All-Endoscopic Brachial Plexus Complete Neurolysis for Idiopathic Neurogenic Thoracic Outlet Syndrome: A Prospective Case Series

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Purpose: To describe an all-endoscopic technique for infra- and supraclavicular brachial plexus (BP) neurolysis and to assess its functional outcomes for patients suffering from nonspecific neurogenic thoracic outlet syndrome (NTOS). **Methods:** Between January 2010 and January 2013, 36 patients presenting an idiopathic nonspecific NTOS benefited from an endoscopic decompression in our institution. The inclusion criteria were a typical clinical NTOS and failure of a 6-month well-conducted nonsurgical treatment. Preoperative findings about other shoulder conditions and complementary procedures were exclusion criteria. Interscalene, costoclavicular, and retropectoralis minor spaces were released endoscopically. The primary endpoint was the Disability of the Arm, Shoulder and Hand (DASH) score improvement 6 months after the surgery. Postoperative criteria such as pain relief, paresthesia, upper limb weakness, and provocative tests were also assessed. **Results:** Of 36 patients, 10 were excluded and 5 were lost during follow-up. The data of the 21 remaining patients were analyzed after 6 months. Pre- and postoperative mean DASH scores were, respectively, 70 (range 36-98) and 34 (range 2-91). The average improvement was 36 (range −20 to 80), with $P = .0002$. Pain and paresthesia were relieved in 80% to 90% of the cases. No complication was reported. **Conclusions:** Although requiring arthroscopic skills and expert knowledge of the anatomy, our technique seems to be safe and reproducible, and it provides significant functional improvements in the selected patients with nonspecific NTOS, with an average postoperative DASH score improvement of 36%. **Level of Evidence:** Level IV, therapeutic case series.

The neurogenic thoracic outlet syndrome (NTOS) is an uncommon condition affecting primarily young and healthy patients, caused by a compression of the brachial plexus (BP). Two different types can be identified, the *true* and the *disputed*.[1] Described by Gilliat et al.[2] in 1970, the true NTOS is a very rare condition defined by a compression of the BP lower trunk caused by a congenital fibrous band, stretched from an elongated C7 transverse process to the first rib, accountable for a clinical and paraclinical objective neurologic deficit in the lower trunk territory. Responsible for more than 90% of all TOS, the disputed, or nonspecific, NTOS is a more controversial entity, because of the common lack of anatomic, clinical, or electrophysiological objective evidence.[3] In this presentation, the entrapment, congenital or acquired, can occur at different levels: through the interscalene triangle, the costoclavicular space, and/or beneath the pectoralis minor (PM) muscle.[1] The symptoms of BP compression are characterized by pain, numbness, and paresthesia in the neck area and the upper limb, with irradiations from the occipital area to the chest wall.[4] Clinical examination can show an irritative syndrome, with a pseudo-Tinel sign after percussion around the coracoid process, along with a reproducible exacerbation during provocative maneuver by the hyperabduction and external rotation of the arm (Wright test).[5] Identified causes of disputed NTOS are mainly posttraumatic compressions of the BP, resulting from macro-trauma of this area, with fractures (clavicle, scapula, or rib) and high-velocity direct impacts (car accident, falling down the stairs, slipping on floors or ice), or microtrauma, described in patients with repetitive work-related stress

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The authors report the following potential conflicts of interest or sources of funding: L.L. reports grants, personal fees, and non-financial support from DePuy Mitek and other from OrthoSpace, outside the submitted work.

Received September 8, 2016; accepted January 30, 2017.

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0749-8063/16486/$36.00

http://dx.doi.org/10.1016/j.arthro.2017.01.050

injuries (assembly lines, typing). In most of the cases, however, the etiology remains unknown. Therefore, despite a rich literature, the treatment is still controversial. The options range from conservative treatment with physical therapy, patient education, and pain medication to surgical alternatives, including PM tenotomy, scalenectomy, and first rib resection.[1,6-8] Recent studies focused particularly on the BP entrapment beneath the coracoid process and the PM tendon, highlighting the neurogenic pectoralis minor syndrome (NPMS) as a major factor in NTOS and showing that isolated PM tenotomy achieves similar efficiency as scalenectomy and first rib resection, for selected patients with NPMS.[8-10]

