All-Endoscopic Resection of an Infraclavicular Brachial Plexus Schwannoma: Surgical Technique

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Abstract: Due to recent progress in shoulder arthroscopy, all-endoscopic brachial plexus (BP) dissection has progressively become a standardized procedure. Based on previously described techniques, we present an additional neurological procedure that may be performed all-endoscopically, that is, the excision of an infraclavicular BP schwannoma. Starting from a standard shoulder arthroscopy with posterior and lateral portals, additional anterior and medial portals are progressively opened outside the joint under endoscopic control to access the BP. At first, dissection of the subcoracoid space allows the identification of the posterior and lateral cords, along with the axillary artery. Then, by performing a pectoralis minor tenotomy, the medial cord and axillary vein are exposed, giving access to the whole infraclavicular plexus. Intraneural dissection is performed using arthroscopic tools such as a long beaver blade, a grasper, and a smooth dissector to progressively extract the encapsulated tumor from the nerve without any damage. Using a standardized technique, endoscopy may be an advantageous tool in selected cases of BP benign peripheral nerve sheath tumors.

Recent progress in shoulder arthroscopy had led several teams to operate outside the glenohumeral joint to perform orthopaedic procedures endoscopically.[1-3] Due to the proximity of the brachial plexus (BP) and its terminal branches, endoscopic surgery in this area may require dissecting these neurological structures to protect them. Subsequently, all-endoscopic neurological procedures have been developed around the shoulder joint.[4,5]

A type benign peripheral nerve sheath tumors (PNSTs), schwannomas are slow-growing tumors with regular margins.[6] While they are the most common peripheral nerve tumors, less than 5% of them arise from the BP.[7] In such cases, an open approach is traditionally used for surgical excision.[8] However, we consider that such encapsulated tumors may be accessible by an endoscopic approach.

The purpose of this report is to describe an additional neurological procedure that may be performed all-endoscopically, that is, the excision of an infraclavicular BP schwannoma.

Surgical Technique

Patient Evaluation

Patient history is crucial and should show evidence of a benign neurological mass lesion, including a non-traumatic, chronic, and insipient onset, associating neurogenic pain, sensation alterations, and/or motion limitations that will inform the physician about the mass localization and guide physical examination.

An inspection should look for muscle atrophy and insensitivity wounds. Palpation may identify a tender, firm, and mobile mass with an irritative pseudo-Tinel sign caused by percussion. Muscle strength is recorded using the British Medical Research Council grading system, along with sensitivity, to locate the lesion within the BP and guide paraclinical exams.

BP magnetic resonance imaging is mandatory to complete clinical assessment and corroborate the diagnosis of benign PNST, as well as to indicate precisely its localization and relationship with surrounding neurovascular elements (Fig 1).

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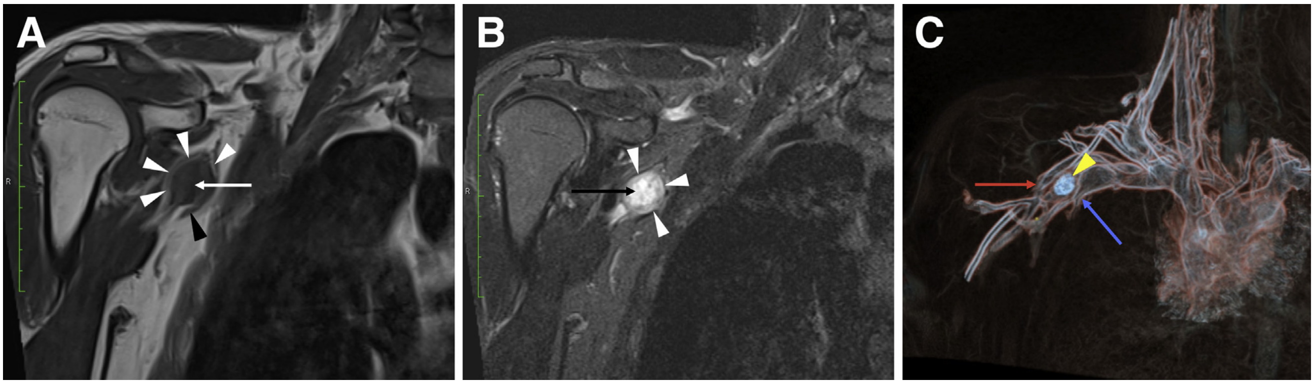

