J Shoulder Elbow Surg (2020) 29, e341–e344

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Contemporary nerve reconstruction for iatrogenic musculocutaneous nerve injury after shoulder stabilization surgery

Scott Ferris, MBBS, FRACS[a,b,*], **Isabella Reid, B-BMed, MD**[b]

[a]*Victorian Plastic Surgery Unit, St Vincent's Private Hospital, East Melbourne, VIC, Australia*
[b]*Plastic, Hand and Faciomaxillary Surgery, The Alfred Hospital, Melbourne, VIC, Australia*

Keywords: Musculocutaneous; nerve; injury; transfer; shoulder; stabilization; Latarjet

Coracoid transfer stabilization surgery to correct anterior shoulder instability has been brought to the attention of nerve reconstructive surgeons due to the significant complication of peripheral nerve injury, most commonly the musculocutaneous nerve (MCN).[6,8] The rate of nerve injury after open coracoid transfer is 1.2%-1.8%, and the rate of MCN injury specifically is 0.43%-0.6%.[3,8] The rate of nerve injury after arthroscopic coracoid transfer has been reported to be 0.6% involving exclusively the MCN.[4]

During coracoid transfer surgery, a portion of the coracoid is osteotomized and transferred to the glenoid to block excessive translation.[18] The Latarjet procedure is the common method of coracoid-transfer shoulder stabilization.[12] Variations of this procedure include the Bristow, Magnuson-Stack, and Putti-Platt procedures. The Latarjet procedure is achieved via the deltopectoral approach. The coracobrachialis is retracted laterally, and a split is made within the subscapularis muscle.[11] Older studies report a constant 5 cm distance from the base of the coracoid tip to the entry point of the MCN into the conjoint tendon of the short head of the biceps and the coracobrachialis.[15,17] This "surgical safe zone" has been contested by more recent studies that have found the MCN to vary and may enter the conjoint tendon at distances shorter than 5 cm.[5,7,9,11] Studies have hypothesized that the short relative length of the MCN puts it at risk for traction injuries during exposure of the Latarjet procedure.[2,9]

There have been great advances in peripheral nerve surgery with the advent of nerve transfer. Nerve transfer is a reconstructive technique whereby an uninjured proximal nerve is coapted to an injured distal nerve to restore function.[13] Oberlin et al[19] in 1994 pioneered a single fascicular ulnar nerve transfer to the biceps branch of the MCN. Mackinnon et al[22] subsequently reported a double fascicular transfer of redundant ulnar and median nerve fascicles to brachialis and biceps branches of the MCN. These nerve transfers for elbow flexion incorporate the now well-accepted benefits of a single nerve coaptation, close to motor target, using an expendable donor, to drastically improve outcomes in proximal nerve injury. Despite these benefits, nerve transfer has yet to be described in detail as a reconstructive technique for MCN injury after coracoid transfer surgery.

Case series

This series is the first to report in detail nerve transfer for the management of iatrogenic MCN palsy after coracoid transfer shoulder stabilization surgery. It characterizes options and outcomes for patients treated during the era of familiarity with nerve transfer for restoration of lost biceps and brachialis function.

Ethics approval was received from St Vincent's Hospital Research Ethics Committee (LNR/16/SVHM/77).

*Reprint requests: Scott Ferris, MBBS, FRACS, Plastic, Hand and Faciomaxillary Surgery, The Alfred Hospital, 55 Commercial Road, Melbourne, VIC 3004, Australia.

E-mail address: scott@scottferris.com.au (S. Ferris).

https://doi.org/10.1016/j.jse.2020.03.025

Table I Reconstructive techniques for patients with musculocutaneous nerve injury after shoulder stabilization surgery

