Case Report

Delayed Motor Nerve Transfer Reconstruction for C5 and C6 Resection during Tumour Surgery

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Abstract

We present a case of a delayed motor nerve reconstruction following resection of the C5 nerve root due to a recurrent aneurysmal bone cyst. Our patient, a 17-year-old male, presented with a major motor radiculopathy of C5 and revision surgery requiring resection of the C5 root. Four peripheral nerve transfers were undertaken to successfully reconstruct the functional loss at more than 14 months from the paralysis onset. Nerve transfer is usually considered only when the target muscles can be reinnervated within 9 months after lower motor neurone loss. The strategies for reducing reinnervation time and the differences in nerve transfer surgery for traumatic lesions will be discussed. Tumour surgeons should consider early involvement of a peripheral nerve surgeon when nerve must be sacrificed during tumour clearance. This allows the option of early targeted reconstruction and provides guidance to the patient on anticipated outcomes after surgery.

Keywords: Aneurysmal bone cyst, cervical spine cyst, nerve transfer, Oberlin, peripheral nerve surgery, radiculopathy, tumour surgery

Introduction

Paralysis of C5 and C6 is frustrating for patients who have an otherwise useful arm and hand. The hand cannot be positioned in space and the working area is considerably reduced. C5 and C6 dysfunction may follow cervical spondyloarthropathy; however, a complete loss of function in both nerves is more commonly seen in upper brachial plexus injuries. Nerve transfer surgery has enabled reliable reconstruction of function in patients presenting with complete loss of C5 and C6 from nerve root avulsion injury. The surgery should be performed early by 6 months to anticipate reinnervation of the target muscles by 9 months before the irretrievable loss of the ability of the muscle to reinnervate through the collapse of the intramuscular neural plexus by 12 months.[1] The priority in tumour surgery is complete excision of the tumour. The reconstructive options are not well understood by tumour surgeons, and typically, patients would be referred for reconstruction with arthrodesis and tendon transfers for late salvage when a successful outcome from tumour surgery has been achieved. Early referral to a specialist peripheral nerve surgeon may provide additional reconstruction options including consideration of nerve transfer surgery.[1,2]

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Case Report

A 17-year-old man was referred to a regional bone tumour service with a neck lump and C5 motor and sensory radiculopathy. Imaging and subsequent biopsy suggested an aneurysmal bone cyst (ABC). He was initially treated with a posterior approach to the spine with C5 laminectomy, intralesional excision of the tumour and C3-T1 instrumented fusion using posterior iliac crest bone graft.

Postoperatively, there was persistence of the C5 motor radiculopathy with the left-sided brachialgia in the C5 distribution. He developed increasing pain in the cervical spine and further imaging demonstrated a recurrence of the tumour. Pre-operative embolisation was performed followed by revision surgery with a combined anterior and posterior approach. The C5 root was resected during the revision

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surgery in an attempt to gain local tumour control and attempt a curative resection.

Following the revision surgery, he had a complete C5 and C6 paralysis with loss of shoulder abduction and external rotation and loss of the clavicular head of pectoralis major plus loss of elbow flexion. His C6 root was noted to be intact intraoperatively during the C5 root resection. The cause of his C6 paralysis is unknown and may be iatrogenic. The neuropathic pain settled following revision surgery, and he was able to stop neuromodulators and opiate analgesia.

He was referred to the regional peripheral nerve service 12 months following the surgery. On examination, the left upper limb posture was shoulder abduction and internal rotation with elbow extension. There was wasting around the shoulder girdle and upper arm with Medical Research Council (MRC) muscle Grade 0 power in the deltoid, supraspinatus, infraspinatus, teres minor, teres major, subscapularis, biceps, brachialis and brachioradialis.

The reconstructive options discussed included shoulder arthrodesis, contralateral trapezius transfer for external rotation and ipsilateral trapezius transfer for shoulder abduction with a functioning free muscle for elbow flexion. However, he wanted to be considered as a candidate for nerve transfer reconstruction. The standard transfers for C5 and C6 were discussed, but a successful outcome was thought unlikely due to the length of time since the onset of complete denervation.

Fourteen months after the onset of paralysis, he underwent nerve transfer surgery. The medial branch of the spinal accessory nerve was transferred to the suprascapular nerve after release of the suprascapular ligament through a posterior trapezius-splitting approach.[1] There was some weak stimulation of infraspinatus at 3 mA and a flicker of supraspinatus at 5 mA. The medial triceps branch was transferred to the axillary nerve after excluding the upper lateral cutaneous nerve of the arm.[1,3] The axillary nerve did not stimulate. After turning the patient from the lateral position to supine, the medial upper arm was exposed and a double fascicle transfer was performed with predominant flexor carpi radialis fascicle from the median nerve to the motor branch to biceps and a predominant flexor carpi ulnaris fascicle from the ulnar nerve to the motor branch to brachialis. All nerve transfers were completed tension free with microsurgical suture using 9'0 nylon, and the repair sites were supported with Tisseel™ tissue glue (Baxter).