Fig 1. Preoperative magnetic resonance imaging of the lesion. Coronal T1-weighted (A) magnetic resonance image of the right shoulder demonstrates a well-defined encapsulated, hypointense, ovoid lesion (white arrow); located within the medial cord, it preserves its continuity (white arrowheads) and produces a mass effect upon surrounding vascular elements (black arrowheads). Coronal T2-weighted STIR (1B) magnetic resonance image allows the identification of a cystic lesion, with a heterogeneous hyperintense central area (black arrow) surrounded by a vascularized capsule (white arrowheads). Three-dimensional STIR-based reconstruction of the shoulder (C) demonstrates the mass effect of the lesion (yellow arrowhead) upon surrounding vascular elements, with the axillary vein medially (blue arrow) and the axillary artery laterally (red arrow).

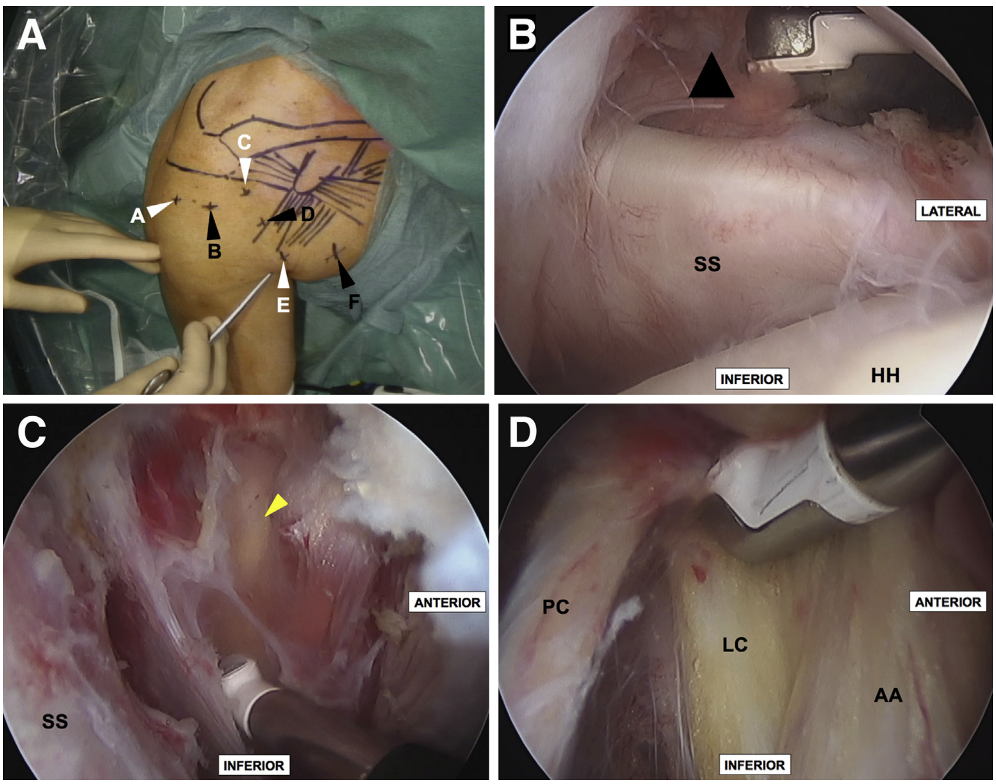

Fig 2. Subcoracoid space dissection of the right shoulder. With the patient in the beach chair position, the whole hemithorax is draped free to allow successive scopic (white arrowheads) and instrumental (black arrowheads) portals (A), at first lateral (A and B), then anterior (C and D), and finally medial (E and F). Starting with a posterior portal for the scope (B) to enter the glenohumeral joint, with the humeral head (HH) lateral and the glenoid medial, the rotator interval is opened (black triangle) above the subscapularis tendon (SS) to proceed outside of the joint. Using lateral and then anterior portals (C) to follow the anterior aspect of the subscapularis tendon (SS), connective tissues are gradually dissected with electrocautery until neurovascular elements are visualized (yellow arrowheads). Further dissection enables the identification of the posterior (PC) and lateral (LC) cords of the brachial plexus, with the axillary artery (AA) anterior (D).