Patient	Type of nerve injury	EMG findings before reconstructive surgery	Time to reconstructive surgery	Reconstructive technique	Duration of follow-up (mo)	Result (MRC muscle power/ active range of motion of elbow flexion (°)
1	Isolated MCN	Complete denervation of biceps and brachialis	7 mo	Dual motor nerve transfer to biceps and brachialis	16	5/5 0-140
2	MCN and axillary	Before first recon: no EMG Before second recon: severe active neuropathy biceps, brachialis, and deltoid	Surgery 1: 4 d Surgery 2: 8 mo	Surgery 1: cable grafting to MCN and axillary nerve Surgery 2: median fascicular transfer to brachialis + 2 × triceps nerve transfer to anterior axillary nerve	32	5/5 0-135
3	Isolated MCN	Severe chronic neuropathy of biceps with features of reinnervation (brachialis not reported)	5.5 mo	Shortening tenorrhaphy of normal brachioradialis	10	4+/5 0-150
4	Isolated MCN	Complete denervation of biceps (brachialis not reported)	2.5 mo	Resection of damaged MCN segment + ulnar fascicular nerve transfer to biceps	24	5/5 0-140

EMG, electromyography; *MRC*, Medical Research Council scale[16]; *MCN*, musculocutaneous nerve.

Four patients were treated over a 2-year time frame. Timing of referral ranged significantly, with surgical reconstruction therefore ranging between 4 days and 7 months from the date of injury (see Table I).

Patient 1 was referred late after a Latarjet procedure for an isolated MCN palsy. Prereconstruction EMG confirmed complete denervation of the biceps and brachialis. At 7 months after injury, the patient underwent exploration with immediate dual motor nerve transfers, using an ulnar fascicle donor to the biceps nerve and a median fascicle donor to a brachialis nerve. The patient regained grade 5 power and 140° of elbow flexion.

Patient 2 had a neurologic and vascular injury recognized on table during an open shoulder stabilization procedure. The patient had vascular reconstruction immediately and, once stabilized, was transferred for nerve reconstruction. Four days after injury the patient underwent exploration and immediate primary cable grafting to the musculocutaneous and axillary nerve that were 80 and 100 mm long, respectively. Eight months after primary reconstruction, the patient was observed to have satisfactory return of function of the biceps muscle, but no function in either the brachialis or deltoid. EMG at this time showed severe active neuropathy in the brachialis and deltoid. He underwent secondary reconstruction using median fascicular transfer to the brachialis, and 2 triceps nerves to the anterior axillary nerve. The patient regained grade 5 power and 0°-140° range of elbow flexion (Fig. 1).

Patient 3 had an MCN palsy after a Latarjet procedure and exhibited significant return of function within the biceps muscle, but persistent difficulty initiating elbow flexion. The electromyography (EMG) findings at this time demonstrated severe chronic neuropathy of biceps but clear features of reinnervation. Brachialis function was not included in the EMG study. Because of residual impaired elbow flexion, the patient underwent surgical exploration at 5½ months after injury. The patient was found to have nerves to the brachialis arising from both the MCN and the radial nerve, and both of the nerves stimulated the brachialis muscle normally at 0.5 mAmps. The patient's clinical presentation of more power in the flexed elbow relative to flexor initiation conflicted with the intraoperative nerve findings. It was therefore decided that the patient would not undergo nerve repair or transfer but instead a shortening tenorrhaphy of the uninjured and functioning brachioradialis to aid initiation of elbow flexion. The patient regained grade 4+ power and 150° elbow flexion.

Patient 4 sustained a neurologic and vascular injury during a Latarjet procedure. The vascular injury was managed as an emergency using a vein graft to the axillary artery. A later referral was made such that nerve reconstruction was only possible 2½ months after the injury. EMG before nerve reconstruction demonstrated complete denervation of the biceps (brachialis was not studied). The patient's reconstruction consisted of ulnar fascicular nerve transfer to the biceps branch of the MCN and resection of the more proximal, damaged segment of the MCN with direct repair under some tension. The patient regained grade 5 power and 140° elbow flexion (Fig. 2).

Figure 1 Patient 2 postop appearance after cable graft for biceps and nerve transfer to the brachialis via the deltopectoral approach (posterior scar for concomitant nerve transfer to axillary).

Figure 2 Patient 4 postop appearance after delayed nerve transfer to the biceps and primary repair musculocutaneous nerve.

Discussion

MCN palsy is a devastating injury. Appropriately selected contemporary constructive techniques offer the possibility of excellent return of function. This paper aims to demonstrate some of the current techniques that can be used, including a perspective on when to choose which technique, as well as show long-term results.