At the same time, recent progress in shoulder arthroscopy has led us to operate outside of the glenohumeral joint cavity, around the terminal branches of both the infraclavicular and the supraclavicular BP, to perform endoscopic procedures, such as the Latarjet technique, suprascapular nerve (SSN) release, or subscapularis tendon repair.[11-15] Because of the proximity of these branches, endoscopic surgery in this area requires a perfect BP visualization to prevent any iatrogenic neurologic impairment.[16-19] Therefore, to avoid BP injuries, we became accustomed to approach and release it endoscopically in our current practice.[20,21] Moreover, in 2015, Lafosse et al.[22] published an anatomic feasibility study for arthroscopic BP complete neurolysis. Based on the facts that disputed idiopathic NTOS surgical management remains uncertain because of the unknown localization of the entrapment, and that arthroscopic neurolysis of the entire BP is feasible, both supra- and infraclavicular, an all-endoscopic treatment for NTOS was developed.

The purpose of our study was to describe an all-endoscopic technique for infra- and supraclavicular BP neurolysis and to assess its functional outcomes for patients suffering from nonspecific NTOS. Our hypothesis was that it was possible to use an all-endoscopic approach to dissect the BP safely and widely, starting distally from the glenohumeral joint to rule out any differential diagnosis, and perform an efficient decompression in NTOS cases.

Methods

Patient Selection

This study was approved by our Institutional Review Board, and informed consent was obtained from all the patients included in the study. Between January 2010 and January 2013, we performed a single-center prospective case series. Thirty-six patients consulting for idiopathic NTOS with a surgical indication for BP release were included and evaluated pre- and postoperatively. The inclusion criteria were a typical clinical presentation of NTOS, unsuccessful well-conducted conservative medical treatment with persistence of the symptoms for at least 6 months. Preoperative exclusion criteria were evidence of vascular TOS such as pallor, coolness, and diminished pulse for arterial TOS or heaviness, edema, and cyanosis for venous TOS; evidence of nerve entrapment outside of the thoracic outlet, proximally by the cervical spine or distally to the axillary space (medial epicondyle, pronator tunnel, radial tunnel, carpal tunnel); an identified traumatic etiology (clavicle fractures mainly); and a history of ipsilateral shoulder surgery. Patients were also excluded after the surgery if complementary surgical procedures were performed along with the endoscopic BP release, or if intra-articular conditions that might simulate NTOS symptoms were found during the arthroscopic exploration, such as glenohumeral osteoarthritis or instability, producing shoulder pain or weakness.

The typical clinical presentation was the triad of pain, paresthesia, and weakness in the neck and the upper limb, associated with positive provocative maneuvers. Pain, described by the patient, was any form of pain, including soreness or tenderness. It was located mostly in the posterior triangle of the neck, in the trapezius area, and more distally in the chest wall over the PM tendon, but it could also radiate in the axilla, shoulder, upper arm, elbow, forearm, and hand. Paresthesias were located primarily in the fourth and fifth fingers, even if, less frequently, all 5 fingers could be involved, or even the first 3 fingers alone. Weakness usually appeared after several months and corresponded to the patient's report of dropping things from the hand, or a difficulty in gripping objects. The provocative maneuvers we ran were the percussion in the coracoid area looking for a pseudo-Tinel sign, the external rotation and hyper abduction stretch test, and also the SSN test. The Wright test would trigger or enhance the symptoms, whereas the SSN test would reproduce the pain in the territory innervated by the SSN, with is a contralateral rotation of the head concomitant to a retropulsion of the shoulder.[14]

Conservative treatment included physical therapy, patient education, and pain medication. During rehabilitation sessions, the primary targeted muscles were the scalene and the PM muscles, with stretching exercises of both. Postural education and activity modifications were taught to the patients, and pain medication was used depending on the type of pain (nociceptive and/or neuropathic).[6] Conservative treatment failure was considered if the patient noted no improvement after 6 months, regardless of serious attendance to the rehabilitation sessions attested by the therapist.

