journal of clinical practice 2022 Vol 13 №3

A CLINICAL CASE OF A COMBINED ENDOSCOPIC TREATMENT: BRACHIAL PLEXUS DECOMPRESSION IN THE THORACIC APERTURE AND SUBACROMIAL SPACER IMPLANTATION

© **E.A. Belyak[1, 2], D.L. Paskhin[2], F.L. Lazko[1, 2], A.P. Prizov[1, 2], M.F. Lazko[1, 2], N.V. Zagorodniy[1], S.A. Asratyan[2], A.A. Akhpashev[1]**

[1] Peoples' Friendship University of Russia, Moscow, Russian Federation

[2] Moscow City Clinical Hospital in honor of V.M. Buyanov, Moscow, Russian Federation

Background: *Thoracic outlet syndrome — compression of the brachial plexus in the area between the clavicle and the first rib — is a commonly spread and important pathology. It occurs, as usual, after a trauma or due to an anatomical malformation of this area. Thoracic outlet syndrome can be combined with a shoulder joint pathology. In the case of a conservative treatment's failure, the standard surgical procedure is decompression of the brachial plexus in the thoracic aperture. This procedure is usually done via an open approach. The development of the endoscopic surgical technique of decompression allows reducing the risk of complications and recurrences, improving the cosmetic result and relieving the rehabilitation period.* ***Clinical case description:*** *A 73-year-old female patient with a clinical picture of posttraumatic brachial plexopathy and a massive shoulder rotator cuff tear. The patient underwent a conservative treatment for 6 months after the trauma without a significant improvement. To confirm the diagnosis, ENMG and an ultrasound investigation of the brachial plexus, as well as MRI of the shoulder joint were performed. Simultaneous shoulder joint arthroscopy with subacromial spacer implantation and brachial plexus decompression in the thoracic aperture were performed to the patient. According to the VAS-scale (Visual Analogue Scale), the severity of pain syndrome before the surgery was 10 cm, while 6 months after the surgery, it decreased to 1 cm. According to the DASH scale (Disabilities of the Arm, Shoulder, and Hand), the dysfunction of the of shoulder joint before the surgery was 76 points, while 6 months after the surgery, it decreased to 12 points. The range of motion in the shoulder joint before the surgery was as follows: flexion 105°, abduction 95°, external rotation 15°, which increased to 160°, 165°, and 45°, respectively, 6 months after the surgery.* ***Conclusion:*** *The results allow us to characterize the method of simultaneous shoulder joint arthroscopy and endoscopic decompression of the brachial plexus in the thoracic aperture as a low-traumatic and effective technique. The technique provides complete brachial plexus decompression in the thoracic aperture which promotes restoration of the function of the upper extremity and shoulder joint, and elimination of pain syndrome from the upper extremity area.*

Keywords: *brachial plexus; endoscopic neurolysis; decompression; neuropathy; neuropathic pain syndrome; shoulder arthroscopy; thoracic outlet syndrome.*

For citation: Belyak EA, Paskhin DL, Lazko FL, Prizov AP, Lazko MF, Zagorodniy NV, Asratyan SA, Akhpashev AA. A Clinical Case of a Combined Endoscopic Treatment: Brachial Plexus Decompression in the Thoracic Aperture and Subacromial Spacer Implantation. *Journal of Clinical Practice*. 2022;13(3): 79–88. doi: https://doi.org/10.17816/clinpract109942

Submitted 01.09.2022 Revised 10.09.2022 Published 30.09.2022

BACKGROUND

The thoracic outlet syndrome is a common problem that causes severe pain in the shoulder and upper limb area and leads to upper limb dysfunction [1, 2]. The pathological process consists of the compression of the neurovascular bundle (brachial plexus and subclavian artery and vein) in a narrow anatomical space between the first rib and the clavicle [3, 4]. The syndrome can be caused by trauma or its consequences (such as fracture of the clavicle or first rib and post-traumatic cicatricial process) and anomalies of anatomical development (such as an additional cervical rib, hypertrophy of the subclavian muscle, and exostoses in the clavicle area) [5]. The thoracic outlet syndrome can be combined with shoulder joint pathologies, especially in traumatic injuries. Conservative treatment, including exercise therapy, physiotherapy, and medication, can provide good results [6]. However, with the inefficiency of conservative treatment, surgical methods are used, which involve eliminating the cause of mechanical compression in the region of the thoracic aperture, namely, removal of scar tissue, resection

of an additional rib and osteophytes, and myotomy of the subclavian muscle [7–10]. Generally, surgical intervention is performed by open access, which is associated with significant blood loss and soft tissue trauma and complications (such as infectious process and postoperative hematoma) [11, 12].

International studies have investigated endoscopic decompression of the brachial plexus in the thoracic aperture region [13, 14]. Although the Russian literature does not present the experience of the fully endoscopic treatment of thoracic outlet syndrome, there are publications on a minimally invasive surgical technique with endoscopic assistance [15]. Similar publications are also found in the international literature [16].

