Double Nerve Transfer to the Axillary Nerve in Traumatic Upper Trunk Brachial Plexus Injuries Using an Axillary Approach: Anatomical Description and Preliminary Case Series

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BACKGROUND: Restoration of shoulder external rotation remains challenging in patients with C5/C6 brachial plexus injuries (BPI).

OBJECTIVE: To describe a double-nerve transfer to the axillary nerve (AN), targeting both its anterior and posterior motor branches, through an axillary route.

METHODS: A total of 10 fresh-frozen cadaveric brachial plexuses were dissected. Using an axillary approach, the infraclavicular brachial plexus terminal branches were exposed, including the axillary, ulnar, and radial nerves. Under microscopic magnification, the triceps long head motor branch (TLHMB), anteromedial fascicles of the ulnar nerve (UF), the anterior motor branch of the axillary nerve (AAMB), and the teres minor motor branch (TMMB) were dissected and transected to simulate 2 nerve transfers, THLMB-AAMB and UF-TMMB. Several anatomical criteria were assessed, including the overlaps between fascicles when placed side-by-side. Six patients with C5/C6 BPI were then operated on using this technique.

RESULTS: TLHMB-AAMB and UF-TMMB transfers could be simulated in all specimens, with mean overlaps of 37.1 mm and 6.5 mm, respectively. After a mean follow-up of 23 mo, all patients had recovered grade-3 strength or more in the deltoid and teres minor muscles. Mean active shoulder flexion, abduction, and external rotation with the arm 90° abducted were of 128°, 117°, and 51°, respectively. No postoperative motor deficit was found in the UF territory.

CONCLUSION: A double-nerve transfer, based on radial and ulnar fascicles, appears to be an adequate option to reanimate both motor branches of the AN, providing satisfactory shoulder active elevations and external rotation in C5/C6 BPI patients.

KEY WORDS: Axillary nerve, Nerve transfer, Brachial plexus, Axillary approach, Teres minor, External rotation, Shoulder

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In approximately 15 of cases of brachial plexus stretch injuries (BPI), posttraumatic deficits are limited to the C5 and C6 roots territory.[1] Active shoulder flexion, abduction, and external rotation are usually compromised in this population because of the palsy of the deltoid, teres minor, and spinati muscles; with the additional palsy of the biceps and brachialis muscles, elbow flexion is most commonly impaired as well.[2] When the preoperative delay is less than 6 to 12 mo, surgical management of such lesions may be conducted primarily using neurologic procedures. In order to address all deficits at once, 3 nerves need to be reinnervated, including the suprascapular nerve (SSN), the axillary nerve (AN), and the musculocutaneous nerve (MCN).[3]

ABBREVIATIONS: AAMB, anterior motor branch of the axillary nerve; **AN,** axillary nerve; **BMRC,** British Medical and Research Council; **BPI,** brachial plexus injuries; **MCN,** musculocutaneous nerve; **SSN,** suprascapular nerve; **TLHMB,** triceps long head motor branch; **TMMB,** teres minor motor branch; **UF,** ulnar nerve

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FIGURE 1. *Left upper limb of an anatomic specimen showing the skin incision drawing, which is a broken line starting from the lateral border of the pectoralis major to the proximal half of the arm medial aspect, allowing to reanimate the motor branches of both the musculocutaneous and the ANs.*

Regarding the AN reinnervation, 2 procedures may be used depending on the injury level. Historically, sural nerve grafts were positioned between a viable cervical root stump and the AN viable stump.[4] In 2003, Leechavengvongs et al[5] described the transfer of the triceps long head motor branch (TLHMB) of the radial nerve to the anterior motor branch of the axillary nerve (AAMB). Allowing addressing both pre- and postganglionic lesions, this technique became popular among the surgical community over the past decade, providing comparable functional outcomes to traditional grafting.[6,7] However, because the teres minor muscle is not reanimated, active shoulder external rotation mainly relies on the reinnervation of the infraspinatus muscle, which may lead to insufficient outcomes.[8,9]

The purposes of this study were to outline the anatomical features of a double-nerve transfer, based on radial and ulnar fascicles, to both the anterior and posterior motor branches of the AN through an anterior route and to assess the functional outcomes that can be expected in patients suffering from C5/C6 BPI, with special attention given to shoulder external rotation.

