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IDEAS AND INNOVATIONS

Peripheral Nerve

Targeted Muscle Reinnervation of the Supraclavicular Nerve to the Motor Branch of the Omohyoid Muscle in Patients Undergoing Thoracic Outlet Syndrome Procedures

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Summary: Transection of the supraclavicular nerve (SCN) through supraclavicular incisions can lead to debilitating neuroma formation. Targeted muscle reinnervation (TMR) proved to be an effective technique for the prevention and treatment of neuroma. In this case series, we propose the TMR of the SCN to the motor branch of the omohyoid muscle (OM) to prevent the formation of neuroma and avoid chronic pain at the supraclavicular area after thoracic outlet syndrome (TOS) procedures. A total of 10 patients underwent the procedure. Dissection of the SCN and its branches was performed through a supraclavicular incision. The branches were transected close to the clavicle. The inferior belly of the OM was identified and its motor branch isolated. Coaptation of the SCN branches with the motor branch of the OM was performed under the microscope and the wound was closed in layers. All the patients denied pain or hypersensitivity at the supraclavicular area on follow-up. In summary, the motor branch of the OM is a viable recipient for the TMR of the SCN and can prevent and treat painful neuromas at the supraclavicular area with minimal morbidity. *(Plast Reconstr Surg Glob Open 2022;11:e4421; doi: 10.1097/GOX.0000000000004421; Published online 13 July 2022.)*

INTRODUCTION

The supraclavicular nerve (SCN) is a superficial sensory nerve that crosses the clavicle and provides sensation over the clavicle, anteromedial shoulder, and proximal chest.[1] Patients that undergo thoracic outlet syndrome (TOS) procedures may complain of chronic pain in this area after surgery.[2] The transected branches of the SCN contribute to the formation of neuromas in this area which manifest as chronic pain.[3]

Few articles in the literature describe the importance of addressing the SCN during TOS procedures.[4] Although the neurolysis and preservation of the SCN can be done, it tends to limit the exposure and sustain a significant amount of trauma from the stretch and desiccation of the nerve during the lengthy surgery. This can cause chronic pain and supraclavicular hypersensitivity for months after surgery due to nerve regeneration and scarring forming neuromas.[5,6]

The immediate target muscle reinnervation (TMR) of the SCN to the motor branch of the inferior belly of the omohyoid muscle (OM) is an option to help prevent neuroma formation and the chronic pain associated with it. At this time, there is no report in the literature describing the use of TMR in patients undergoing TOS procedures.

METHODS

Our study is a case series of 10 patients who underwent the TOS procedure through a supraclavicular approach to treat neurogenic TOS (NTOS). After a supraclavicular incision is performed, just above the clavicle between the sternocleidomastoid muscle and the trapezius muscle, dissection is carried down through the subcutaneous tissue and platysma muscle with exposure of the underlying supraclavicular fat pad. At this level, the SCN and its branches are identified. Neurolysis of the SCN is carried out until the main trunk is identified more cranially in the neck incision (Fig. 1).

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Fig. 1. The supraclavicular nerve and its branches: medial (green arrow), intermediate (blue arrow), and lateral (yellow arrow).

The distal segments are divided at the level of the clavicle and tagged for later use in the case. Attention is then turned to the supraclavicular fat pad. Dissection is carried down until the inferior belly of the OM is identified and carefully dissected free from the fat pad and divided at the intermediate tendon on the medial aspect of the incision. Careful division is taken to preserve vascularity and the motor nerve going to the muscle flap. The muscle flap is then elevated laterally to mobilize it out of the way and utilized for later TMR (Fig. 2). **(See Video 1 [online]**, which displays dissection and isolation of the supraclavicular nerve branches and of the motor branch of the OM.)

The remaining steps of thoracic outlet release are performed with neurolysis of the suprascapular, phrenic, thoracodorsal, and brachial plexus as well as division of the anterior and middle scalene muscle and resection of the segment of the first rib overlying the brachial plexus. The supraclavicular fat pad edges are then sutured together using 3-0 Vicryl suture in a simple interrupted fashion.

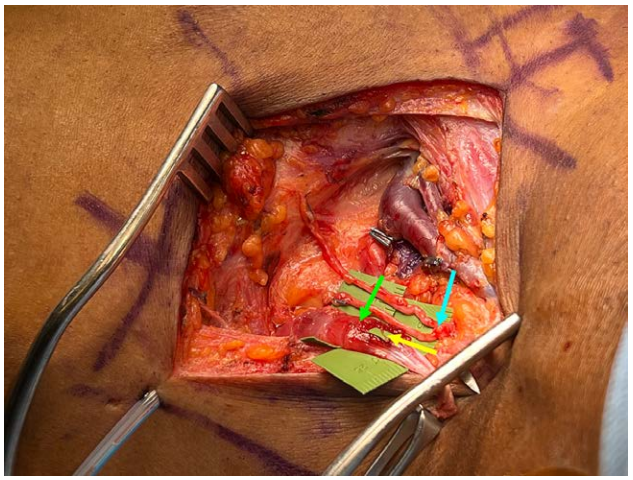

Fig. 2. The inferior belly (green arrow) of the OM brought to the superficial layer and the motor branch (yellow arrow) over the green background. The main trunk of the supraclavicular nerve is identified by the blue arrow.

Takeaways

Question: How to prevent neuroma formation and chronic pain at the supraclavicular area secondary to supraclavicular incisions.

