SCIENTIFIC ARTICLE

Minimum 4-Year Follow-Up on Contralateral C7 Nerve Transfers for Brachial Plexus Injuries

David Chwei-Chin Chuang, MD, Catherine Hernon, MD

Purpose Contralateral C7 (CC7) transfer for brachial plexus injuries (BPI) can benefit finger sensation but remains controversial regarding restoration of motor function. We report our 20-year experience using CC7 transfer for BPI, all of which had at least 4 years of follow-up.

Methods A total of 137 adult BPI patients underwent CC7 transfer from 1989 to 2006. Of these patients, 101 fulfilled the inclusion criteria for this study. A single surgeon performed all surgeries. A vascularized ulnar nerve graft, either pedicled or free, was used for CC7 elongation. The vascularized ulnar nerve graft was transferred to the median nerve (group 1, 1 target) in 55 patients, and to the median and musculocutaneous nerves (group 2, 2 targets) in 23 patients. In another 23 patients (group 3, 2 targets, 2 stages), the CC7 was transferred to the median nerve (17 patients) or to the median and musculocutaneous nerve (6 patients) during the first stage, followed by functioning free muscle transplantation for finger flexion.

Results We considered finger flexion strength greater or equal to M3 to be a successful functional result. Success rates of CC7 transfer were 55%, 39%, and 74% for groups 1, 2, and 3, respectively. In addition, the success rate for recovery of elbow flexion (strength M3 or better) in group 2 was 83%.

Conclusions In reconstruction of total brachial plexus root avulsion, the best option may be to adopt the technique of using CC7 transfer to the musculocutaneous and median nerve, followed by FFMT in the early stage (18 mo or less) for finger flexion. Such a technique can potentially improve motor recovery of elbow and finger flexion in a shorter rehabilitation period (3 to 4 y) and, more importantly, provide finger sensation to the completely paralytic limb. *(J Hand Surg 2012;37A:270–276. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic II.

Key words Contralateral C7 transfer, brachial plexus injury.

Additional material is available online.

TOTAL ROOT AVULSION of the brachial plexus remains a major reconstructive challenge. To date, nerve transfer alone[1–3] or nerve transfer and functioning free muscle transplantation (FFMT)[4,5] is the only option to restore motor and sensory function for this irreparable injury. However, the available number of nerves for motor and sensory restoration is always insufficient and the reconstruction has considerable donor site morbidity.

Gu et al[6] introduced the use of the contralateral C7 (CC7) spinal nerve for brachial plexus root avulsion injury in 1986. It was an innovative solution providing a substantial number of axons for motor and sensory restoration of the paralyzed limb without greatly compromising the function of the donor limb.[6,7] Contralateral C7 transfer from the healthy limb can provide finger sensation in the paralyzed hand and restore motor

From the Department of Plastic Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan.

Received for publication December 28, 2010; accepted in revised form October 11, 2011.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: David Chwei-Chin Chuang, MD, Department of Plastic Surgery, Chang Gung Memorial Hospital, No. 5, Fu-Shing Road, Taoyuan, Taiwan; e-mail: dearchuang@gmail.com.

0363-5023/12/37A02-0010$36.00/0
doi:10.1016/j.jhsa.2011.10.014

function of the shoulder, elbow, or hand.[5,8,9] Despite the promising long-term results from Gu et al[10] for wrist and finger flexion, in which 54% of patients achieved greater than M3 strength, subsequent reports were less optimistic. Terzis and Kokkalis,[11] Waikakul et al,[12] and Songcharoen et al[13] reported 34%, 29%, and 29% of patients, respectively, achieving M3 of finger flexion. Few patients who have undergone this procedure achieved independent function of the reconstructed limb. Consequently, this technique has not been widely adopted and remains controversial.

In 2002, Mcguiness and Kay[14] reported on CC7 transfer by passing the grafted nerve through the prevertebral (or prespinal) space to repair the median nerve in an obstetric brachial palsy. Xu et al[15] revised the approach in 2008, making the tunnel posterior to the scalenus anterior muscle. They stated it may shorten the nerve grafts required. Gu[16] wondered whether this shortened distance would accelerate the functional result.