METHODS

Cadaveric Study

Our institutional anatomic bequest program obtained 5 right and 5 left fresh-frozen cadaveric hemi-torsos, which were thawed at ambient temperature the night preceding dissection. The donors were 4 men and 6 women and had a mean age of 68 ± 14 yr (range, 47-82 yr).

With the anatomical subject placed supine with the arm 90° abducted from the torso, an anterior axillary approach was used, with a broken-line incision that started from the lateral border of the pectoralis major muscle and extended to the proximal half of the arm medial aspect (Figure 1). The axillary fascia was opened in order to retract the axillary fat pad inferiorly and expose the latissimus dorsi tendon.[10] The axillary vascular bundle along with the infraclavicular brachial plexus were then retracted superiorly to expose the AN entering the quadrangular space. Under microscope magnification, the AN was dissected to identify its terminal division, giving an anterior branch (ie, AAMB) and a posterior branch. Further dissection of the posterior branch allowed identifying a subsequent division, giving 2 branches as well, including 1 motor, posterior (ie, TMMB), and 1 sensory, between the 2 motor branches (Figure 2). In order to confirm their nature, both motor branches, anterior and posterior, were followed to their entry area into the deltoid and teres minor muscles, respectively. To increase the motor branches lengths, intraneural dissection was conducted in a retrograde fashion, separating the AAMB and TMMB from the sensory branch as proximally as possible, until intraneural plexus formations precluded any further dissection. The radial nerve was then exposed, and the TLHMB was identified and dissected until its entry into the triceps muscle belly.[5] Finally, the ulnar nerve (UF) was identified within the axilla fossa, and intraneural microdissection was initiated at the level of the upper border of the latissimus dorsi tendon; a single fascicle from the UF antero-medial quadrant, assumed to correspond to one of the extrinsic flexor fascicles,[11] was isolated (Figure 3). Once all 4 motor branches were identified, they were cut as proximal as possible for the AN branches and as distal as possible for the ulnar and radial fascicles. Finally, the TLHMB and AAMB were brought together flush, whereas the UF and TMMB were positioned similarly, simulating end-to-end nerve transfers (Figure 4).

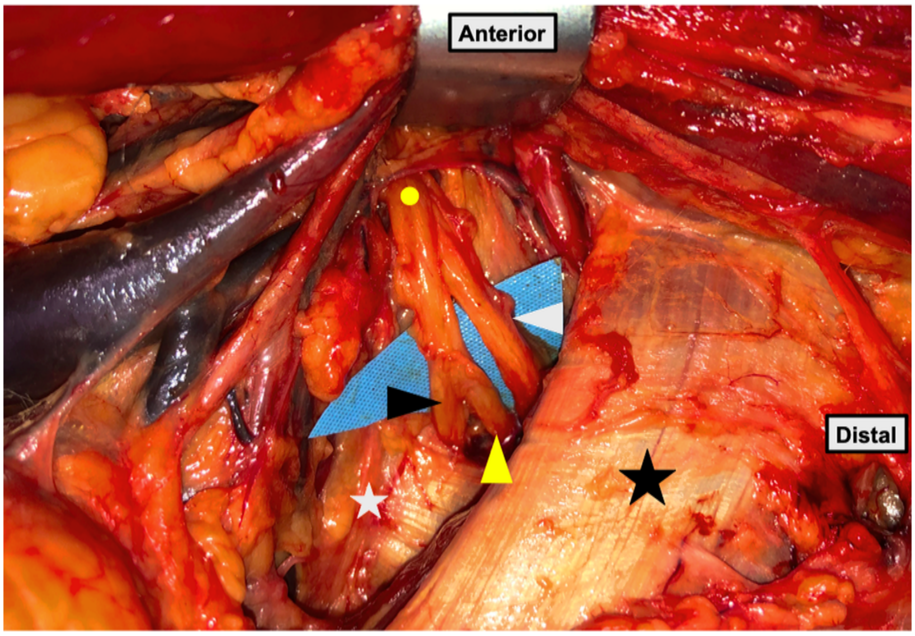

FIGURE 2. *Once the axillary fat pad and neurovascular bundle are mobilized posteriorly and anteriorly, respectively, the AN (yellow dot) is found entering the quadrangular space between the latissimus dorsi (black star) and the triceps long head (white star) tendons. Please note the successive AN divisions, proximally between the anterior motor branch (white arrowhead) and the posterior branch, and then distally between the sensory branch (yellow arrowhead) and the TMMB (black arrowhead) (anatomic specimen, left upper limb).*