Documented treatment strategies of MCN palsy after shoulder stabilization are limited. This may be in part because the majority of these MCN injuries resolve spontaneously within 4 months, as demonstrated by several retrospective reviews of neurologic outcomes after shoulder stabilization surgery.[1,6,10,21] Only one of these reviews reported persistent neurologic symptoms that occurred in 2 patients neither of whom underwent nerve exploration or repair.[10] A case series by Richards et al[20] documented the management of 7 cases of persistent MCN palsy. Six of the 7 cases were explored surgically, at an average of 19 weeks after primary shoulder stabilization. Of the cases explored, all showed recovery of MCN motor palsy after either removal of suture entrapment, nerve grafting, neurolysis, and/or delayed primary repair. Long-term follow-up of these patients demonstrated significant clinical improvement, from initial complete paralysis to restored 4-5/5 power with persistent sensory impairment. One recent study with preventative aims observed a reduction of nerve injury with the introduction of a nerve-stretch reduction protocol during the Latarjet procedure based on intraoperative neuromonitoring.[23] There remain no detailed reports of nerve transfer for reconstruction of MCN injury after coracoid transfer.

There is no doubt that nerve transfers confer significant benefits that are well described.[14] It must be remembered however that proximal stumps of injured nerves above the level of injury are potential sources of large numbers of function-specific axons. Oftentimes, these available nerve donors have a higher axon count that could be safely sacrificed for heterotopic nerve transfer. For this reason, using the proximal stump of the MCN should be seriously considered, even if it means nerve grafting with resultant axonal loss across 2 nerve coaptations. As can be seen in this series, early intervention with musculocutaneous-musculocutaneous repair or nerve grafting can yield excellent results.

We propose, based on our experience, that for early referred patients who at exploration have a proximal nerve stump in excellent condition and where the distance from the prepared stump to the target muscle is 150 mm or less, nerve grafting should be undertaken. Alternatively, in situations where surgery is late, where there is no good quality proximal stump, where primary surgery has failed, or where distances to target muscles are excessive, reconstruction should be undertaken by nerve transfer. We recommend immediate referral to a reconstructive nerve surgeon for open known injuries. For unexpected postoperative palsies where there is a realistic possibility of a neuropraxia that will resolve, first nerve surgeon review should occur at 3 months. This allows assessment and intervention as required such that intervention by nerve repair, transfer, or graft can be performed sufficiently early to maximize reconstructive outcomes.

Conclusion

This case series demonstrates techniques and outcomes in 4 patients who have sustained injury to the MCN during shoulder stabilization surgery. All patients ultimately achieved excellent return of elbow flexion power and range of motion. We describe how this was achieved by different techniques for different circumstances. In patients referred early, with an excellent quality proximal MCN stump, and a short zone of injury, traditional cable nerve grafting can yield excellent results. In the setting of delayed referral, delayed surgery, or revision surgery for MCN palsy with normal donor nerves, nerve transfer can reliably produce excellent results as demonstrated in this series.