This paper describes the experience of endoscopic treatment of a patient with thoracic outlet syndrome and massive damage to the rotator cuff, presents a surgical technique, and traces long-term clinical results (6 months after surgery).

CLINICAL CASE

Patient information

Female patient S., aged 73 years, sought medical help from a traumatologist–orthopedist of the V.M. Buyanov City Clinical Hospital of the Moscow City Health Department for severe pain in the shoulder and right upper limb, weakness, and decreased limb sensitivity due to a household injury sustained 4 months ago when she fell on the right arm.

Case history. On the day of the injury, clinical and X-ray examinations were performed at the district traumatology center, and a diagnosis of a closed fracture of the surgical neck of the right shoulder with a moderate displacement of the fragments was made. The right upper limb was immobilized, and conservative treatment of the fracture was recommended.

Six weeks after the injury, the immobilization was removed, and the patient started a rehabilitation course to improve movements in the shoulder joint. Despite the treatment, severe pain persisted in the shoulder and upper limb area. The control radiography of the shoulder joint revealed the consolidation of the humerus fracture; thus, rehabilitation was continued, which the patient adhered to; however, the pain syndrome was not alleviated and shoulder joint and limb function did not improve.

Physical and instrumental diagnostics

In the V.M. Buyanov City Clinical Hospital, during a clinical examination, the neurological and orthopedic status of the patient was assessed.

The Job and Hawkins–Kennedy tests of the shoulder joint were positive. The Wright, Tinel, and Allen tests of the brachial plexus were positive. According to the linear scale of pain intensity (visual analog scale [VAS]), the pain syndrome was approximately at 10 cm. The amplitude of active movements in the shoulder joint was 120° flexion, 100° abduction, 20° external rotation, and internal rotation up to the iliac wing. The degree of movement disorders in the upper limb on the British Medical Research Council (BMRC) muscle strength scale was approximately 3 points (M3), the degree of sensory impairment on the Seddon scale was 3 points (S3), the degree of dysfunction of the right upper limb on the disabilities of the arm, shoulder, and hand scale (DASH) was 76 points.

The instrumental examination revealed several disorders:

- Magnetic resonance imaging of the shoulder joint revealed signs of grade I–II osteoarthritis of the right shoulder joint and massive damage to the tendon of the supraspinous muscle with signs of fatty atrophy of the supraspinous muscle (grades III–IV according to the Goutallier classification).
- Ultrasound examination of the brachial plexus and vascular bundle on the right in the region of the thoracic aperture showed signs of dynamic compression of the neurovascular bundle.
- Electroneuromyography of the brachial plexus detected damage to the primary bundles of the right brachial plexus and a decrease in the amplitude of the M-response according to stimulation electroneuromyography.

Provisional diagnosis

Based on the examination results, the patient was diagnosed with post-traumatic brachioplexopathy on the right, thoracic outlet syndrome, and massive damage to the rotator cuff of the right shoulder joint.

Dynamics and outcomes

For 2 months, the patient underwent control conservative treatment (physiotherapy exercises, physiotherapy, anti-inflammatory therapy, and neurotropic therapy) without a significant effect. Thus, a combined surgical intervention consisting of arthroscopy of the shoulder joint and endoscopic decompression of the brachial plexus in the region of the thoracic aperture was planned.

Endoscopic surgical technique

The surgery was performed with the patient in the beach-chair position under general anesthesia

https://doi.org/10.17816/clinpract109942

journal of clinical practice 2022 Vol 13 №3

(endotracheal anesthesia), and anatomical landmarks and endoscopic ports were mapped with a marker (Fig. 1). Fluoroscopy control was not used during surgery.

At stage 1, diagnostic arthroscopy of the shoulder joint was performed with the examination of intraarticular structures, which revealed Outerbridge grade II chondromalacia of the humeral head and the articular process of the scapula and massive irreparable damage to the tendon of the supraspinous muscle. Then, tissues were released in the region of the rotator interval, and the coracoid process and joint tendon were exposed. The arthroscope was transferred to the formed anteroexternal port, whereas the working instrument was located in the standard anterior port. The location of the arthroscope and instrument is schematically presented in Fig. 2. The intraoperative image of the location of ports and instruments is presented in Fig. 3.

Further, tissues were released in the area of the subscapular muscle and anterior to it by the dissection of scar and adhesive tissues. Neurolysis of the previously visualized axillary and radial nerves was performed (Fig. 4). The release of tissues in the area of the coracoid process and subsequent visualization of the coracoid–acromial ligament and pectoralis minor allowed the decompression of this region by the excision of the pectoralis minor from the medial edge of the coracoid process (Fig. 5). After visualization and neurolysis of the musculocutaneous nerve (Fig. 6), the pulsation of the axillary artery located under it was determined (Fig. 7).