Using a slide caliper with an accuracy of 0.1 mm (Mitutoyo, Kawasaki, Japan), different measurements were made under microscope magnification. These included the lengths and stump diameters of all 4 branches, along with the overlap that could be obtained for each transfer (ie, TLHMB-AAMB and UF-TMMB) with the stumps placed side-by-side without tension.

Clinical Study

All patients presenting with a C5/C6 BPI who underwent a double-nerve transfer to reanimate the AN between November 2016 and October 2017 at our institution were included.

Patients were placed supine with the head rotated toward the contralateral shoulder, with the whole upper limb and ipsilateral hemitorso draped free. A V-shaped supraclavicular approach was first used to expose the supraclavicular plexus and reconstruct the SSN. In patients presenting with a postganglionic lesion and at least 1 graftable root, sural nerve grafts would have been used; in patients without any graftable root, C7 pectoral fascicles (C7PF) were transferred directly to the SSN.[12] Then, with the arm 90° abducted from the body, an anterior axillary incision was made and was extended to the proximal half of the medial side of the arm in order to reconstruct both the AN and the MCN through the same approach. Starting at the distal part of the incision, a double-nerve transfer was performed to reanimate the elbow flexion (ie, ulnar-to-biceps and median-to-brachialis, U-B/M-B).[13] Using the proximal part of the incision, an additional double nerve transfer to the AN was conducted. As previously described, the AN was dissected in order to separate the sensory branch from the 2 motor branches (ie, AAMB and TMMB); intraoperative electrostimulation (Vari-Stim, Medtronic, Dublin, Ireland) was used on both motor branches before any transection to confirm their palsy. The radial nerve was dissected to expose the TLHMB. Once its nature and satisfactory function was confirmed by electrostimulation, the TLHMB was transferred to the AAMB. The UF was exposed at the level of the latissimus dorsi tendon upper border, and a fascicle to the extrinsic flexor muscles was transferred to the TMMB. Considering that UF selection relied on distal muscular response to intraoperative electrostimulation, it was of primary importance to reinnervate the biceps branch before the TMMB in order to avoid transferring to the biceps a fascicle that had been proximally transferred to the TMMB.

Investigations were conducted in accordance with the ethical standards of the Declaration of Helsinki of 1964 and with the MR-003 methodology[14]; the protocol of the study was registered in the CNIL register (no. 2 205 341 v 0), and all the patients were informed and consented before data collection and/or analysis. The retrospective review of the charts provided the demographics and medical history of the patients, the clinical findings that were observed during initial examination, the surgical procedures that had been performed, and the follow-up data. Pre- and postoperative muscle strength was assessed according to the British Medical and Research Council (BMRC) grading system, whereas active ranges of motion (ie, elbow flexion and extension and shoulder flexion, abduction, external rotation with the arm at the side of the body – ER1, external rotation with the arm 90° abducted – ER2, and internal rotation) were measured with a goniometer.