To confirm idiopathic NTOS, every patient underwent clinical and radiographic cervical spine examination to rule out bone abnormalities, electromyographic study to eliminate distal sites of nerve entrapment, and a dynamic Doppler examination to eliminate vascular

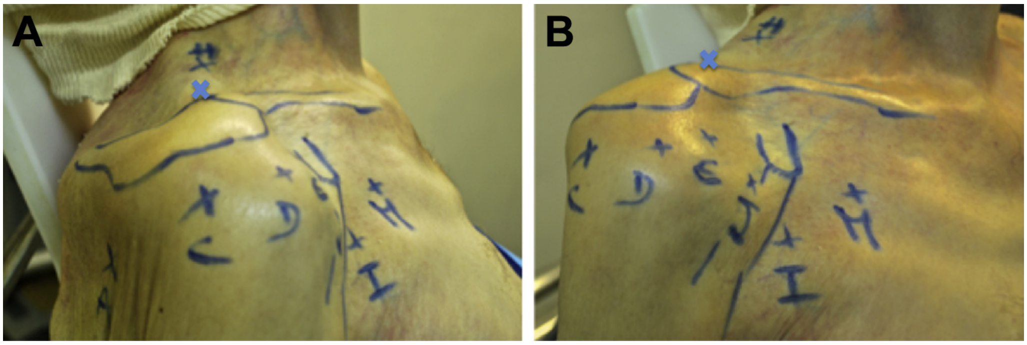

Fig 1. Lateral (A) and anterior (B) views of the cutaneous drawings of the shoulder surface anatomy and portals' location, right side. Supraclavicular portals: C (lateral), D (anterolateral), TT1 (transtrapezial 1, lateral—appended), and TT2 (transtrapezial 2, medial); infraclavicular portals: E (anterior), I (coracoid axis), J (I-E middistance), and M (medial). (A, posterior portal for articular assessment.)

involvement. Doppler examination of the subclavian and axillary vascular bundles was performed in 3 different positions—first at rest, second in an abducted and externally rotated arm position, and finally with a 1-kg inferior traction of the arm, maintained against the torso. Computed tomographic or magnetic resonance angiographies were realized only if clinical or Doppler evidence of vascular involvement were found. Magnetic resonance imaging of the shoulder was also routinely performed for preoperative assessment.

Surgical Technique

The same senior surgeon (L.L.) performed every case, using always the same BP dissection technique, described in 2015 by Lafosse et al.[22] in an anatomic study. The patients were set up in a beach chair position and operated on under general anesthesia, combined with an interscalene locoregional anesthesia. The whole upper extremity was draped free; 1 assistant was holding and manipulating the arm. Every case benefited in the first place from an arthroscopic exploration of the glenohumeral joint to identify any intra-articular condition (rotator cuff tear, capsulolabral lesions, osteoarthritis) that may be accountable for NTOS-like symptoms (shoulder pain, weakness) or need a complementary procedure.

We used 8 endoscopic approaches, 4 supraclavicular and 4 infraclavicular (Fig 1). The supraclavicular portals were 2 subacromial and 2 transtrapezial portals. The C and D portals were subacromial, respectively, lateral and anterolateral. The transtrapezial portals were lateral (transtrapezial 1 [TT1]) and medial (transtrapezial 2 [TT2]), both located 2.5 centimeters posteriorly from the upper border of the trapezius. The TT1 portal was at the level of the suprascapular notch, created under endoscopic control from the C and D portals. The TT2 portal was at the level of the middle of the clavicle, created under endoscopic control from the D and LT portals. The portals E, I, J, and M were infraclavicular. The E portal was anterior, 2 cm ahead of the acromioclavicular joint, facing the rotator interval. The I portal was in the axis of the coracoid process and faced it, 2 to 3 cm below. The J portal was at middistance from the I and E portals. The M portal was 4 cm anterior to the clavicle and 3 cm medial to the coracoid process.

The first step was to release the supraclavicular BP, starting with the SSN, using the technique previously described by Lafosse et al.[15] The C portal was used for visualization and the other supraclavicular portals for instrumentation. The anterior border of the supraspinatus muscle was followed until the coracoclavicular