Disclaimer

The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Banas MP, Dalldorf PG, Sebastianelli WJ, DeHaven KE. Long-term follow up of the modified Bristow procedure. Am J Sports Med 1993; 21:666-71.
2. Burge P, Rushworth G, Watson N. Patterns of injury to the terminal branches of the brachial plexus: the place for early exploration. J Bone Joint Surg Br 1985;67:630-4.
3. Butt U, Charalambous CP. Complications associated with open coracoid transfer procedures for shoulder instability. J Shoulder Elbow Surg 2012;21:1110-9. https://doi.org/10.1016/j.jse.2012.02.008
4. Butt U, Charalambous CP. Arthroscopic coracoid transfer in the treatment of recurrent shoulder instability: a systematic review of early results. Arthroscopy 2013;29:774-9. https://doi.org/10.1016/jarthro.2012.11.022
5. Clavert P, Lutz J-C, Wolfram-Gabel R, Kempf JF, Kahn JL. Relationships of the musculocutaneous nerve and the coracobrachialis during coracoid abutment procedure (Latarjet procedure). Surg Radiol Anat 2009;31:49-53. https://doi.org/10.1007/s00276-008-0426-2
6. Ferlic DC, DiGiovine NM. A long-term retrospective study of the modified Bristow procedure. Am J Sports Med 1988;16:469-74.
7. Flatow EL, Bigliani LU, April EW. An anatomic study of the musculocutaneous nerve and its relationship to the coracoid process. Clin Orthop Relat Res 1989;244:166-71.
8. Griesser MJ, Harris JD, McCoy BW, Hussain WM, Jones MH, Bishop JY, et al. Complications and re-operations after Bristow-Latarjet shoulder stabilization: a systematic review. J Shoulder Elbow Surg 2013;22:286-92. https://doi.org/10.1016/j.jse.2012.09.009
9. Hawi N, Reinhold A, Suero EM, Liodakis E, Przyklenk S, Brandes J, et al. The anatomic basis for the arthroscopic Latarjet procedure: a cadaveric study. Am J Sports Med 2016;44:497-503. https://doi.org/10.1177/0363546515614320
10. Ho E, Cofield RH, Balm MR, Hattrup SJ, Rowland CM. Neurologic complications of surgery for anterior shoulder instability. J Shoulder Elbow Surg 1999;8:266-70.
11. LaPrade CM, Bernhardson AS, Aman ZS, Moatshe G, Chahla J, Dornan GJ, et al. Changes in the neurovascular anatomy of the shoulder after an open Latarjet procedure: defining a surgical safe zone. Am J Sports Med 2018;46:2185-91. https://doi.org/10.1177/0363546518773309
12. Latarjet M. Technic of coracoid preglenoid arthroereisis in the treatment of recurrent dislocation of the shoulder. Lyon Chir 1958;54: 604-7.
13. Mackinnon S, Colbert S. Principles and techniques of peripheral nerve repair, grafts, and transfers. In: Thorne C, Chung KC, Gosain A, Guntner GC, Mehrara BJ, Rubin JP, et al., editors. Grabb and Smith's plastic surgery. 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2014.
14. Mackinnon SE, Colbert SH. Nerve transfers in the hand and upper extremity surgery. Tech Hand Up Extrem Surg 2008;12:20-33. https://doi.org/10.1097/BTH.0b013e31812714f3
15. Matsen FI, Thomas S, Rockwood CJ, Wirth M. The shoulder. Philadelphia, PA: WB Saunders; 1998. p. 233-76.
16. Matthews WB. Aids to the examination of the peripheral nervous system. J Neurol Sci 1977;33:299.
17. May VR Jr. A modified Bristow operation for anterior recurrent dislocation of the shoulder. J Bone Joint Surg Am 1970;52:1010-6.
18. Millett PJ, Clavert P, Warner JJP. Open operative treatment for anterior shoulder instability: when and why? J Bone Joint Surg Am 2005;87: 419-32. https://doi.org/10.2106/JBJSD.01921
19. Oberlin C, Béal D, Leechavengvongs S, Salon A, Dauge MC, Sarcy JJ. Nerve transfer to biceps muscle using a part of ulnar nerve for C5-C6 avulsion of the brachial plexus: anatomical study and report of four cases. J Hand Surg Am 1994;19:232-7.
20. Richards RR, Hudson AR, Bertoia JT, Urbaniak JR, Waddell JP. Injury to the brachial plexus during Putti-Platt and Bristow procedures. A report of eight cases. Am J Sports Med 1987;15:374-80.
21. Shah AA, Butler RB, Romanowski J, Goel D, Karadagli D, Warner JJP. Short-term complications of the Latarjet procedure. J Bone Joint Surg Am 2012;94:495-501. https://doi.org/10.2106/JBJS.J.01830
22. Tung TH, Novak CB, Mackinnon SE. Nerve transfers to the biceps and brachialis branches to improve elbow flexion strength after brachial plexus injuries. J Neurosurg 2003;98:313-8. https://doi.org/10.3171/jns.2003.98.2.0313
23. Woodmass JM, Welp KM, Chang MJ, Borque KA, Wagner ER, Warner JJP. A reduction in the rate of nerve injury after Latarjet: a before-after study after neuromonitoring. J Shoulder Elbow Surg 2018;27:2153-8. https://doi.org/10.1016/j.jse.2018.05.028