Then, tissues at the base of the coracoid process were released to visualize the subclavian muscle, and the lateral part of the subclavian muscle from the clavicle was excised (Fig. 8), which allowed for the creation of a full-fledged “window” for access to the thoracic aperture. The trunks of the brachial plexus and divisions extending from them were visualized due to the dissection of adhesive and scar tissues in this area (Fig. 9), and decompression was achieved, among other things, by the excision of the lateral portion of the subcoracoid muscle. Neurolysis of the brachial plexus and decompression of the entire neurovascular bundle were performed. Intraoperative images of the components of the brachial plexus after neurolysis are presented in Figs. 10 and 11.

The subclavian artery is located directly under the upper trunk of the shoulder joint and slightly anterior to it; because it could be easily visualized, its pulsation could be determined (Fig. 12). The final stage of the surgery was the placement of a subacromial spacer InSpace (Stryker, USA) in the subacromial space caused by massive irreparable damage to the supraspinatus tendon. The stages of spacer installation are presented in Fig. 13.

The surgery was completed by suturing postoperative wounds and applying an aseptic dressing. The upper limb was immobilized in a cravat bandage. The appearance of the shoulder area after the surgery is shown in Fig. 14.

Fig. 1. Marking of anatomical landmarks and endoscopic portals before surgery.

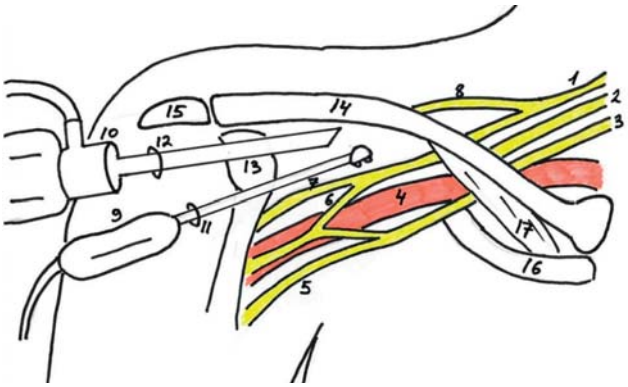

Fig. 2. Schematic view of placement of arthroscope and instrument during approach to thoracic aperture: *1* — upper cord of brachial plexus; *2* — median cord of brachial plexus; *3* — inferior cord of brachial plexus; *4* — subclavian artery; *5* — medial branch of brachial plexus; *6* — superior branch of median nerve; *7* — musculocutaneous nerve; *8* — suprascapular nerve; *9* — working instrument (ablator); *10* — arthroscope; *11* — anterior working portal; *12* — antero-lateral working portal; *13* — coracoid process; *14* — clavicle; *15* — acromial process of scapula; *16* — first rib; *17* — subclavian muscle.

Fig. 3. Placement of arthroscope and working instrument during approach to thoracic aperture.

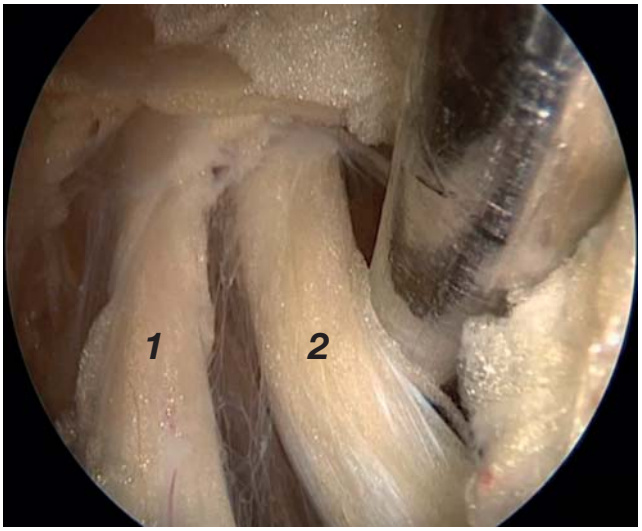

Fig. 4. Axillary nerve (*1*) and radial nerve (*2*) after performing neurolysis.

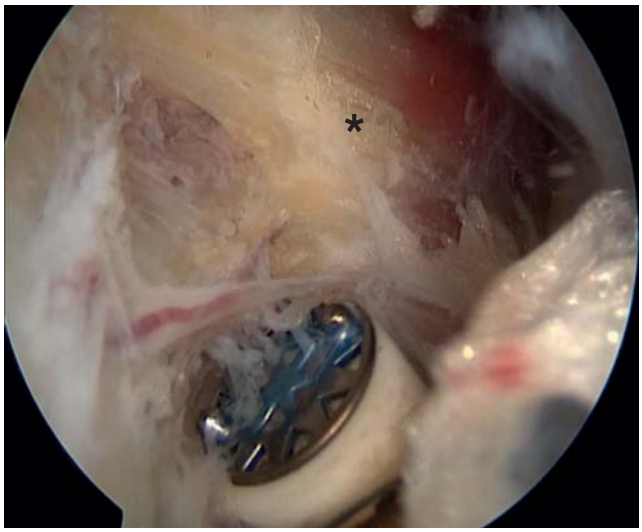

Fig. 5. Detachment of pectoralis minor muscle (*) from medial margin of coracoid process.