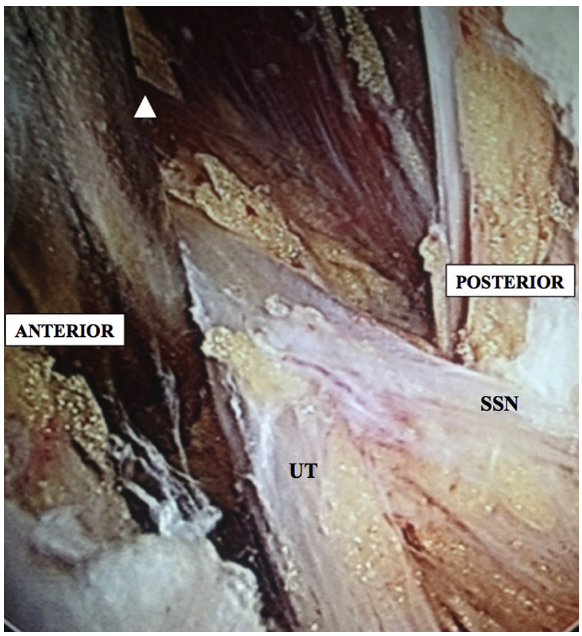

Fig 2. Endoscopic decompression of the brachial plexus (trunks), with the suprascapular nerve (SSN) release and exposition of the upper trunk (UT) exiting from the interscalene triangle (white triangle). Transtrapezial 1 portal, left shoulder.

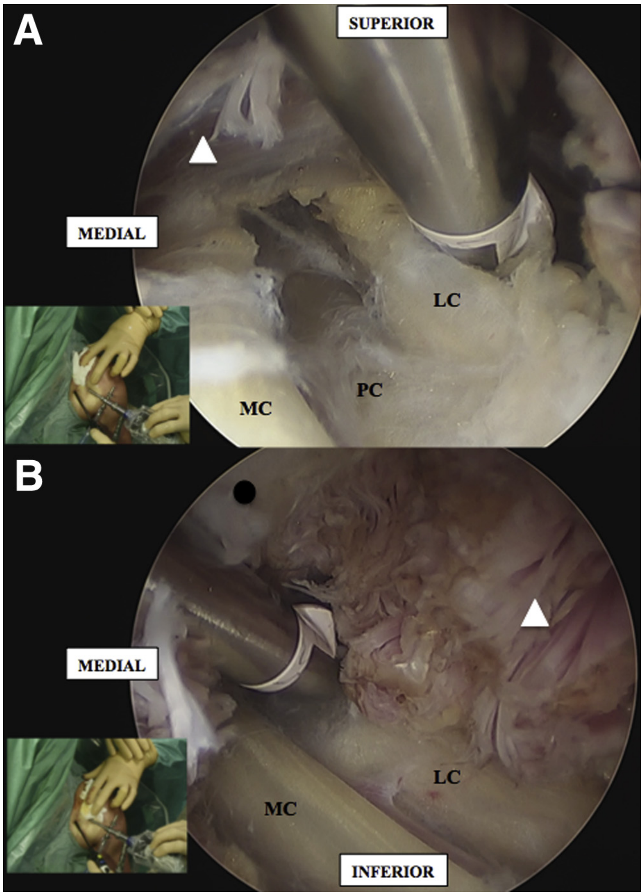

Fig 3. Endoscopic decompression of the BP (cords) through the costoclavicular space. The 3 cords, medial (MC), posterior (PC), and lateral (LC), are lying underneath (A) the subclavian muscle (white triangle) and the clavicle (black circle), and are released once the subclavian muscle is detached (B). J portal, left shoulder.

dissected. The retropectoral space was then enlarged anteriorly, between the coracoid process and the pectoralis major, using a smooth trocar and with the help of the water flow.

Once the retropectoral space was opened, the arthroscope was placed into the J portal, so the dissection was continued proximally to the upper border of the PM, until the subclavian space. Once the cords were identified, along with the axillary artery, the subclavian muscle was detached from the clavicle (Fig 3) and followed them toward the supraclavicular space, until the interscalene space so the release could be completed if necessary from this point of view.

The space between the conjoint tendon and the PM was then opened and dissected to visualize the BP terminal branches (musculocutaneous nerve first) and the axillary artery. Only then the PM tendon was cut and released from the coracoid process safely, so the dissection was continued distally by carefully cutting the surrounding fibrous bands (Fig 4).

