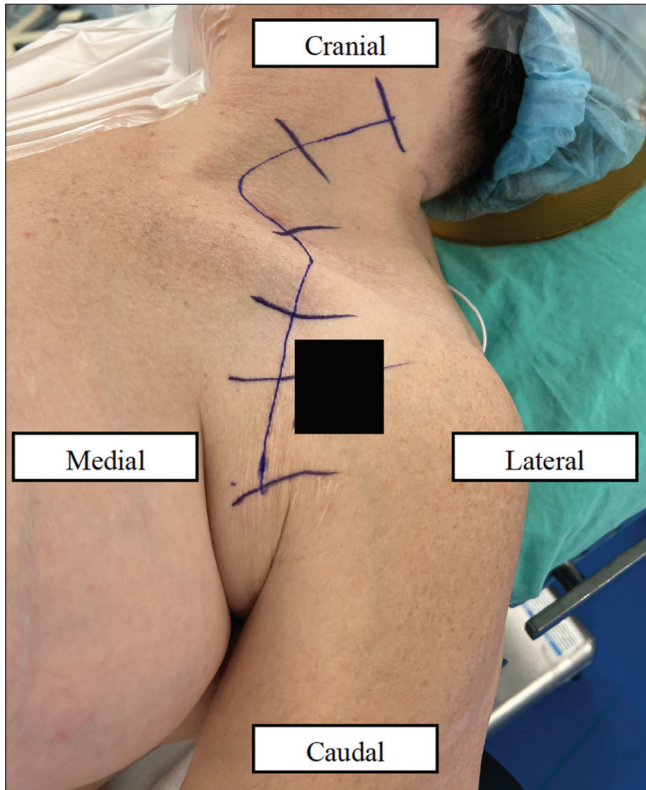
The patient was positioned supine with the head turned to the right under general anesthesia, and a curvilinear incision [Figure 2] was created along the patient's previous scar and extended for supraclavicular and infraclavicular exposure. Initial dissection was completed through scar tissue and platysma until fascia at the clavicle was encountered. At this time, the orthopedic surgery team osteotomized a 2 cm block of the mid-clavicle [Figures 3a and b], creating a window [Figure 3c]. The Deltoid and pectoralis major muscles were retracted superiorly and inferiorly, respectively. The subclavius and pectoralis minor were transected for exposure of the underlying neurovascular structures with embedded scar tissue and schwannoma [Figure 4]. Deep dissection was continued supraclavicularly, going lateral to the sternocleidomastoid and scalene muscles toward deeper structures until the nerves were visualized. The maximal size of exposure allowed for approximately a 6 cm clavicular window when the two clavicular edges were distracted after the 2 cm osteotomy. This created near-total exposure of the tumor in the mediolateral axis. Vessel loops were then used to identify neurovascular structures, and electromyography monitoring was used to identify the BP components [Figure 4]. On further dissection, the lower trunk was identified as well as the anterior division and medial cord. On identification of the schwannoma in the lower trunk, EMG was utilized to determine a safe entry zone and a gross total resection was completed with a predominantly extracapsular approach [Figure 5]. The medial and lateral cords were then exposed, followed by the median and ulnar nerves. A small schwannoma was identified and resected



**Figure 1:** (a-c) Magnetic resonance imaging T1 imaging of the left brachial plexus schwannoma. (a) Sagittal view of the brachial plexus schwannoma with arrows locating the tumor. (b) Coronal view of the schwannoma with maximal height annotated. (c) Axial view of the schwannoma with arrows locating the tumor.



on the median nerve in the standard extracapsular fashion. There was no evidence of bleeding or chyle leak, and an adjunctive hemostatic product was applied to the operative field. Orthopedic surgery colleagues returned to refix the clavicle with a plate and screws [Figure 6]. The osteotomized clavicle segment was coated with a demineralized bone matrix, blood aspirate, and marrow mixture. Soft tissue and skin were closed in a standard fashion.



**Figure 2:** Patient positioning and preoperative marking. Black box covering surgeon initials for preoperative site marking.