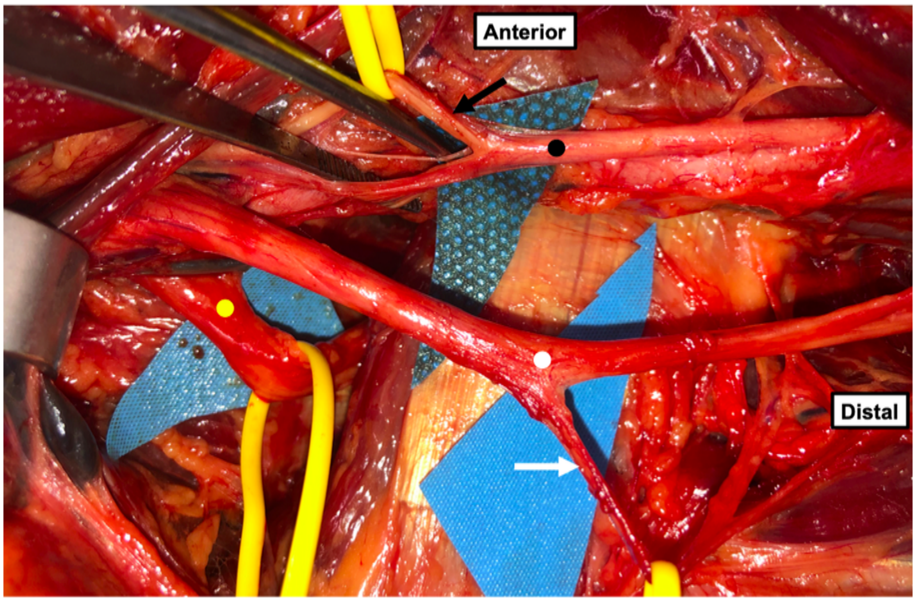

FIGURE 3. *Once the AN (yellow dot) is tagged, the infraclavicular plexus is dissected in order to expose the radial (white dot) and ulnar (black dot) nerves. The TLHMB (white arrow) and an anteromedial ulnar fascicle (black arrow) are tagged as well and prepared for transfers (anatomic specimen, left upper limb).*

RESULTS

Anatomical Study

With mean overlaps of 37.1 ± 9.3 mm (range, 23.8-48.5 mm) for the TLHMB-AAMB transfer and 6.5 ± 2.7 mm (range, 2.1-12.1 mm) for the UF-TMMB transfer, tensionless end-to-end nerve sutures could be simulated in all specimens for both transfers (Table 1). No particular anatomical variation was noted.

Clinical Outcomes

Six male patients fulfilled our inclusion criteria, with a mean age of 37 ± 14 yr (range, 24-64 yr) at the time of surgery. One of them spontaneously recovered satisfactory active elbow flexion; subsequently, no MCN reconstruction was attempted. Similarly, SSN reconstruction was not performed in 1 patient because of satisfactory responses of both spinati muscles to intraoperative electrostimulation. Additionally, 1 patient presented with a chronic and nonreparable posterosuperior rotator cuff tear on the preoperative shoulder magnetic resonance imaging scan (ie, muscular fatty infiltration and tendon retraction at the glenoid level of both spinati muscles); subsequently, no SSN reconstruction was attempted.

After a mean follow-up of 23 ± 4 mo (range, 18-27 mo), grade-3 strength or above was observed in all patients, both in the deltoid and teres minor muscles (Table 2). Subsequently, all patients achieved at least 90° of active shoulder flexion and 10° of active shoulder ER2 (Figure 5). In addition, all patients but 1 achieved positive shoulder ER1. The patient with the rotator cuff tear still had a positive ER1-lag sign; however, with satisfactory active control of the teres minor muscle, the lag sign was limited to −20° at last follow-up against −80° on preoperative examination.

With particular attention paid to the UF, which was harvested at 2 different levels in 5 cases (ie, axilla and humeral canal), no motor deficits were observed postoperatively. A transient sensitive deficit was noted in 2 patients (ie, grade-1 paresthesia in the fourth and fifth fingers), with full spontaneous recovery observed within 4 mo after surgery (**Table**, **Supplemental Digital Content**).

DISCUSSION

In this study, we demonstrated the anatomic feasibility and outlined the technical details of a double nerve transfer to the AN motor branches through an axillary approach using radial and ulnar fascicles as donors. We also reported the preliminary functional results of the first 6 patients who underwent such reconstruction at our institution in the setting of a C5/C6 BPI. By performing partial harvests of the radial and UF at a proximal level, satisfactory outcomes were observed, combining acceptable postoperative shoulder motions and no motor deficit in the territory of the harvested nerves. Considering the glenohumeral axial muscular imbalance resulting from proximal BPI,