The musculocutaneous nerve and the lateral branch of the median nerve, coming from the lateral cord, were the first branches to be visualized. After reclining medially those branches with the axillary artery, the axillary and radial nerves were exposed laterally and posteriorly, reaching for the quadrilateral space. The ulnar nerve was then dissected, more medial than the rest of the BP, coming from the medial cord along with the medial branch of the median nerve. The posterior cord and its terminal branches were also exposed by a posterior approach (retro coracoid) through the TT1 portal, by following the anterior border of the subscapularis muscle (Fig 5). The dissection was stopped

ligaments. At this point, the transverse ligament was identified, perpendicular to the coracoclavicular ligaments, and was cut through the TT1 portal, freeing the SSN from the suprascapular notch. To complete the SSN dissection proximally until the upper trunk, the TT1 portal was used for the arthroscope so the TT2 portal could be created for instrumentation. After its release, the SSN was followed proximally until the trunks, first the superior and then the middle and the inferior, through TT1 and TT2. At this level, the fibrous bands found around the trunks between the scalene muscles were released, and an intraneural dissection was performed using a smooth trocar (Fig 2). No scalenectomy, first rib resection, or BP roots dissection was performed.

The dissection was then continued distally, with the exposition of the infraclavicular BP. It was started from the subacromial space using the C portal for the arthroscope. After opening the clavipectoralis fascia, the conjoint tendon and the coracoid process were

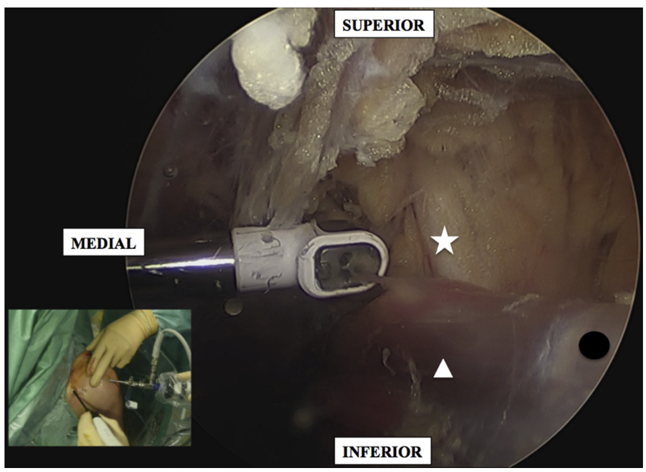

Fig 4. Endoscopic decompression of the brachial plexus (terminal branches) through the retropectoralis minor space. The pectoralis minor (white triangle) is anterior to the musculocutaneous nerve (white star) and will be cut laterally and detached from the coracoid process (black circle). E portal, left shoulder.

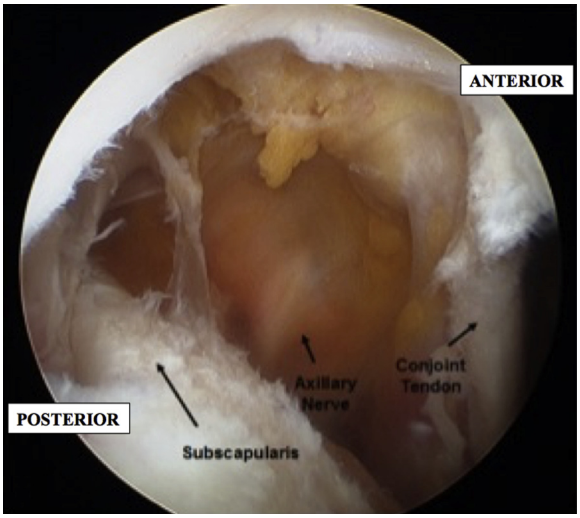

Fig 5. Endoscopic retrocoracoid approach of the brachial plexus. (posterior cord, axillary and radial nerves). Visualization of the axillary nerve following the subscapularis anterior border. C and E portals, right shoulder.

after all the branches were identified and released from any adhesions and fibrous bands.

After surgery, patients were kept in observation for 24 hours; no immobilization was needed, and no particular physical therapy was recommended, only self-rehabilitation by daily living activities. Sports employing the shoulder griddle were not allowed for 6 weeks.

Evaluation

Clinical evaluations were realized preoperatively and during the follow-up consultations at 6 and 12 months after the surgery. Patients were followed for a minimum of 1 year, and then every 6 months if needed during 1 more year.

To assess clinical and functional outcomes, all the patients were asked to complete the Quick-DASH questionnaire at every consultation, to obtain the DASH score. The primary endpoint was the difference between the preoperative and the 6-month follow-up values of this score, according to previous studies.[23] If a functional deterioration was noted at the 1-year consultation, further evaluation were continued until 2 years after the surgery; in those cases, the postoperative DASH score used for statistical analysis was the highest of the 4 postoperative values.