### Postoperative course

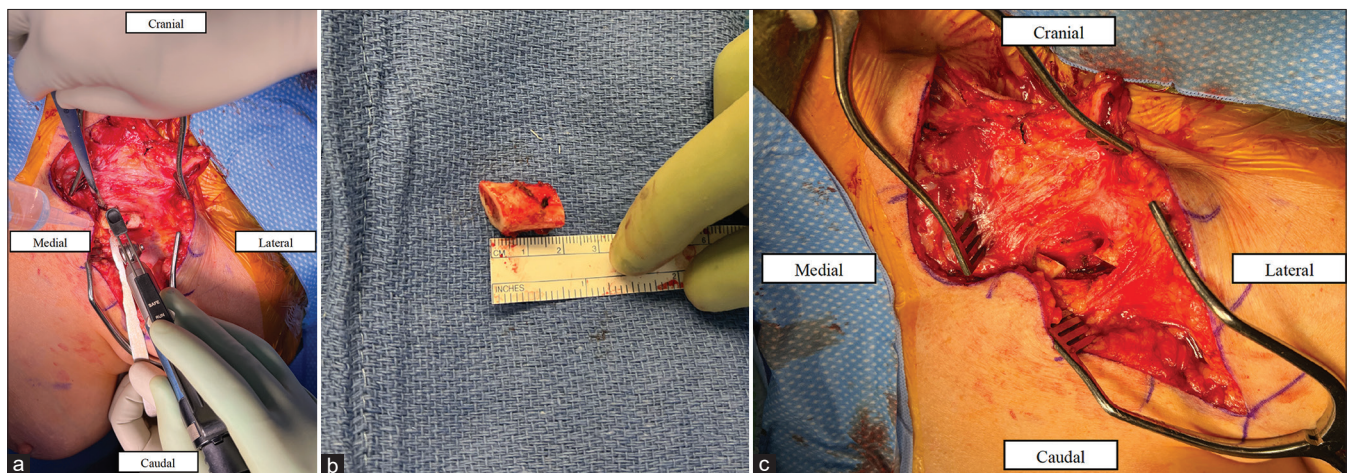
The patient was seen three months postoperatively with the resolution of her left arm pain. She had residual weakness of finger abduction but was able to use her arm functionally. Her clavicle healed without complication. Postoperative imaging revealed successful resection of the mass.

### DISCUSSION

In this case report, a patient with NF2 disease underwent initial debulking of a BP schwannoma with symptomatic recurrence five years later. According to a spinal schwannoma study by Fehlings *et al.*, recurrence after surgery is approximately 5% and occurs several years after resection.<sup>[5]</sup> In addition, patients who have NF2 have a higher recurrence rate of spinal schwannomas. Risk factors for recurrence include subtotal intralesional resection, younger age, and large size.<sup>[5,10]</sup> The likely cause of recurrence in this patient is the history of NF2 and subtotal resection at the initial surgery due to the clavicle obstructing the surgeon's view.

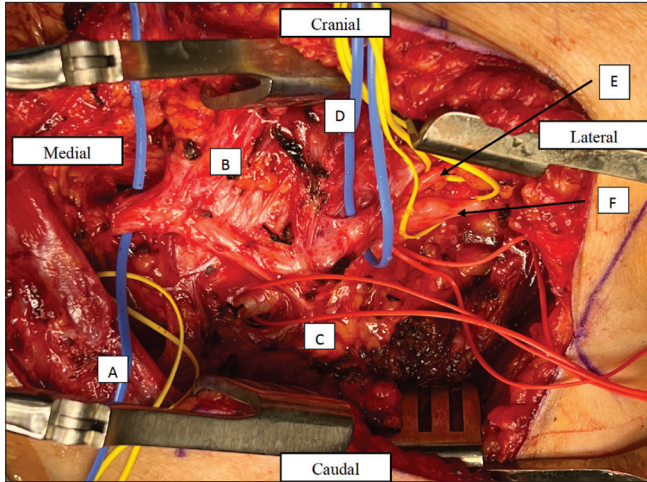
The clavicle is a bone that allows for a full shoulder range of motion while protecting the BP and large vascular structures such as the subclavian artery and vein.<sup>[8]</sup> Clavicular osteotomies for BP access have been internationally described in German and French literature.<sup>[2,3]</sup> Technique papers by Thatte *et al.* in India and Zadnik *et al.* in Baltimore, Maryland, describe the use of a single clavicular osteotomy<sup>[13,14]</sup> with clavicular bone rotational retraction for BP exposure and refixation as opposed to taking out a clavicular block as described in our case. These reports, however, were described among patients undergoing operative management of a traumatic BP injury rather than a nerve sheath tumor.

When a single osteotomy is utilized to transect the clavicle, exposure is limited by the ability to retract the two clavicular segments medially and laterally. That distance is also mitigated

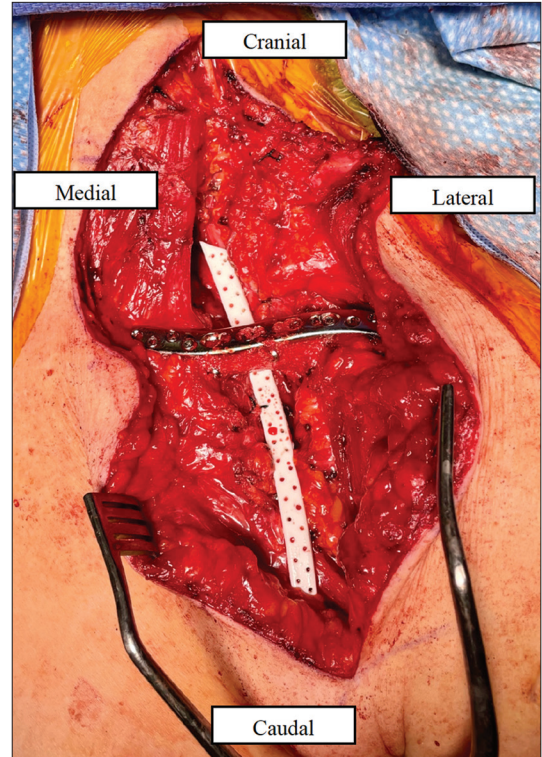


**Figure 3:** (a-c) Clavicular osteotomy with orthopedic surgery. (a) Mid-clavicular osteotomy. (b) Resected mid-clavicular segment. (c) Clavicular window to the brachial plexus.