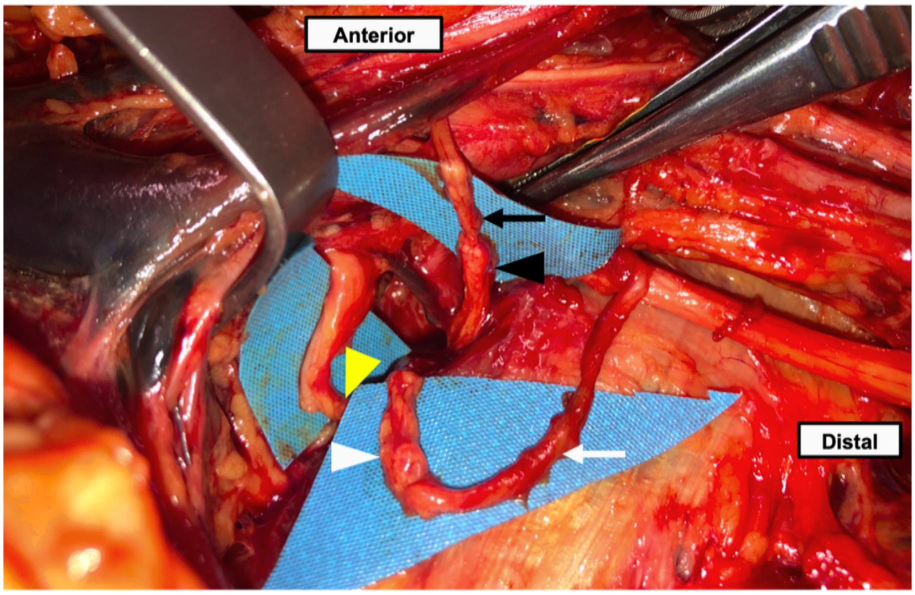

FIGURE 4. *After cutting the axillary motor branches as proximal as possible and the radial and ulnar fascicles as distal as possible, the TLHMB (white arrow) is brought together flush with the axillary anterior motor branch (white arrowhead), whereas the ulnar fascicle (black arrow) is brought together flush with the TMMB (black arrowhead), simulating tensionless epiperineural sutures. Please note the remaining sensory branch of the AN (yellow arrowhead) entering the quadrangular space (anatomic specimen, left upper limb).*

TABLE 1. Anatomical Measurements[a]

	TLHMB-AAMB transfer	
Nerve	**Length[b]**	**Stump diameter**
TLHMB	54.4 ± 9.8 (40;64.1)	2.7 ± 0.6 (1.9;3.5)
AAMB	33.3 ± 4.9 (25.4;41.9)	3.2 ± 0.6 (2.1;4.1)
Overlap with the 2 stumps placed side-by-side		37.1 ± 9.3 (23.8;48.5)
	UF-TMMB transfer	
Nerve	**Length**	**Stump diameter**
UF	28.3 ± 6 (19.1;37.4)	2.3 ± 0.5 (1.8;3.2)
TMMB	24.4 ± 8.6 (13.9;36.6)	2.2 ± 0.5 (1.4;3)
Overlap with the 2 stumps placed side-by-side		6.5 ± 2.7 (2.1;12.1)

[a]Data reported in millimeters as mean ± standard deviation (range).
[b]Axillary motor branches were measured from their proximal stumps to their entry into the quadrangular space (ie, triceps tendon); ulnar and radial fascicles were measured from their division from the nerve to their distal stump.
TLHMB: triceps long head motor branch; AAMB: axillary anterior motor branch; UF: ulnar fascicle; TMMB: teres minor motor branch.

we believe that reanimating as many shoulder external rotators as possible is crucial to obtain satisfactory shoulder active function.

Teres Minor Reconstruction

As one of the 2 primary shoulder external rotators, the teres minor muscle is of primary importance regarding shoulder function. Kuechle et al[15] demonstrated that if the infraspinatus had the greatest ER1-moment arm, it was the teres minor that had the greatest ER2-tendon excursion, both in the sagittal, scapular, and coronal planes. In addition, Ackland et al[16] reported on the primary role that both muscles (ie, teres minor and infraspinatus) played regarding posterior glenohumeral stabilization in the transverse plane, balancing the action of the internal rotators. Such biomechanical data appear to be of primary importance when considering glenohumeral function and have already been confirmed clinically. In degenerative rotator cuff impairments, Collin et al[17] reported on significantly lower external rotation ranges of motion, both at 0° and 90° of shoulder abduction, in cases of teres minor tears combined with an infraspinatus tear.