All the NTOS symptoms were also evaluated as secondary endpoints. The pain, the paresthesia, and the weakness were noted at different areas, preoperatively as present or absent, and postoperatively as persistent or relieved, as well as the different provocative maneuvers. The pain was self-evaluated with a 10-point visual analog scale, and a score equal or superior to 1/10 was considered painful. The strength was graded by the physician out of 5 comparatively to the other side and according to the Medical Research Council Scale (MRCS), considered either normal if it was 5/5 or weak if it was 4/5 or less.

Statistical Analysis

We ran a statistical analysis using a Wilcoxon signed-ranked test with continuity correction for the primary outcome, and the McNemar χ^2 test with continuous correction for the paired nominal data that were the secondary outcomes. Statistical significance was defined as $P < .05$.

Results

Patient Flowchart

Between January 2010 and January 2013, 36 patients suffering from NTOS were included and benefited from endoscopic BP release (Fig 6). The mean age was 38.6 years at the date of surgery.

No patient was excluded preoperatively, but 10 patients (27.8%) were excluded after the surgery. Seven patients (19.5%) required complementary procedures (Table 1), whereas 3 patients (8.3%) presented intra-articular conditions that could participate in the symptomatology they were presenting (Table 2). Five patients (13.9%) were lost during follow-up; 4 did not come to the consultations and 1 patient died from lung cancer.

The data of the 21 remaining patients (58.3%) were analyzed. They were evaluated at 6 and 12 months after the surgery, and then every 6 months if needed. The mean follow-up was 30.6 months (range 10-48).

DASH Score

The average difference between preoperative and postoperative values of the DASH score was 36 (range −20 to 80), with $P = .0002$, demonstrating a significant functional improvement (Table 3). Preoperatively, the average DASH score was 70 (range 36-98); no patients presented minor symptoms and 9 patients had a functional incapacity. Six months after the

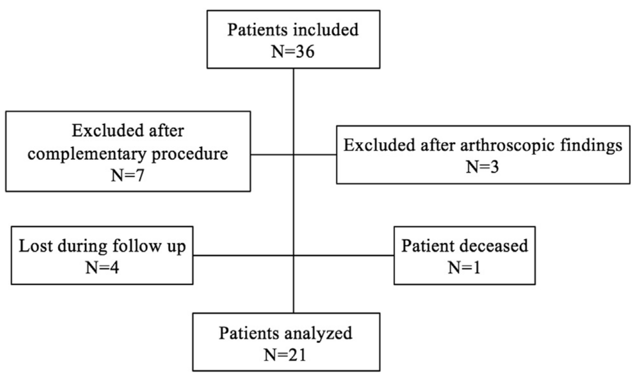

Fig 6. Patient flowchart.

Table 1. Complementary Procedures Excluding the Patients

Complementary Performed Procedures	Number of Patients
Biceps tenodesis and AC joint resection	2
Bankart/SLAP lesions repair	2
AC joint resection	1
Glenohumeral arthrolysis	2

AC, acromioclavicular.

surgery, the mean DASH score was 34 (range 2-91); 1 patient remained incapacitated and 9 patients presented minor symptoms (Fig 7).

The difference between pre- and postoperative values was less than 25 in 7 cases (33%), between 25 and 50 in 8 (38%) cases, and greater than 50 in 6 cases (29%). In 1 case, the condition of the patient aggravated after the surgery and the functional outcome worsened, with the score increasing from 71 to 91 (patient 12). In 2 cases, the functional outcome did not improve (patients 9 and 16).

NTOS Symptomatology

For all 3 symptoms of pain, paresthesia, and provocative maneuvers, more than 75% of the patients were significantly relieved after surgery ($P < .01$; Table 4). Weakness was normalized 6 months after surgery in 60% to 70% of the cases ($P < .05$).

Complications

There was no complication reported. All procedures were performed as previously described.

In 3 cases, surgery was a failure. In 1 case, the patient never improved and was in a worse condition 6 months after the surgery. In 2 cases, the patients improved for the first 6 months but a progressive recurrence of the symptoms over the second year appeared until they got back to their preoperative status 2 years after surgery.

Discussion

This study suggests that an all-endoscopic technique may safely and efficiently treat patients with nonspecific idiopathic NTOS.