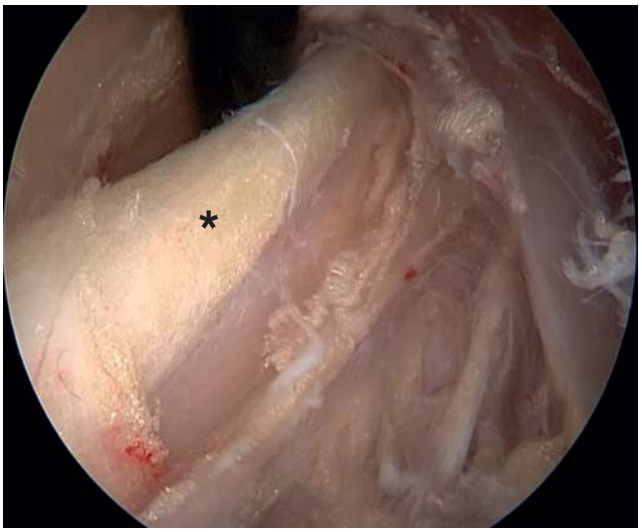

Fig. 6. Musculocutaneous nerve (*) after performing neurolysis.

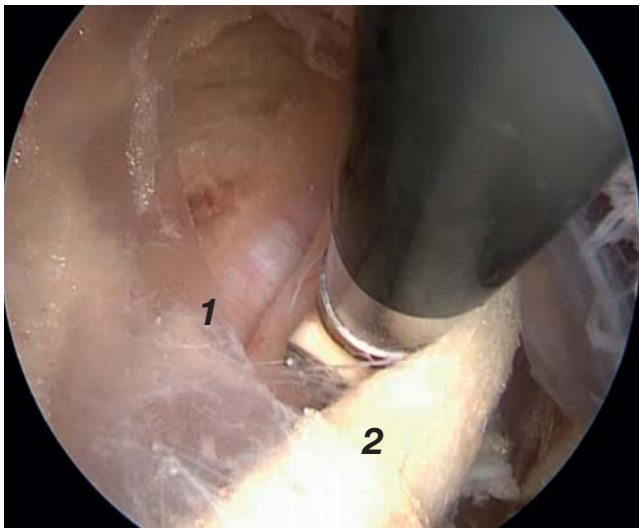

Fig. 7. Co-position of axillary artery (*1*) and musculocutaneous nerve (*2*).

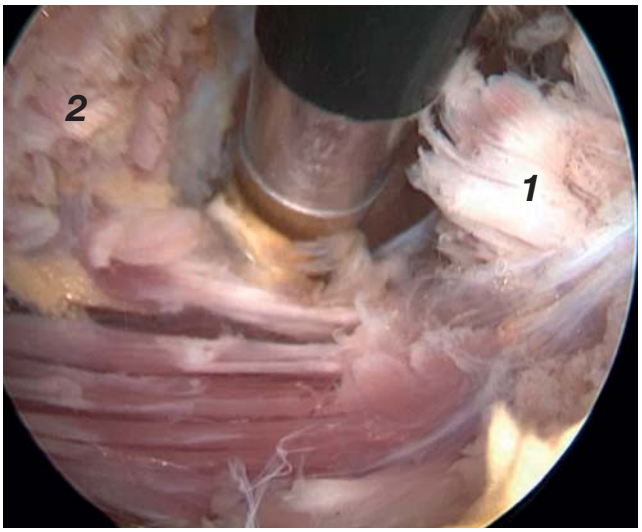

Fig. 8. Detachment of lateral portion of subclavian muscle from clavicle: *1* — detached part of subclavian muscle; *2* — clavicle.

https://doi.org/10.17816/clinpract109942

journal of clinical practice 2022 Vol 13 №3

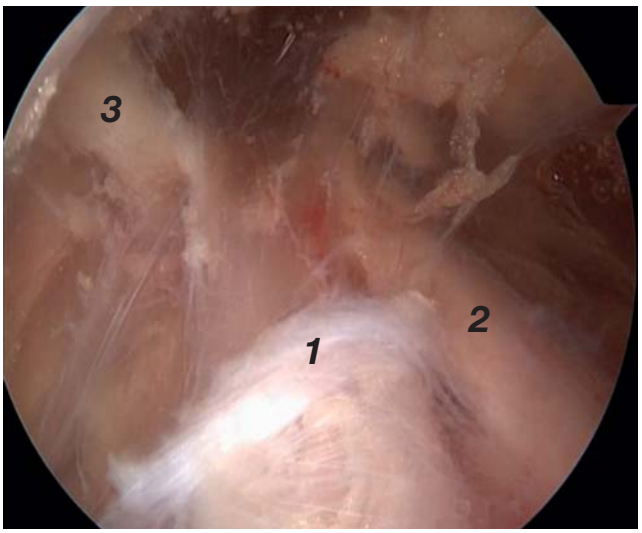

Fig. 9. Components of brachial plexus in thoracic aperture area: *1* — upper trunk; *2* — division from the upper trunk; *3* — suprascapular nerve.