Despite these biomechanical and clinical findings, teres minor reinnervation is not commonly performed in proximal BPI patients (Table 3).[7,18] Therefore, active shoulder external rotation will mainly rely on the reinnervation of the infraspinatus. Pruksakorn et al[19] noted great inadequacies when comparing counts of myelinated axons found in the suprascapular and the spinal accessory nerves, (ie, 1603 ± 416 and 6004 ± 647, respectively). Moreover, Terzis and Kostas[9] showed that, following SSN reconstruction, infraspinatus activity was significantly lower than supraspinatus activity. These data may explain some of the limited results regarding shoulder external rotation that were previously outlined by several teams using this transfer (ie, SAN-to-SSN).[8,9,20,21]

TABLE 2. Cohort Details[a]

	Demographics	
Patients No)	**Age years)**	**Sex ratio M/F, No)**
6	37 ± 14 (24;64)	6/0
	Preoperative examination	
Motions	**Active ranges of motion degrees)**	**Strength values BMRC/5)**
Elbow flexion	13 ± 33 (0;80)	0.5 ± 1.2 (0;3)
Elbow extension	−5 ± 8 (−20;0)	4.8 ± 0.4 (4;5)
Shoulder flexion	0 ± 0 (0;0)	0 ± 0 (0;0)
Shoulder abduction	3 ± 8 (0;20)	0.2 ± 0.4 (0;1)
Shoulder ER1	−67 ± 23 (−80;−20)	0.3 ± 0.8 (0;2)
Shoulder ER2	−48 ± 16 (−60;−20)	0 ± 0 (0;0)
Shoulder internal rotation	105 ± 15 (90;130)	4.7 ± 0.5 (4;5)
	Surgical procedures	
MCN No)	**SSN No)**	**AN No)**
U-B/M-B (5)	C7PF-SSN (4)	TLHMB-AAMB/UF-TMMB (6)
None (1)	None (2)	
	Preoperative delay (months) 4.2 ± 1.5 (3;7)	
	Postoperative examination	
Motions	**Active ranges of motion degrees)**	**Strength values BMRC/5)**
Elbow flexion	117 ± 10 (100;130)	4.2 ± 0.4 (4;5)
Elbow extension	−8 ± 13 (−30;0)	5 ± 0 (5;5)
Shoulder flexion	128 ± 34 (90;170)	3.8 ± 0.4 (3;4)
Shoulder abduction	117 ± 33 (80;160)	3.8 ± 0.4 (3;4)
Shoulder ER1	38 ± 36 (−20;80)	3.5 ± 0.8 (2;4)
Shoulder ER2	51 ± 31 (10;85)	3.7 ± 0.5 (3;4)
Shoulder internal rotation	107 ± 14 (90;130)	4.3 ± 0.5 (4;5)
	Follow-up (months) 23.2 ± 3.8 (18;27)	

[a]Data reported as mean ± standard deviation (range), unless otherwise indicated.
No: number of patients and/or procedures (reported as absolute values); M: male; F: female; BMRC: British Medical Research Council grading system; ER1: external rotation with the arm at the side of the trunk; ER2: external rotation with the arm 90° abducted; U-B/M-B: ulnar-to-biceps and median-to-brachialis nerve transfers; C7PF-SSN: C7 pectoral fascicles-to-suprascapular nerve transfer; TLHMB-AAMB/UF-TMMB: triceps long head motor branch-to-axillary anterior motor branch and ulnar fascicle-to-teres minor motor branch nerve transfers.

