Selective motor hyperreinnervation by using contralateral C-7 motor rootlets in the reconstruction of an avulsion injury of the brachial plexus

Case report

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Brachial plexus avulsion injuries are a clinical challenge. In recent experimental studies the authors have demonstrated the high degree of muscle reinnervation attained when a C-4 motor rootlet was directly connected to the musculocutaneous nerve. This degree of reinnervation was attributed to the good chance that a muscle fiber can be reinnervated by a motor fiber when the number of regenerating motor neurons is increased and when competitive sensory fibers are excluded from the process. The authors present the first clinical case in which this phenomenon has been observed. This 26-year-old man, who was involved in an automobile accident, presented with an upper brachial plexus avulsion, for which he underwent operation 4 months later. The axillary and suprascapular nerves were directly surgically connected to the motor rootlets of the C-7 contralateral root by using two cables of sural nerve graft. Two years postsurgery, the patient was able to perform shoulder abduction of 120° and hold an 800-g weight at 90°. These results are encouraging, and in selected patients motor rootlet transfer might prove to be a useful surgical strategy.

KEY WORDS • brachial plexus • spinal cord • nerve repair • avulsion injury • nerve regeneration • nerve graft
Case Report

History. This 26-year-old man had been involved in an automobile accident, in which he sustained an exposed articular knee fracture for which he underwent immediate surgical treatment. In addition to the knee injury he presented with a left-sided brachial plexus avulsion.

Examination. On clinical examination 2 months after the accident, the patient’s brachioradial, biceps, deltoid, supraspinous, and infraspinatus muscles were found to be paralyzed and were scored M0. More distal muscles were normal and were rated as M5. The patient’s grasping strength was 26 kg, whereas his pinch strength was 5 kg. Two-point discrimination was 4, 4, and 4 mm for the thumb, index, and little finger, respectively. The clinical examination indicated a C5–6 injury. The patient complained of pain in his shoulder and hand. When asked to rate the level of pain on a scale of 1 to 10, he gave it a score of 8 to 9. His other arm was normal, and all the muscles tested on that side were scored M5. The grasping strength on his right side was 31 kg, whereas the pinch strength was 7 kg. Two-point discrimination was 4, 3, and 4 mm for the thumb, index, and little finger, respectively. One month after the initial follow-up examination, there was no recovery in shoulder and elbow movements. A computerized tomography myelography study was performed, and the results revealed upper root brachial plexus avulsion in the left side. The patient underwent operation 4 months after the accident, and at that time clinical and electromyographic examinations showed no recovery of biceps, deltoid, or rhomboid muscles.

Operation. The patient underwent operation after induction of general anesthesia. With the patient supine, a small incision was made in the supraclavicular region of the relevant plexus to retrieve the nerve grafts from behind. The patient was shifted to the prone position, and both sural nerve grafts were removed, while the contralateral C7 root was located via a cervical dorsal approach. Only a limited hemilaminectomy was performed between the C-6 and C-7 vertebrae. The dorsal and ventral roots of the contralateral C-7 were identified. The ventral rootlets, which were two in number, each one measuring approximately 2 mm in diameter and 18 mm in length, were cut just in front of the dorsal root ganglion (Fig. 1). The rootlets were then attached to two cables of the sural nerve grafts by using fibrin glue. The dura mater was sutured and a coat of fibrin glue was applied. The suprascapular nerve was dissected through a separate dorsal incision over the scapular spine, sectioned, and connected with No. 10-0 sutures to one of the sural grafts, which was tunneled from the cervical incision to the scapular incision through the paravertebral muscles. This graft measured 13 cm in length. The remaining sural graft was tunneled anteriorly through the paravertebral muscles and was retrieved in the ventral supraclavicular incision. The dorsal incisions were closed in layers, and the patient was turned to a dorsal decubitus position. The brachial plexus involved was then entirely exposed through a zig-zag incision along the posterior border of the sternocleidomastoid muscle, the clavicle, and the deltopectoral groove to the upper arm. The C5 and C-6 roots were found to be avulsed from the spinal cord. The C-7 root was scarred, but had remained in continuity with the spinal cord, and a neurolysis was performed. The musculocutaneous nerve was found to be very scarred, from its origin up to the coracobrachial muscle, and we decided that this nerve would be unsuitable for a nerve graft. The axillary nerve was dissected and explored as distally as possible, sectioned proximally, and attached to the sural cable graft by using No. 10-0 sutures. This graft measured 22 cm in length. The incision was closed, and 3 days later the patient was discharged.

Postoperative Course. One week postsurgery, a slight decrease in the strength of the contralateral triceps muscle was observed; however, 15 days later, triceps strength was normal. All the remaining muscles on the contralateral side were rated as M5, and no sensory deficits were observed. The grasping and pinch strength were similar to preoperative values. Eight months postsurgery, contractions were observed in the suprascapular muscle, and 13 months postsurgery contractions were identified in the deltoit muscle.

Two years postsurgery, the patient was capable of 120° of active shoulder abduction (Fig. 2). He was able to hold an 800-g weight at 90° of abduction. He was able to keep his shoulder abducted for more than 30 seconds. The patient was capable of active shoulder abduction without visual control. He was also able to place his arm accurately anywhere in the space without visual feedback. No active external rotation of his shoulder was observed. His deltoid strength was scored M3+ and his supraspinous strength was M4. No biceps, infraspinatus, or brachioradial contractions were identified. Electromyographic data demonstrated nascent, reinnervational potentials, insertional activity, and polyphasic potential, thus confirming the reinnervation of deltoid and supraspinous muscles. No signs of reinnervation were observed in the biceps and rhomboid muscles, grasping and pinch strength improved to 30 kg and 6 kg, respectively, and the patient was free of pain.
Selective motor rootlet transfer in brachial plexus repair

**Discussion**

The good results obtained in this clinical case confirm the experimental results in rats. A very good shoulder abduction was achieved despite the use of long grafts. This is probably because the motor neurons of a single motor root were used for reinnervation of a few muscles, increasing the number of regenerating motor neurons. In addition, sensory neurons were excluded from regeneration, avoiding fiber misdirection. The patient was free of pain, probably as a result of the brachial plexus surgery and motor recovery. In general, patients who attain good functional recovery are free of pain.17

In two clinical cases, Liu, et al.,13 have reported some initial weakness in a few muscles after C-7 section. However, there was no long-term functional defect. In our patient, C-7 motor root section led to no permanent defects in the contralateral limb, confirming the reports of several authors.4,8,9,12,13 This is explained by the fact that the territory of a single root is overlapped by the adjacent ones.4,8 After C-7 section, temporary numbness in the index finger and thumb are generally observed. In the present clinical case, no numbness or sensory deficits were demonstrated because the sensory rootlets were not damaged.

Misdirected regrowth, or muscle cocontraction, has been recognized to impair the results of nerve recovery, especially in brachial plexus surgery.5,6 Therefore, by connecting a donor nerve (in our case contralateral C-7 rootlets), not to roots but to specific agonist nerves (in our case axillary and suprascapular nerves), misdirected regrowth is eliminated.

Motor rootlet transfer has been demonstrated to produce a high rate of muscle reinnervation in experimental and clinical studies. The possibility of using other rootlets, such as C-3 and C-4, exists. In selected cases, brachial plexus reconstruction involving motor rootlet transfer may constitute a useful alternative.

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**References**


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![Fig. 2. Photographs of the patient 2 years postsurgery demonstrating active shoulder abduction.](image-url)


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