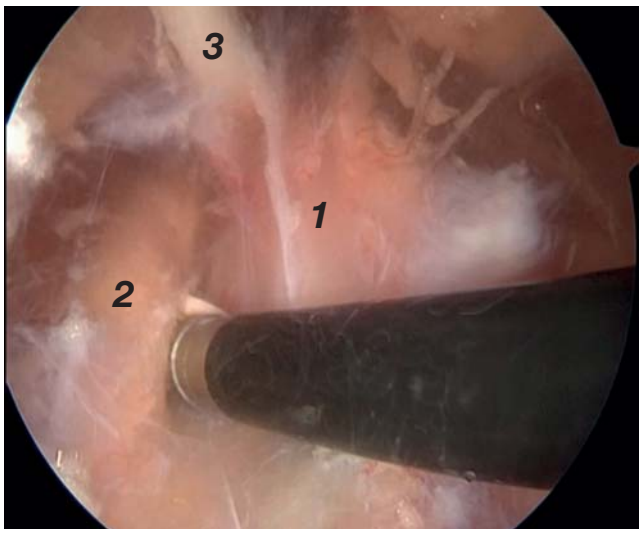

Fig. 10. Components of brachial plexus after decompression: *1* — upper trunk; *2* — median trunk; *3* — suprascapular nerve.

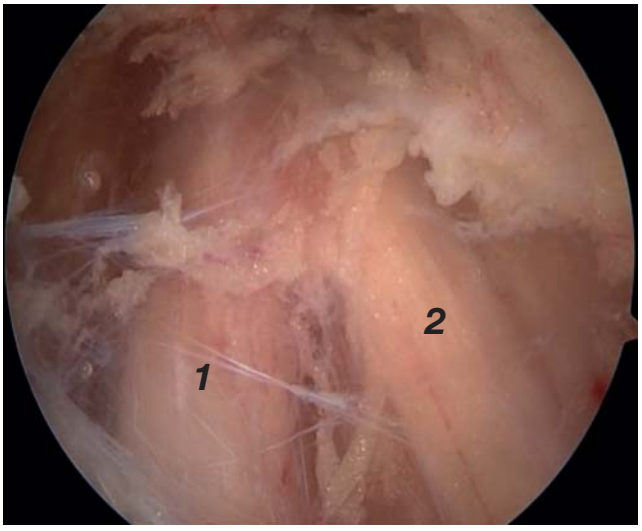

Fig. 11. Components of brachial plexus after decompression: *1* — upper trunk; *2* — division from upper trunk.

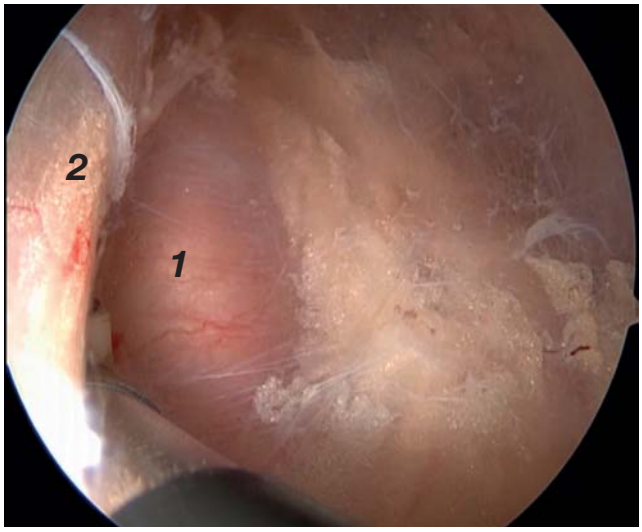

Fig. 12. Subclavian artery (*1*); upper trunk of brachial plexus shifted posteriorly (*2*).

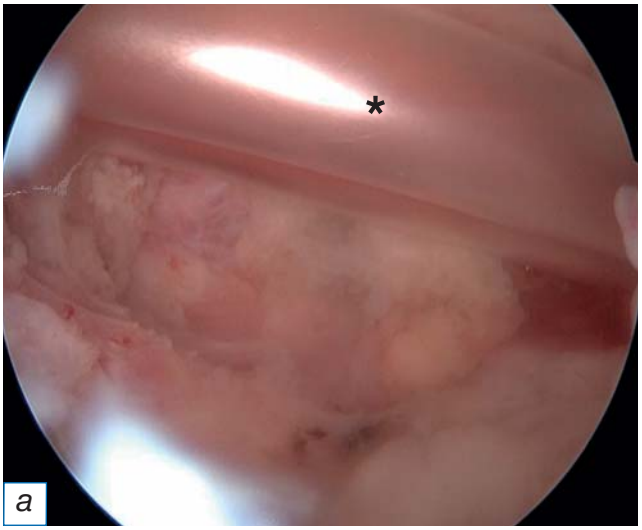

Fig. 13. Introducing of subacromial spacer: *a* — spacer (*) in folded position introduced into a shoulder joint; *b* — spacer (*) after dilatation.