Findings: Ten patients underwent TMR of the SCN to the motor branch of the OM following the TOS procedure through a supraclavicular approach. On follow-up, all patients denied supraclavicular pain or hypersensitivity.

Meaning: This new technique is an effective approach to prevent the formation of neuromas and chronic pain at the supraclavicular area following the TOS procedure through a supraclavicular incision.

The inferior belly of the OM is then brought to the superficial layer and a checkpoint nerve stimulator is used to identify the motor branch of the OM. The branches of the SCN are divided at the end to freshen the edge and an end-to-end coaptation with the motor branch of the OM is performed to allow a pathway for nerve spreading and regeneration into the muscle flap. The nerve transfer is carried out using 8-0 nylon epineural sutures. The coaptation site is then buried into the fibers of the muscle flap to allow sprouting of these nerves into the surrounding muscle flap (Fig. 3). **(See Video 2 [online]**, which displays microcoaptation of the supraclavicular nerve to the motor branch of the OM.)

RESULTS

A total of 10 patients underwent the procedure. The patients were operated on by a single surgeon from February 2021 to April 2022. The age of the patients at the time of the surgery ranged from 32 to 61 years old with a mean age of 38. The causes of NTOS were trauma in four patients, idiopathic in three, fall in one, previous orthopedic surgery in one, and mass effect in one patient. The duration of symptoms before the procedure ranged from a few months to 12 years in the case of traumatic NTOS. All patients were diagnosed based on clinical findings including history and physical examination. Additionally, patients underwent electromyography of the muscles in the arm and magnetic

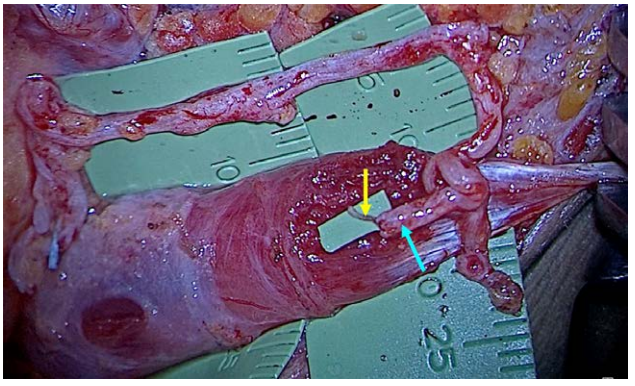

Fig. 3. Microscopic view of the motor branch of the OM (yellow arrow) coapted with the supraclavicular nerve (blue arrow).

resonance neurography (MRN). The additional time added by the new technique was 15 minutes on average. There were no complications related to the new technique itself in the follow-up period with the 10 patients operated on. The average follow-up was 8 months. Of the 10 patients operated on, five of them have already completed 1-year follow-up and all the patients continue to deny supraclavicular pain or hypersensitivity. They also referred progressive improvement of strength and recovery of sensation on the arm and hand ipsilateral to the surgery. Of the 10 patients, one is still taking opioids secondary to forearm pain related to persistent brachial plexus compression; however, this is not associated with our new technique for prevention of neuromas in the supraclavicular area.

DISCUSSION

NTOS is responsible for the majority of TOS cases, representing more than 80% of the patients with the remaining 20% of the cases involving venous or arterial compression.[7,8] Diagnosis of NTOS is often made by exclusion and most of the time is very challenging.[9,10] The syndrome is mainly caused by compression of the brachial plexus by the thoracic outlet structures, most commonly the anterior and medial scalene muscles and the first rib and generally present with pain and weakness on the ipsilateral arm and hand.[10]

Exposure is critical for this highly complex area that contains major blood vessels (subclavian artery and vein), the thoracic duct on the left side, the phrenic nerve, and the brachial plexus with its distal nerve branches.[4,11]

The TMR of the SCN to the motor branch of the OM has not been published previously. With this new technique, stretch and desiccation are avoided and excellent exposure of the brachial plexus is obtained. TMR has already been proved to be an efficient technique for neuroma prevention.[12–14] If the fresh edges of the transected SCN are not targeted to a motor nerve, it can lead to the formation of neuroma and chronic pain. Vögelin et al[15] described the occurrence of pain and hyperesthesia in the territory of the supraclavicular nerves with four of the 29 patients requiring desensitization therapy after TOS procedures. The 41st edition of *Gray's Anatomy* mentions the formation of neuroma after the transection of SCN through supraclavicular incisions.[16]

The main function of the OM is to depress the hyoid bone after it has been elevated, which generally happens during speaking and swallowing. However, most of this function is already performed by the other infrahyoid muscles,[17] which allow the division of the OM without repair in multiple surgeries including modified radical neck dissection, reconstruction of head and neck defects, or as an option in treating highly bowed vocal folds.[18,19] Therefore, the muscle can be considered as an optimal muscle target for reinnervation.

The technique requires basic microsurgical training and does not contain highly complex steps or offer major challenges. One of the limitations is not being able to find the motor branch of the OM, which did not occur in the 10 patients we operated on. The nerve stimulator provides reassurance during the procedure and the microscope allows easy visualization of the motor branch.

CONCLUSION

TMR of the SCN to the motor branch of the OM has not been explored previously. Given that most of the sensation over the clavicle, anteromedial shoulder, and proximal chest is provided by this nerve, preventing neuroma formation, and consequently, chronic pain over this area is extremely important to achieve good outcomes after TOS procedures. The literature clearly portrays how complex this syndrome is and the importance of further developing additional approaches to treat the whole spectrum of the pathology, including the pain and its multiple forms of manifestation.

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