The Axillary Approach

Most commonly, nerve transfers to the AN are performed through a posterior approach.[5,22,23] In 2007, Bertelli et al[10] proposed an axillary approach using the latissimus dorsi instead of the teres major as a landmark. When using this route for AN reconstruction in C5/C6 BPI patients, all transfers can be performed without any intraoperative position change, thus saving operating time. Moreover, such approach facilitates the intraneural dissection of both AN motor branches, which is a key element in achieving tensionless epiperineural sutures. However, while using this approach, Bertelli et al[10] harvested only the THLMB as a donor, except in 1 patient presenting a reduced diameter of the TLHMB, for whom they used the triceps medial head motor branch as well. Considering the diameter of the TMMB that we observed in our dissections, we believe that using another independent donor is crucial to achieve satisfactory reinnervations of both recipients. Khair et al[24] supported this macroscopic impression, reporting greater axonal counts in the AAMB than in the TLHMB (ie, medians of 4052 and 2302 axons, respectively). Therefore, with the possibility to expose the whole infraclavicular plexus and its terminal branches so they can be used as donors, using an axillary approach appears adequate to such reconstruction.

Ulnar Nerve Harvests

By performing a proximal extension of the humeral canal exposure that is commonly used to reconstruct the MCN motor branches, this approach enables harvesting the UF at 2 different levels.

In order to limit UF impairment while reanimating the TMMB, an option would be to restore elbow flexion using a single transfer, median-based, as proposed by Sungpet et al.[25] Indeed, comparative studies seem to show that, regarding elbow flexion reanimation, there is no significant differences between

FIGURE 5. *A 28-yr-old patient suffering from a C5/C6 BPI demonstrating satisfactory shoulder function 26 mo after a double-nerve transfer to the AN motor branches (ie, TLHMB-AAMB/UF-TMMB) associated with a single transfer to the SSN (ie, C7PF-SSN) and a double-nerve transfer to the MCN motor branches (ie, U-B/M-B).*

single and double transfers in terms of strength and/or functional outcomes.[26,27] However, to the best of our knowledge, only 2 comparative studies have been published on this topic, including a retrospective one,[26] and a prospective one with limited sample size (ie, 40 patients analyzed in total instead of 84 in each group, as predetermined by the power analysis).[27] Therefore, considering the primary importance of elbow flexion as well as the lack of strong scientific evidence regarding the equivalence of single and double transfers to reanimate it, we harvested 2 UF fascicles in all our patients. Despite such double harvest, the only clinically detectable postoperative deficits were sensory and transient, most probably caused by excessive fascicular traction during intraneural dissection. We believe that such finding can be explained by the very proximal nature of both harvests, allowing intraneural plexus formations to maintain sufficient innervation.[28]

Regarding fascicular selection, the cadaveric study was literature-based, and fascicles were harvested from the anteromedial quadrant of the nerve.[11] In clinical cases, fascicular selection was based on intraoperative electrostimulation. A comprehensive intraneural dissection was performed at the harvest levels, and fascicular stimulation was conducted in order to separate motor from sensory fascicles. Once motor fascicles were identified within the nerve, the ones with the greatest extrinsic response were selected, distally for the biceps branch and then proximally for the teres minor branch; however, as previously stated, major interfascicular overlapping remains at these levels within the nerve, and minor intrinsic response was observed as well when stimulating the selected fascicles. Therefore, because the harvested fascicles were not pure extrinsic fascicles, postoperative intrinsic motor deficits most likely have occurred, but those were infraclinic in all cases. This lack of obvious clinical consequences following the harvest of intrinsic fascicles within the UF was first outlined by Bertelli and Ghizoni[29] in upper trunk BPI and was then confirmed in more extensive palsies.[30]

When performing doubles harvest, staging of the transfers is crucial. Indeed, because selection of donor fascicle relies on preharvest intraoperative electrostimulation, performing the distal transfer first is mandatory. Indeed, once the first ulnar fascicle is transferred to the biceps branch, there is no risk to select the same one when stimulating ulnar fascicles more proximally for the second transfer, because this fascicle is already cut, and no response can be produced. However, if the proximal transfer is made first, because the nerve is not cut between the stimulator and the muscle and no Wallerian degeneration has occurred yet, downstream stimulation of the same fascicle, when performing the distal transfer, will produce a motor response.