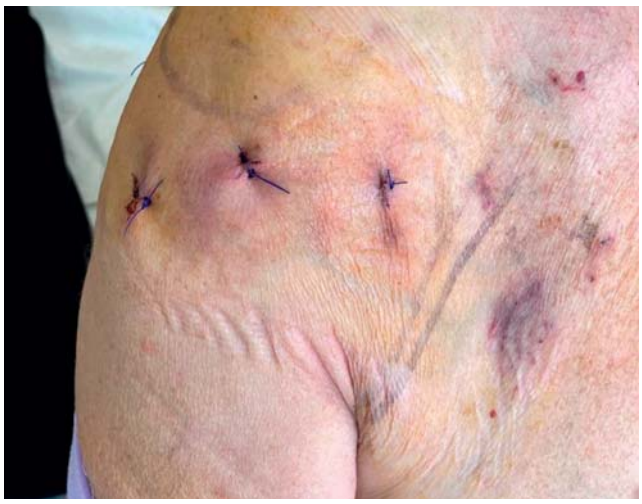

Fig. 14. External view of the shoulder area after endoscopic surgery.

During the surgery, soft tissues and subcutaneous fat of the shoulder area were moderately infiltrated with saline solution, which was the medium for endoscopic intervention. The next day after the surgery, by the time of dressing, the physiological solution was completely absorbed, and the edema regressed.

The day immediately after the surgery, the patient started to develop passive movements in the shoulder joint (pendulum exercise). Immobilization of the upper limb in an orthosis was performed for 7 days. The sutures were removed on day 8 after the surgery, and the postoperative wounds healed by primary intention. After the removal of sutures postoperatively, the patient started rehabilitation in a rehabilitation center.

The postoperative period was uneventful, and the day after the surgery, the patient noted a pronounced decrease in pain. Complications in the early and late postoperative periods were not noted.

A follow-up clinical examination and evaluation on scales was performed 6 months after the surgery. According to the VAS scale, the pain syndrome was at 1 cm (practically absent). The amplitude of active movements in the shoulder joint increased, with flexion of 160°, abduction of 165°, external rotation of 45°, and internal rotation up to the level of the spinous process of the L3. The degree of movement disorders in the upper limb according to the BMRC scale was approximately 0 points (absent, M0). Sensory disorders also regressed (Seddon score 0, S0). According to the DASH scale, the degree of right upper limb dysfunction was approximately 12 points.

Control ultrasound examination of the brachial plexus and vascular bundle on the right in the region of the thoracic aperture revealed no signs of dynamic compression of the neurovascular bundle. The control electroneuromyography of the right brachial plexus showed no signs of damage to the bundles of the shoulder joint. Stimulation electroneuromyography revealed restoration of the amplitude of the M-response.

DISCUSSION

With thoracic outlet syndrome, conservative treatment can provide good results. A good or very good clinical effect is achieved in 76%–100% of cases in the early period (within a month), whereas in the long-term period (more than 1 year), this result is maintained in 59%–88% of patients [17]. According to literature data, conservative treatment demonstrates unsatisfactory results in patients with plexopathy of more than 6 months and patients with concomitant shoulder joint pathology (rupture of the rotator cuff tendons, avulsion of the fibrocartilagenous rim, etc.). Risk factors that predict the ineffectiveness of conservative treatment include obesity, crush syndrome (traumatic rhabdomyolysis), traumatic genesis, severity of symptoms, and psychoemotional characteristics [18]. In such cases, simultaneous surgical intervention should be considered to eliminate both neurosurgical (brachial plexus compression) and orthopedic (rotator cuff suture, fibrous rim) pathologies. According to Mailis [19], surgical treatment is more effective (by 20%) than conservative treatment, and performing arthroscopy of the shoulder joint and endoscopic decompression of the brachial plexus simultaneously in the area of the thoracic aperture can obtain excellent cosmetic results, reduce the risk of complications, and accelerate and facilitate rehabilitation.

In the Russian literature, no studies have reported fully endoscopic decompression of the brachial plexus in the region of the thoracic outlet. A team from the Tyumen Federal Center of Neurosurgery, under the supervision of Sufianov, developed a technique for mini-invasive access to the brachial plexus in the area of the thoracic outlet and its decompression [15], which implies a mini-incision (5–7 cm) in the armpit, visualization and revision of the neurovascular bundle, and further release of the brachial plexus in the proximal direction to the thoracic aperture under endoscopic control. Thus, an endoscopically assisted method is presented, which was associated with all the disadvantages of open access.