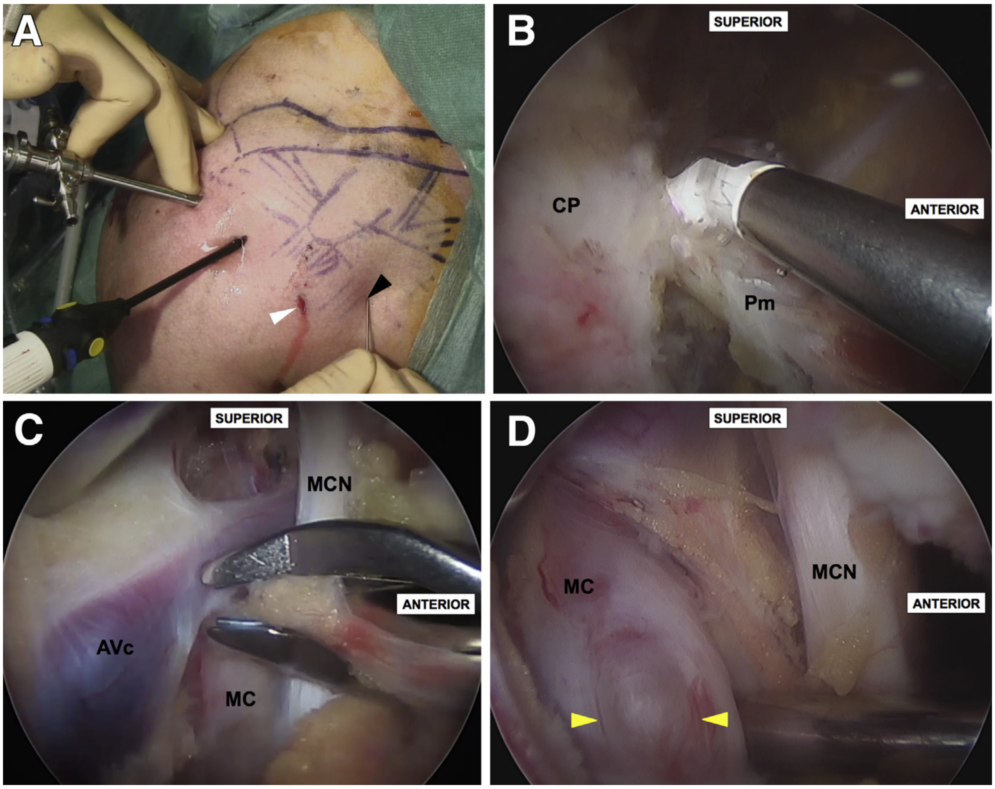

Fig 3. Accessing the medial cord of the right shoulder. With the patient in the beach chair position, medial portals are created through anterior portals for the scope (white arrowhead, facing the tip of the coracoid process) and instruments (black arrowhead, 2 cm medial to the first) under endoscopic control (A). Then, using these medial portals, the first step is the tenotomy of the pectoralis minor (Pm), detached from the coracoid process (CP) tip (B). Then ligatures of collateral veins from the axillary vein (AVc) are performed using vascular clips (C) to properly expose the medial cord (MC), with the musculocutaneous nerve (MCN) retracted anteriorly. A smooth probe is used to identify the lesion within the cord (yellow arrowheads) and guide intraneural dissection (D).

Patient Preparation

Under general anesthesia, the patient is set up in the beach chair position with gentle anteroinferior traction applied on the arm using a simple device such as a rope and a vertical pole attached to the table; the neck, upper limb, and ipsilateral hemithorax are draped free, so that conversion to an open approach remains possible at all times.

Subcoracoid Space Dissection

First a standard shoulder arthroscopy posterior portal is created for the scope to safely start the dissection from an anatomic cavity, that is, the glenohumeral joint (Video 1) (Fig 2).