Post-operative rehabilitation included protection in a sling with body strap for 3 weeks and then continuation of the 6-stage Birmingham nerve transfer rehabilitation protocol.[4] The protocol aims to reduce scar at the site of surgery, maintain passive joint range of motion, strengthen the donor muscle, optimise the rate of recovery of strength in the recipient muscle, assist in the cortical mapping of the new transfer and restore useful motor function.

At 18 months postoperatively, he has MRC Grade 4 power in shoulder abduction with a brachiothoracic angle of 100°. Endurance is poor, and he continues to strengthen the recipient muscles with regular swimming. Shoulder external rotation is functional with a weak MRC Grade 4. Elbow flexion is a strong MRC Grade 4.

Discussion

Nerve transfer surgery is a reliable method of restoration to paralysed muscles but should be performed by 6 months to allow reinnervation of the target muscle by 9 months. Nerve transfer is an extra-anatomical reconstruction and can be considered remote to the site of tumour surgery when a tumour resection bed scar or subsequent irradiation renders later anatomical reconstruction of resected nerves with grafts likely to be unsuccessful.

The nerve transfers in this case were selected to provide nerve coaptation sites as close to the denervated target muscles as possible given the long period of paralysis. The spinal accessory to the suprascapular nerve through a posterior approach involves siting of the neurorrhaphy to the supraspinatus muscle than the anterior approach plus decompression of the suprascapular ligament. Decompression of compression sites on regenerating nerves improves the likelihood of a successful outcome.[5] The use of the medial triceps branch for transfer to the axillary nerve has two benefits over the more common long head branch popularised by Leechavengvongs *et al*.[3] The medial branch is longer allowing a neurorrhaphy closer to the target muscles with more motor axons allowing successful reinnervation of anterior deltoid, posterior deltoid and the nerve to teres minor. The double nerve transfer to the elbow flexors allows for useful function even if each transfer achieves only MRC Grade 3 power due to late surgery; the elbow flexion function is typically MRC Grade 4 in 90% of cases of double nerve transfer due to a summative effect.[6-8]

The timing of nerve transfer surgery remains critical. Following a lower motor neurone loss, there is progressive deterioration of the intramuscular neural plexus and muscle atrophy. The muscle becomes unresponsive to reinnervation after a delay considered to be 9–12 months in a case of complete traumatic paralysis. The number of motor axons in the donor nerve is critical to the success of a nerve transfer. Tötösy de Zepetnek *et al*.[9] reported that a minimum ratio of 0.3 is required to achieve normal muscle function.

Loy *et al*. and Oberlin *et al*. have both published cases of successful delayed nerve transfer following traumatic injuries.[10,11] However, our patient suffered his nerve injury following resection of a tumour. In traumatic cases, the donor nerve may be injured albeit a lower grade with early recovery. In tumour cases, the donor nerve should be completely normal. Age is an important factor when predicting motor recovery. Li *et al*. conducted a large study to identify factors predicting motor recovery in upper limb peripheral nerve injuries.[12] They found that a younger age, among other factors, significantly

improved prognosis following injury. Our patient was only 17 at the time of his surgery and this likely had an important role in his recovery.

Another factor that should be considered is the speed of onset of paralysis. In cases of progressive motor loss due to nerve compression, there may be adaptive change at the neuromuscular interface with adoption of denervated muscle fibres through collateral sprouting from intact axons creating giant nonfunctional motor units.[13] These motor units may be able to be recruited by neo-regeneration after nerve sectioning and repopulation from a donor nerve with a greater axon density for useful function. This could explain the successful late transfers in degenerative spondyloarthropathy reported by Afshari *et al*.[14]

Nerve transfer surgery should be considered when an important motor nerve must be resected during tumour surgery. Remote transfer at the denervated muscle avoids further surgery in a scarred bed, and early reinnervation may mitigate late referral. The upper limit cut-off for a successful motor nerve transfer is unknown and is multifactorial. Whenever possible, early nerve transfer should be undertaken in complete nerve lesions before irreversible muscle atrophy because the reinnervation can be rapid and full.

Ethical approval

No ethical approval was required for this publication of this report. The patient has provided his written consent for this case to be published.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

Author's contributions

DMP conceived the aims of this report and performed the nerve transfer surgery and gave input into the final draft. SP wrote the initial and final draft. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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