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Comparative study of intercostal nerve transfer to lower trunk and contralateral C7 root transfer in repair of total brachial plexus injury in rats

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Brachial plexus;
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Summary *Aim:* The aim of this study is to compare the treatment outcome of nerve transfer using intercostal nerves (ICNs) or contralateral C7 (cC7) root in rats.
Methods: Ninety adult Sprague–Dawley rats were randomly divided into three groups of 30 each: group A (cC7 root transfer), group B (ICNs transfer), and group C (control). Electrophysiological examination, muscle tension test, neuromorphology, and muscle fiber cross-sectional area measurements obtained from the three groups were compared to evaluate neurotization outcome 4, 8, and 12 weeks postoperatively.
Results: Median nerve regeneration and the flexor digitorum superficialis (FDS) muscle functional recovery of group B were worse than group A from comparison of both groups' parameters.
Conclusions: Neurotization of ICNs to the lower trunk is difficult to replace cC7 root transfer to the median nerve for restoration of hand function in total brachial plexus injury (BPI). Therefore, at present, the more important implication of the comparative study is that traditional cC7 root transfer remains the mainstay strategy to repair forearm flexor muscle function.

Abbreviations: cC7, contralateral C7; intercostal nerves, ICNs.

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Introduction

Although total brachial plexus injury (BPI) has a devastating effect on patients, the emergence of a surgical technique in transferring the nerve for reconstruction has partially reversed the tide.[1] Some encouraging results have been achieved in the reconstruction of shoulder and elbow function through multiple nerve transfers, including spinal accessory nerve and intercostal nerve transfer, in patients with total BPI. However, the effectiveness of restoring hand function, especially finger flexion, remains unsatisfactory.

In order to seek more donor sources for hand function restoration, Gu et al.[2] first introduced the contralateral C7 (cC7) transfer for the treatment of BPI in 1986, and then reported that 54% of patients achieved greater than M3 for wrist and finger flexion as promising long-term treatment outcomes.[3] Subsequently, Waikakul et al.,[4] Songcharoen et al.[5] and Terzis and Kokkalis[6] reported 29%, 29%, and 34% of patients, respectively, achieving M3 of finger flexion. These results were less optimistic, which could be attributed to only partial fascicle selection of cC7 as the donor. Therefore, functional recovery of the whole cC7 root transfer, especially the motor function, was superior in terms of thoroughly using the large source of nerve fibers.[7] Using ipsilateral vascularized ulnar nerve grafts for median nerve reconstruction compared with nonvascularized grafts, Terzis and Kostopoulos[8] displayed the superior clinical outcomes of cC7 transfer. Thus, the blood supply for the nerve graft is vital in supporting the regeneration of C7. In addition, with the aim to ensure intact blood supply, performing this surgery is recommended and is divided into two stages. Therefore, cC7 root transfer using a vascularized pedicle ulnar nerve graft has been established as one of the optimal methods to restore prehension function for total BPI without compromising the function of the healthy limb,[9,10] though there still exists some controversial points.

When it comes to intercostal nerve (ICN) transfer, neurotization has been a valuable procedure used in the reconstruction of elbow flexion or extension and shoulder abduction function in brachial plexus palsy patients[11–21] since its initial introduction by Seddon in 1963.[22] Is it possible for this surgical procedure, as an alternative method, especially when cC7 root cannot be sacrificed, to repair lower trunk for restoring finger flexion function in total BPI? No studies have compared the cC7 root transfer with ICN transfer. In this study, the aim is to evaluate functional recovery outcomes of forearm flexor muscles using either cC7 root transfer or ICN transfer to the lower trunk.

Materials and methods

Animal preparation

This study was conducted on 90 adult Sprague—Dawley rats, each weighing 200—250 g. Rats were divided randomly into three groups, with 30 each in group A (cC7 root transfer), group B (ICNs transfer), and group C (control). Before the operation, the rats were administered with anesthesia with intraperitoneal injection of 10% chloral hydrate solution (3 ml/100 g body weight; Shanghai Reagent Company, Shanghai, China). The animal care and experimental procedures were conducted in accordance with the Laboratory Animal Care and Use Guidelines of the Animal Research Committee, Shanghai Medical College, Fudan University.

Surgical procedures

Total BPI

After successful anesthesia, the rats of experimental groups were fastened in the supine position, shaved, and sterilized with iodine. By setting the rats' left brachial plexus as the experimental site, a supraclavicular transverse incision was made to expose C5 and C6 roots by severing the anterior scalene muscle and C7, C8, and T1 roots by pulling the left clavicle to the medial and inferior side. After the left brachial plexus roots from C5 to T1 were exposed, the roots from C5 to T1 were cut off at the level of the intervertebral foramen to stimulate total BPI.

Contralateral C7 root transfer

In group A, the contralateral C5—T1 roots were exposed through a supraclavicular transverse incision. The C7 nerve root was then dissected, blocked with 2% lidocaine, and severed at the division-to-cord level. The left ulnar nerve was used as a graft and distally severed at the wrist level. After being carefully dissected from the wrist level to the middle of the upper arm, the pedicle vascularized ulnar nerve graft was harvested, and the distal end of the graft was coapted to the cC7 root by moving the graft to the contralateral body through the subcutaneous tissue of the front chest. After 4 weeks, the reversed point of the ulnar nerve graft and the injured median nerve were exposed from the incision at the middle of the upper arm. Using 11/0 Prolene and 10× microscope magnification, the distal end of the ulnar nerve graft was coapted to the proximal stump of the injured median nerve with a tension-free direct neurorrhaphy after cutting both the nerves.

Intercostal nerve transfer to lower trunk

In group B, a longitude incision was made along the midaxillary line from the seventh intercostal space to the top of axillary fossa, extending to the lower border of clavicle. The serratus anterior was split to expose the third to sixth ribs. To expose the main trunk of the intercostal nerves and their branches, the external intercostals close to the lower margin of the ribs were stripped. The muscular branches were freed proximally to the main trunk at the postaxillary line level, blocked with 2% lidocaine, and then severed at the preaxillary line level. The pectoralis major muscle was pulled upward to facilitate transferring the distal end of injured lower trunk to the axillary fossa. The third to sixth muscular branches of the intercostal nerves were coapted to the lower trunk with a tension-free direct neurorrhaphy using 11/0 Prolene and 10× microscope magnification.

In group C (control group) the brachial plexus was exposed without nerve division and transfer.