As previously described by Lafosse et al.,[1] infraclavicular BP dissection starts with the exposition of the subcoracoid space to identify the axillary and radial nerves, which will allow the localization of BP cords and the axillary artery. Two subacromial lateral portals are created (Fig 2A), 2 cm distal to the middle of the acromion lateral border and 2 cm distal to the acromion anterior angle, respectively. They are successively used to open the rotator interval with the radiofrequency probe (Fig 2B) and create 2 anterior portals in the axis of the acromioclavicular joint, one proximal to the scope and the other 2 cm distal to the instruments; since they allow access outside of the glenohumeral joint, these portals need to be opened under endoscopic

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Progressive dissection is needed to visualize the whole brachial plexus, starting lateral to the glenohumeral joint, then anterior, and finally medial.	Dissection difficulties in overweight people with short necks.
Dissect cords and branches from proximal to distal, performing superoinferior gentle traction motions using the radiofrequency probe.	Soft tissue adhesions due to previous surgeries.
Cautious and progressive dissection between perineural veins, using vascular clips when required.	Improper hemostasis during tumor exposition.
Intraneural dissection is a 2-step procedure: open the tumor sheath using a beaver blade and then extract the tumor using a grasper and blunt instruments.	Excessive anteroposterior traction during tumor removal producing shear forces within neural tissue.
	Local recurrence because of incomplete removal.

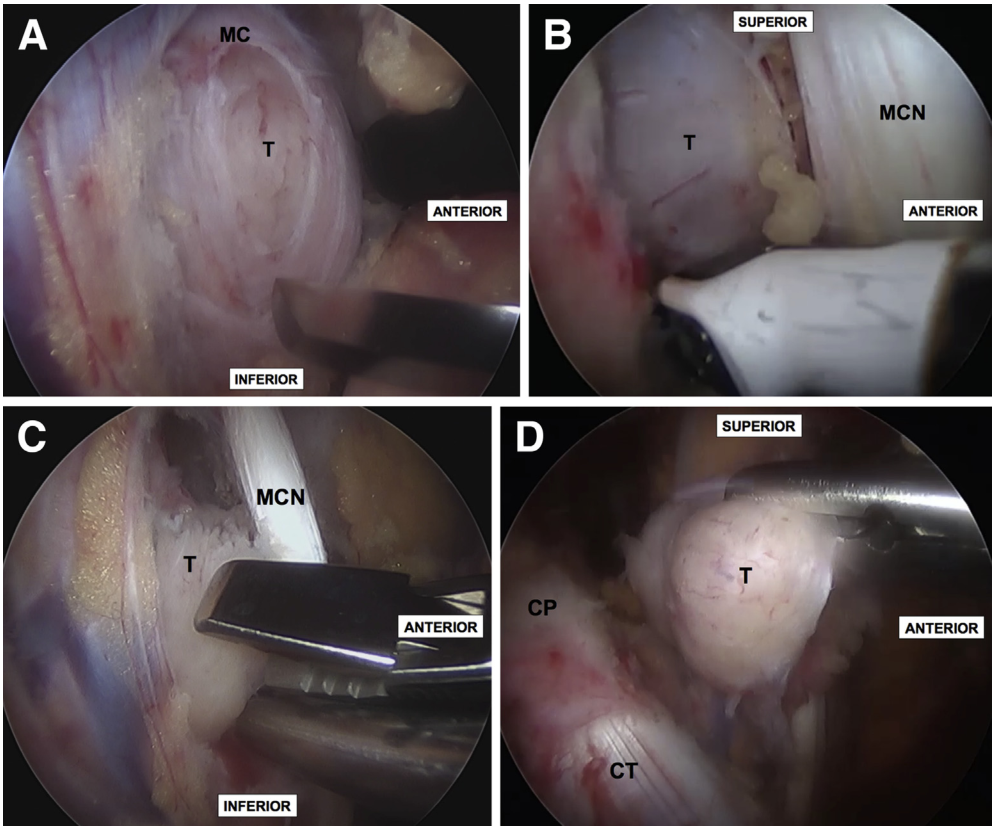

Fig 4. Arthroscopic dissection of the intraneural mass of the right shoulder. With the patient in the beach chair position, using the medial portals, a longitudinal incision of the medial cord (MC) is performed with a long beaver blade (A) to expose the tumor (B). Arthroscopic grasper and smooth dissector are successively used to dissect the tumor (T) away from the cord (C) and remove it through the instrumental portal (D). (CP, coracoid process; CT, conjoint tendon; MCN, musculocutaneous nerve).

magnification using a tracking needle. After opening the clavipectoralis fascia, the subscapularis tendon anterior aspect is followed underneath the coracoid process. Precautious soft tissue dissection with the radiofrequency probe allows the surgeon to progressively identify the axillary and radial nerves (Fig 2C) and follow them proximally, up to the posterior cord. Once the posterior cord is identified, the distal part of both the lateral cord and the axillary artery may be dissected as well through these anterior portals (Fig 2D); however, complete visualization of the BP will require the release of the pectoralis minor.