An original endoscopic technique for the decompression of the brachial plexus in the region of the thoracic aperture was developed on cadaver material

https://doi.org/10.17816/clinpract109942

by a team of French authors [14, 20], where they demonstrated the possibility of endoscopic access to the brachial plexus and decompression. The method implies two endoscopic ports, namely, in the area of the coracoid process for access to the subclavian part of the plexus and in the supraclavicular fossa for access to the primary trunks. In 2017, the authors analyzed the clinical results of using this technique in 36 patients with thoracic outlet syndrome; on average, the function of the shoulder joint improved by 36% according to the DASH scale, which generally coincides with our result [14].

Studies have reported successful endoscopic resection of the first rib in thoracic outlet syndrome, and methods of transaxillary and thoracoscopic access have been developed [13, 21–24]. In our clinical case, a soft tissue component (scar and adhesive tissues) caused the development of thoracic outlet syndrome, which determined the scope of surgical intervention.

CONCLUSIONS

In this study, endoscopic decompression of the brachial plexus in the region of the thoracic outlet and arthroscopy of the shoulder joint showed good clinical results in the treatment of a female patient with post-traumatic thoracic outlet syndrome and concomitant massive damage to the rotator cuff of the shoulder. Endoscopic access enabled achieving good cosmetic results, minimal soft tissue trauma, and early rehabilitation recovery. All stages of the surgery were performed using standard arthroscopic equipment.

The results obtained on a separate clinical example indicated that endoscopic decompression of the brachial plexus in the region of the thoracic outlet is effective and safe.

INFORMED CONSENT

We received from the patient written informed permission for the publication of her pictures in medical journal, including its electronic version (date of signature 01.09.2022).

ADDITIONAL INFORMATION

Author contribution. *E.A. Belyak*, *D.L. Paskhin*, *M.F. Lazko* — treatment of patients, performing surgeries; *E.A. Belyak*, *A.P. Prizov* — forming data and analysis of instrumental studies; *E.A. Belyak*, *F.L. Lazko*, *S.A. Asratyan*, *N.V. Zagorodniy*, *A.A. Akhpashev* — processing and discussion of the results of the study, writing the text of the article; *E.A. Belyak*, *D.L. Paskhin*, *F.L. Lazko* — search and analytical work, discussion of the results of the study, writing the text of the article. The authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

Funding source. The study had no sponsorship.

Competing interests. This study was not supported by any external sources of funding.

REFERENCES

1. Kuhn JE, Lebus GF, Bible JE. Thoracic outlet syndrome. *J Am Acad Orthop Surg*. 2015;23(4):222–232. doi: 10.5435/JAAOS-D-13-00215
2. Куцай Н.В., Головина Е.Р., Аджисалиев Г Р. Современные методы лечения синдрома верхней апертуры грудной клетки // *Инновации. Наука. Образование*. 2020. № 24. С. 1933–1939. [Kutsyy NV, Golovina ER, Adjisaliev GR. Modern methods of treatment of upper chest aperture syndrome. *Innovations. The science. Education*. 2020;(24):1933–1939. (In Russ).]
3. Masocatto NO, Da-Matta T, Prozzo TG, et al. Thoracic outlet syndrome: a narrative review. *Rev Col Bras Cir*. 2019;46(5): e20192243. doi: 10.1590/0100-6991e-20192243
4. Магомедов Р.К., Цуладзе И.И., Древаль О.Н., Чапандзе Г.Н. Клинико-диагностические особенности нейроваскулярного компрессионного синдрома в области верхней грудной апертуры // *Российский нейрохирургический журнал им. проф. А.Л. Поленова*. 2021. Т. 13, № S1. С. 106. [Magomedov RK, Tsuladze II, Dreval ON, Kapanadze GN. Clinical and diagnostic features of neurovascular compression syndrome in the upper thoracic aperture. *Russ Neurosur J named after Professor A.L. Polenov*. 2021;13(S1):106. (In Russ).]
5. Laulan J, Fouquet B, Rodaix C, et al. Thoracic outlet syndrome: definition, aetiological factors, diagnosis, management and occupational impact. *J Occup Rehabil*. 2011;21(3):366–373. doi: 10.1007/s10926-010-9278-9
6. Collins E, Orpin M. Physical therapy management of neurogenic thoracic outlet syndrome. *Thorac Surg Clin*. 2021;31(1):61–69. doi: 10.1016/j.thorsurg.2020.09.003
7. Peek J, Vos CG, Ünlü Ç, et al. Outcome of surgical treatment for thoracic outlet syndrome: systematic review and meta-analysis. *Ann Vasc Surg*. 2017;40:303–326. doi: 10.1016/j.avsg.2016.07.065
8. Boglione M, Ortíz R, Teplisky D, et al. Surgical treatment of thoracic outlet syndrome in pediatrics. *J Pediatr Surg*. 2022;57(9):29–33. doi: 10.1016/j.jpedsurg.2021.08.017
9. Магомедов Р.К., Муин Р.А. Нейроваскулярный компрессионный синдром в области верхней грудной апертуры: клинико-диагностические аспекты и хирургическое лечение // *Вестник неврологии, психиатрии и нейрохирургии*. 2015. № 7. С. 55–64. [Magomedov RK, Musin RA. Neurovascular compression syndrome in the upper thoracic aperture: clinical and diagnostic aspects and surgical treatment. *Bulletin Neurol Psychiatry Neurosur*. 2015;(7):55–64. (In Russ).]
10. Гаибов А.Д., Кахоров А.З., Садриев О.Н., Юнусов Х.А. Хирургическое лечение синдрома верхней грудной апертуры // *Вестник хирургии им. И.И. Грекова*. 2015. Т. 174, № 1. С. 78–83. [Gaibov AD, Zakharov AZ, Sadriev ON, Yunusov HA. Surgical treatment of upper thoracic aperture syndrome. *Bulletin Sur named after I.I. Grekov*. 2015;174(1):78–83. (In Russ).] doi: 10.24884/0042-4625-2015-174-1-78-83
11. Ciampi P, Scotti C, Gerevini S, et al. Surgical treatment of thoracic outlet syndrome in young adults: single centre experience with minimum three-year follow-up. *Int Orthop*. 2011;35(8): 1179–1186. doi: 10.1007/s00264-010-1179-1