We previously reported on a series of 15 patients who underwent CC7 transfer in 1993.[17] After an interval of 11 to 20 months, 8 of these patients subsequently underwent FFMT to the affected limb using median nerve branches as the neurotizer. Some patients achieved useful finger flexion.[18,19] We continue to employ CC7 transfer and have extended its use to different conditions such as adult brachial plexus injury (BPI), obstetrical brachial plexus palsy (OBPP), traction avulsion amputation of the arm associated with lower plexus root avulsion, and severe spasticity of the hand due to cerebral palsy. The purpose of this article was to retrospectively review our BPI patients who have had CC7 transfer, to evaluate the functional outcomes achieved by different nerve graft routes (prevertebral vs subcutaneous; cross-chest vs cross-neck), different recipient nerves (median nerve alone vs median and musculocutaneous nerves), and different strategies (1 stage with CC7 transfer to the median nerve vs 1 stage with CC7 transfer to the median and musculocutaneous nerves vs 2 stages with CC7 transfer followed by FFMT).

PATIENTS AND METHODS

Between 1989 and 2006, we explored and performed reconstruction in nearly 1,500 adults with BPI. Of these, 137 patients were treated by CC7 transfer. There were 123 male and 14 female patients, with a mean age of 23 years (range, 21 mo to 53 y). The most common mechanism of injury was motorcycle accident. Severity of brachial plexus root avulsion included total root avulsion (C5-T1 ± C4) in 120 patients, 4 root avulsions (C6-T1) in 14, and 3 root avulsions (C7-T1) in 3.

The minimum follow-up period was 4 years. To simplify the investigation, the following patients were excluded: 11 patients in whom the target nerve was neither the median nerve nor the median and musculocutaneous nerves (of these 11 patients, the CC7 was transferred to the C8 in 5 patients and to the radial and axillary nerves in 2 patients; the CC7 stump was placed in the biceps muscle for stage reconstruction in 2 patients, to the C6 in 1 patient, and to the median and the posterior division of the upper trunk in 1 patient), 7 patients in whom a staged operation was not completed, 2 patients with traction avulsion amputation of the arm with lower root avulsion, and 9 patients who were lost to follow-up.

A total of 101 patients fulfilled the inclusion criteria for this study. A single surgeon operated on the patients. We used a vascularized ulnar nerve graft (VUNG) in all cases to elongate C7 from the healthy side. The VUNG was placed either cross-chest or cross-neck. Cross-chest VUNG was a pedicled type (based on the superior ulnar collateral artery), used when we did not intend to explore the brachial plexus on the injured side such as in patients who had previous brachial plexus exploration. Pedicled VUNG required 1 artery repair for supercharging. The distal ulnar nerve stump was coapted to the contralateral C7 stump and the proximal ulnar nerve was coapted to the median nerve. We performed both coaptations at the same time, obviating the need of a second-stage operation described by Gu et al.[6]

In contrast, free VUNG used a segment of ulnar nerve harvested with the accompanying vessels and required 1 artery and 1 vein repair. We used it in most of our patients (86 patients, 85%) and tunneled it across the neck, either subcutaneously (73 patients, 72%) or prevertebrally. We placed the free VUNG either in antegrade (68 patients, 67%), or retrograde depending on recipient vessel availability.[20] We used the whole C7 spinal nerve, transected it distal to the divisions, and fixed it over the sternocleidomastoid muscle with 2 sutures in preparation for coaptation to the VUNG stump.

We separated 101 patients into 3 groups for finger flexion assessment. In group 1 patients (n = 55), the median nerve was the recipient nerve and was grafted in a 1-stage procedure. In group 2 patients (n = 23), the median and musculocutaneous nerves were the target nerves and were grafted in a 1-stage procedure. In group 3 patients (n = 23), the CC7 was transferred either to the median nerve or to the median and musculocutaneous nerve during the first stage, and this was