Limitations

The findings of this study should be taken in the light of its inherent limitations. First, as a retrospective case series, prospective data collection and comparison groups are lacking; subsequently, this limits our ability to compare such double reinnervation to classic reinnervation of the sole AAMB. In addition, this study was conducted on a small size sample because of the relative rarity of proximal BPI. Nonetheless, with positive values of active shoulder ER1 and ER2 in all patients who had an intact rotator cuff, such technique appears to be promising.

CONCLUSION

In conclusion, a double-nerve transfer to the anterior and posterior motor branches of the AN is anatomically feasible and appears to provide satisfactory clinical outcomes in terms of shoulder external rotation without increasing the morbidity of the reconstruction. Using an axillary approach as a proximal extent of the humeral canal exposure allows proper staging of

TABLE 3. Nerve Transfers to Restore External Rotation in Upper-Trunk Brachial Plexus Palsy

Authors	Year	Follow-up months)	Transfers No)	Stabilized shoulders No)	Mean active ranges of motion °)		BMRC strength No)	
					ER1	ER2	ER1	ER2
Alnot et al[4]	1998	≥36	SAN-to-SSN (10)	6	NA	NA	≥3 (6)	NA
Leechavengvongs et al[5]	2003	20	SAN-to-SSN (7)	7	NA	NA	NA	NA
Leechavengvongs et al[20]	2006	32	SAN-to-SSN (15)	15	7	NA	NA	4 (7)/3 (4) 2 (2)
Bertelli and Ghizoni[8]	2007	31	SAN-to-SSN TB-to-TMMB (8)	8	31	NA	NA	≥3 (8)
			SAN-to-SSN (6)	6	−9	NA	NA	5 (3)/3 (3)
Bertelli and Ghizoni[29]	2010	24-26	SAN-to-SSN TB-to-TMMB (28)	28	35	NA	NA	5 (16)/4 (9) 3 (2)/2 (1)
Baltzer et al[21]	2016	28	SAN-to-SSN (9)	7	22	NA	≥3 (3) 2 (6)	NA
Current study	2019	23	C7PF-SSN UF-TMMB (6)	6	38	51	4 (4)/3 (1) 2 (1)	4 (4)/3 (2)

No: number of patients/cases; BMRC: British Medical Research Council grading system; SAN: Spinal accessory nerve; SSN: suprascapular nerve; TB: triceps branch; TMMB: teres minor motor branch; C7PF: pectoral fascicle from the C7 root; UF: ulnar fascicle; ER1: shoulder external rotation with the arm at the side of the trunk; ER2: shoulder external rotation with the arm 90° abducted; NA: not available.

UF harvests while saving intraoperative time. Prospective comparative studies are now needed to prove the benefit of such reconstruction over the classic single transfer to the AN anterior branch.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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Supplemental Digital Content. Table. Detailed clinical data.

COMMENT

We congratulate the authors in their cadaveric feasibility study and small clinical series demonstrating a new method for upper trunk brachial plexus repair in which dual nerve transfers are used for reinnervation of the axillary nerve. Such a transfer was performed in the setting of simultaneous distal ulnar fascicle transfer for reinnervation of the elbow flexion. The authors demonstrate generous overlap of the involved fascicles in their cadaveric study and promising clinical results with all patients achieving antigravity strength in the deltoid and teres minor musculature. Despite dual proximal and distal ulnar nerve fascicle donation, the authors report no loss of intrinsic muscle strength in their series of six patients. Rather, transient sensory deficits were noted.

These results are intriguing, both from the perspective of functional recovery of the axillary nerve and the absence of noticeable postoperative ulnar distribution motor deficits. Most surgeons would take pause before harvesting two ulnar fascicles: First, it may be difficult to isolate multiple promising fascicles for transfer. Similarly, dual transfer in this manner may result in inadvertent harvest of the same fascicle. Second, generous donation of ulnar nerve fascicles increases risk postoperative intrinsic hand weakness. In our opinion, single distal transfer of a median nerve fascicle for elbow flexion may pose less risk with similar functional outcomes. However, as the authors appropriately note, current literature regarding the benefit of dual versus single nerve transfers is limited. Further study is needed to validate the appropriate number of nerve transfers to achieve maximum benefit.

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