The dissection is continued, anteriorly to the coracoid process and the conjoint tendon, to enlarge the retropectoral space, between the coracoid process posteriorly and the pectoralis major anteriorly, using a smooth trocar (Depuy Mitek, Zuckwil, Switzerland) and the radiofrequency probe.

Pectoralis Minor Tenotomy

Medial portals are then created under endoscopic control, with 1 for the scope about 4 cm below the coracoid process tip and the second, instrumental, 2 cm medial to the first (Fig 3A). The upper and lower borders of the pectoralis minor tendon are exposed along with the limit between the conjoint tendon and the pectoralis minor tendon. With the cords visualized proximally and the musculocutaneous nerve distally, the pectoralis minor tendon is released from the coracoid process so that the infraclavicular BP can be fully exposed (Fig 3B). In case of a more proximal tumoral localization, one can even carry on with the dissection by detaching the subclavian muscle from the clavicle, which gives access to the supraclavicular plexus.[1]

Once the infraclavicular BP exposition is complete, radiofrequency is used to identify and separate the different cords (Table 1). Accessory venous branches of the axillary vein may stand in the way to the medial cord, and vascular clips must be used to perform a satisfactory hemostasis (Fig 3C). With the axillary artery retracted laterally and the medial along with the medial cord retracted anteriorly, the tumor can be identified within the cord using an endoscopic probe (Depuy Mitek; Fig 3D).

Intraneural Dissection

The nerve sheath is then opened using a long beaver blade (Depuy Mitek) to expose the tumor (Fig 4 A and B). The arthroscopic grasper and dissector are used to remove the mass (Depuy Mitek), combining movements of traction and smooth dissection (Fig 4C). When completely detached, the tumor is extracted through the instrumental portal and sent to pathology for

Table 2. Advantages and Risks of the Technique

Advantages	Risks
Complete brachial plexus dissection with minimal perineural scarring tissue.	Open conversion in case of neurovascular injury.
Low infection risk.	Incomplete mass removal.
Facilitated dissection due to scope magnification and water hyperpressure.	Difficult tumor localization using probe palpation.
Cosmetically pleasing.	Glenohumeral joint scarring tissue.

analysis, to confirm its benign nature and its complete removal (Fig 4D).

Postoperative Care

The patient is discharged the day after surgery to look for any postoperative early complication such as hematoma or neurological deficit. No immobilization is needed, and immediate mobilization is allowed along with daily living activities; return to physical activity is authorized 15 days after surgery once the incisions are healed.

Discussion

This is a description of an all-endoscopic resection technique of a benign PSNT affecting the BP medial cord.

Despite numerous and well-known benefits (e.g., satisfactory visualization due to scope magnification, facilitated dissection due to water hyperpressure, less morbidity than open approaches,[9,10] less cost than robotic surgery,[9,11] possibility of intraoperative conversion to an open approach), few applications of endoscopy have been outlined in BP surgery (Table 2).[12,13] Lafosse et al.[4,5,14] previously reported on its usefulness in suprascapular neuropathy and idiopathic neurogenic thoracic outlet syndromes.

In our opinion, the main shortcoming of this technique is the learning curve, since expert arthroscopic skills are required to prevent any iatrogenic neurovascular injury. In fact, because a clean section of the cord is unlikely as long as the operator keeps the beaver blade parallel to the nerve axis while opening the tumor sheath, stretching injuries during dissection and/or tumor removal and overheating lesions due to extended use radiofrequency may occur.

Another controversy may lie in the nature of tumoral surgery. In fact, thorough preoperative assessments, both clinical and radiographic, must be conducted to preoperatively ascertain the benign nature of the tumor.

In our experience, this technique appears to be safe and reproducible provided that the operator feels confident about arthroscopic dissection outside the glenohumeral joint and that the tumor to be extracted is encapsulated and its relationship to the neurovascular surrounding structures is well defined preoperatively.

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