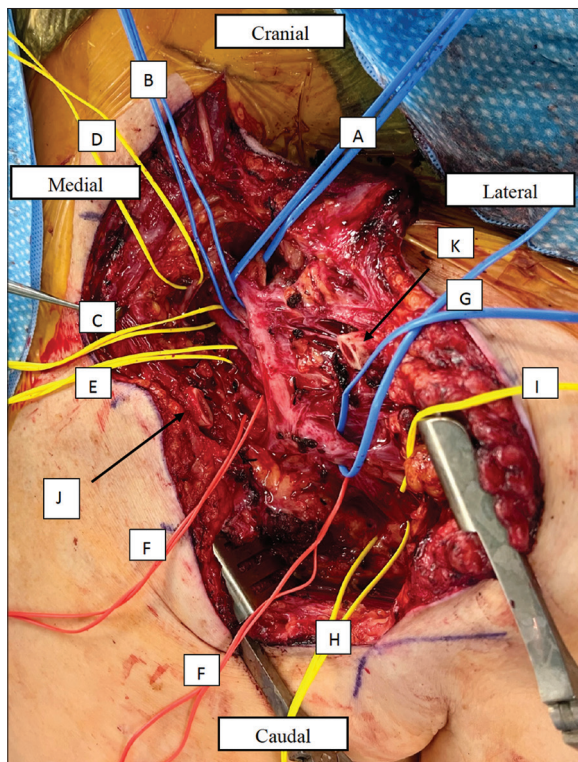




**Figure 4:** Letters corresponding to intraoperative vessel loops. A. Upper trunk; B. Schwannoma and scar tissue; C. Red loops leading to subclavian artery; D. Lateral cord; E. Musculocutaneous nerve; F. Median nerve.



**Figure 6:** Mid-clavicular segment refixated with Synthes plate and demineralized bone matrix, aspirate, and bone marrow mixture. Jackson-Pratt drains are placed deep to the clavicle.



**Figure 5:** Letters corresponding to intraoperative vessel loops. A. Upper trunk; B. Middle trunk; C. Lower trunk, C8 nerve root; D. Phrenic nerve; E. Lower trunk, T1 nerve root; F. Subclavian artery; G. Lateral cord; H. Median nerve; I. Musculocutaneous nerve; J. Medial clavicle; K. Lateral clavicle.

by retaining the full length of the clavicle. Another approach with a single osteotomy is to rotate the two segments out of the operative field. Exposure with this approach is, however, limited by the arch of rotation and the soft-tissue connections

to the clavicle that keep it in place. This type of retraction may also distort the BP anatomy and may increase the risk of injury to the delicate underlying neurovascular structures. The advantage of a clavicular window is better exposure with less need for soft-tissue retraction or rotation.

The clavicular window provides wide exposure to the BP that was successful in this report. Utilizing a clavicular window improved exposure of the distal trunks and their divisions when the clavicle would have otherwise limited access to this region. One theoretical difficulty would be to replace the removed clavicle fragment in the same spot without rotation; this could easily be avoided by preplacing the screw holes before cutting the clavicle. Short-term follow-up with this patient has so far been without complications, but there is still a risk of clavicular non-union, BP neurapraxia from malunion,<sup>[1,4]</sup> and hardware malfunction.<sup>[6]</sup>

Ultimately, the clavicular window allows for extensive BP exposure for total resection of BP tumors that span the length of supraclavicular and infraclavicular components of the BP with significant retroclavicular involvement. Due to bony segment resection, there are less retraction and rotation forces on the surrounding soft tissue that may distort or create traction injury to the BP as compared to if the full length of the clavicle was left in place. The clavicular window

should be considered when the surgical approach requires wide exposure of the retroclavicular BP.

## CONCLUSION

A mid-clavicular window is created by removing a segment of clavicular bone for wide exposure in a case of BP schwannoma with significant retroclavicular involvement. This is a novel method that has not yet been described and may offer a better option for extensive retro clavicular schwannomas or tumors spanning the entire length of the supraclavicular and infraclavicular BP to aid in more complete resection.

## Ethical approval

The Institutional Review Board approval is not required. Patient related content reviewed by institution HIPAA committee.

## Declaration of patient consent

Patient's consent not required as patient's identity is not disclosed or compromised.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

## Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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