Surgical Technique

BP Neurolysis. This study describes an all-endoscopic complete BP neurolysis from shoulder arthroscopic portals. Starting from the glenohumeral joint allows the physician to assess the articulation, looking for differential diagnosis and if necessary performing complementary procedures. Moreover, the saline fluid used in shoulder arthroscopy is very convenient to perform BP neurolysis, because the pressure helps the surgeon find dissection planes and the continuous flow prevents overheating nerve injuries (Sunderland 1 or 2 lesions).[24] Previous studies have described BP endoscopic neurolysis, but the aim of these studies were to assess its accessibility through specific portals, so nerve transfers could be performed in BP palsy cases, mainly with the Da Vinci robot.[25,26] Because nerve transfers were the goals, the dissection was very limited and the use of saline fluid for exposure was impossible.[27]

Table 2. Intra-articular Findings Excluding the Patients

Intra-articular Conditions	Number of Patients
Glenohumeral osteoarthritis	2
Glenohumeral instability	1

Table 3. DASH Scores

Patients	Preoperative Scores, %	Postoperative Scores, %	Differences, %
1	93	21	72
2	71	55	16
3	71	52	19
4	57	7	50
5	59	2	57
6	39	32	7
7	57	2	55
8	93	57	36
9	36	35	1
10	82	2	80
11	80	30	50
12	71	91	−20
13	82	71	11
14	98	59	39
15	80	7	73
16	66	66	0
17	48	5	43
18	66	40	26
19	91	48	43
20	45	14	31
21	84	9	75
Mean values	70	34	36 (P = .00024)

DASH, Disability of the Arm, Shoulder and Hand.

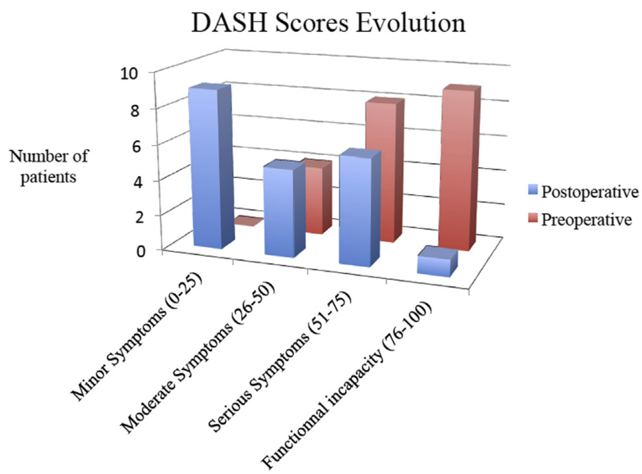

Fig 7. Variations between the preoperative and postoperative Disability of the Arm, Shoulder and Hand (DASH) scores.

Table 4. NTOS Symptomatology

Symptoms	Preoperative Assessment (Patient Presenting the Symptom)		Postoperative Assessment (Patient Relieved From the Symptom)		
	Number of Patients*	%	Number of Patients†	%	*P* Values
Pain					
Neck and trapezius	14	67	11	79	.003
Chest wall	17	81	15	88	.0003
Shoulder	18	86	14	78	.0005
Hand	14	67	12	86	.001
Paresthesia					
First 3 digits	12	57	10	83	.004
Last 2 digits	14	67	11	79	.003
Weakness					
Supra- and infraspinatus	20	95	12	60	.001
Deltoid	17	81	11	65	.003
Hand	10	48	7	70	.02
Provocative maneuvers					
Tinel sign	17	81	16	94	.0002
Wright test	20	95	17	85	.0001
SSN stretch test	18	86	14	79	.0005

NTOS, neurogenic thoracic outlet syndrome; SSN, suprascapular nerve.
*Of 21 patients.
†Of N patients presenting the symptom preoperatively.