12. Кахоров А.З., Гаибов А.Д., Султонов Д.Д. Осложнение хирургического лечения синдрома верхней грудной апертуры // *Вестник Таджикского национального университета. Серия естественных наук*. 2015. № 1–4. С. 243–246. [Kakharov AZ, Gaibov AD, Sultanov DD. Complication of surgical treatment of upper thoracic aperture syndrome. *Bulletin Tajik National University. Series Natural Sci*. 2015;(1–4):243–246. (In Russ).]
13. George RS, Milton R, Chaudhuri N, et al. Totally endoscopic (VATS) first rib resection for thoracic outlet syndrome. *Ann Thorac Surg*. 2017;103(1):241–245. doi: 10.1016/j.athoracsur.2016.06.075
14. Lafosse T, Le Hanneur M, Lafosse L. All-endoscopic brachial plexus complete neurolysis for idiopathic neurogenic thoracic outlet syndrome: surgical technique. *Arthrosc Tech*. 2017;10;6(4):e967–e971. doi: 10.1016/j.eats.2017.03.006
15. Патент РФ № 2637616 C1. Суфианов А.А., Гизатуллин М.Р., Якимов Ю.А. Способ эндоскопической ревизии, невролиза и декомпрессии плечевого сплетения. [Patent RF No 2637616 C1. Sufianov AA, Gizatullin MR, Yakimov YuA. Method of endoscopic revision, neurolysis and decompression of the brachial plexus. (In Russ).] Режим доступа: https://yandex.ru/patents/doc/

AUTHORS' INFO

The author responsible for the correspondence:
Evgeniy A. Belyak, MD, PhD;
address: 6, Miklukho-Maklaya str.,
Moscow, 117198, Russia;
e-mail: belyakevgen@mail.ru; eLibrary SPIN: 7337-1214;
ORCID: https://orcid.org/0000-0002-2542-8308

Co-authors:
Dmitry L. Paskhin;
e-mail: yas-moe@mail.ru; eLibrary SPIN: 8930-1390;
ORCID: https://orcid.org/0000-0003-3915-7796

Fedor L. Lazko, MD, PhD;
e-mail: fedor_lazko@mail.ru; eLibrary SPIN: 8504-7290;
ORCID: https://orcid.org/0000-0001-5292-7930

Aleksey P. Prizov;
e-mail: aprizov@yandex.ru; eLibrary SPIN: 6979-6480;
ORCID: https://orcid.org/0000-0003-3092-9753

Maxim F. Lazko, MD, PhD;
e-mail: maxim_lazko@mail.ru;
ORCID: https://orcid.org/0000-0001-6346-824X

Nikolay V. Zagorodniy, MD, PhD,
correspondent member of RAS;
e-mail: zagorodniy51@mail.ru; eLibrary SPIN: 6889-8166;
ORCID: https://orcid.org/0000-0002-6736-9772

Sarkis A. Asratyan, MD, PhD;
e-mail: dr.sako@mail.ru; eLibrary SPIN: 1037-4232;
ORCID: https://orcid.org/0000-0001-8472-4249

Alexander A. Akhpashev, MD, PhD;
e-mail: akhpashev@yandex.ru; eLibrary SPIN: 9965-1828;
ORCID: https://orcid.org/0000-0002-2938-5173

https://doi.org/10.17816/clinpract109942