Arthroscopy. Disputed idiopathic NTOS surgical management remains currently controversial, as highlighted by an abundant literature. Indeed, depending on the case presentation, but mainly on the surgical team, scalenectomy or first rib resection, a combination of the 2, or PM tenotomy was performed.[9,10,28-33] Several elements support our technique. First, a complete dissection is realized, releasing the 3 identified anatomic sites of potential entrapment. The postoperative data corroborate this, because effective and significant functional improvements were reported for both supra- and infraclavicular territories (Table 4). Second, this technique benefits from the advantage of endoscopy and its devices. The radiofrequency allows performing the interscalene dissection, the subclavian muscle resection and the PM tenotomy, with minimal damages in the surrounding tissue, potentially preventing long-term recurrences caused by excessive scar tissue.[34,35] Indeed, studies focusing on other nerve entrapment sites have shown that endoscopic neurolysis techniques produced less scar tissue than open procedures.[36,37] The arthroscope is used as an internal probe, to ascertain that the space made with the radiofrequency is wide enough, ensuring a satisfying static and dynamic release. Moreover, under arthroscope magnification, the BP is perfectly visualized, so it can be protected at all times and potential signs of distress due to chronic compression can be identified—an interesting point in this syndrome, because during 36 dissections, no evidence of typical nerve distress was identified as it can be seen in carpal tunnel syndrome, for instance, outlining the lack of obvious underlying anatomic lesion, and thus the absence of a gold standard surgical option. At last, no complication was reported in 36 cases, indicating that this technique seems to be safe, provided that the physician has advanced skill in shoulder arthroscopy and an expert knowledge of the local anatomy.

Clinical Outcomes

Comparison to Current Literature. Assessment criteria after NTOS surgery are not well established; however, the DASH score appeared to be a reliable tool.[23,38,39] Studies relating to open surgery techniques have similar findings on the average difference between pre- and postoperative scores, no matter the technique performed. Cordobes-Gual et al.[23] reported a mean significant DASH score difference of 36.16% ($P = .01$) in NTOS cases, after combined scalenectomy and first rib resection. Vemuri et al.[9] reported an average significant difference also in NTOS cases, of 29.6% ($P < .01$) and 41.5% ($P < .01$), respectively, after isolated PM tenotomy and PM tenotomy associated with scalenectomy and first rib resection. In addition, van Kampen et al.[40] showed that a patient should present a DASH score decrease of at least 16.3 points to be clinically relevant, which was observed in 71.4% of our patients. Theses findings highlight the favorable outcomes of our endoscopic surgical management of NTOS. Significant improvements in other symptoms, such as pain, paresthesia, and provocative maneuvers, were also similar to the literature.[41] The decrease of the weakness was less important, ranging from 60% to 70% depending on the area, even if the pre- and postoperative data were significantly different; this finding also is supported by the literature.[42] In our series, this could be explained either by definite nerve damages due to severe or extended comprehension or by an early follow-up consultation, which is the most likely because a definite neurologic examination should not be made before 2 years.

Failures. Despite a general success, failure was observed in 3 cases. No peculiar perioperative findings were found. The first 2 cases were initially improved at the 6-month consultation, but the symptoms recurred after 1 year. Our 2 main hypotheses would be a secondary entrapment due to the postoperative scarring process, or an incomplete initial decompression. Another explanation could be the extended duration of the symptoms prior to surgery, which was more than 5 years in both cases; however, this hypothesis would not explain the initial regression followed by a recurrence of the symptoms.

A third patient never improved, and even got worse after surgery; his DASH score increased by 20 points in 2 years. Our 2 primary hypotheses would be a failure of initial complete decompression, or an incorrect initial diagnosis.

Limitations

Several limitations appear in this series, starting with the design of the study, which is a case series without a control group. Because the sample size was already limited, a controlled trial would have taken much more time, delaying the publication of the preliminary outcomes. The NTOS literature being rich, we used previously published data to compare our results.

Another limitation was the small sample size compared with other studies.[29,30] This can be explained by our primary recruitment, which is mainly shoulder surgery compared with other centers specialized in this pathology. In addition, muscle strength was evaluated as a qualitative nominal data, which subsequently limited the assessment quality of the postoperative recovery.

The last main limitation was the large proportion of postoperative exclusions. Seven patients were excluded because of complementary procedures (Table 1) and 3 because of intra-articular findings that could interfere with the interpretation of the outcomes (Table 2). Because a shoulder magnetic resonance imaging was performed routinely during preoperative assessment, such procedures and conditions were anticipated; we decided nonetheless to include those patients to increase the number of patients going under surgery to enhance the feasibility and safety of this procedure, even if we could not include them in the analysis of the primary and secondary outcomes. Otherwise, 5 patients (14%) were lost during follow-up, which is similar to previous studies.[41,42]

Conclusion

Although requiring arthroscopic skills and expert knowledge of the anatomy, our technique seems to be safe and reproducible and provides significant functional improvements in the selected patients with nonspecific NTOS, with an average postoperative DASH score improvement of 36%.

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