Nerve Transfer to Deltoid Muscle Using the Intercostal Nerves Through the Posterior Approach: An Anatomic Study and Two Case Reports

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Purpose: To evaluate the feasibility of restoring the deltoid function in patients with C5 through C7 root avulsion injuries by transferring 2 intercostal nerves to the anterior branch of the axillary nerve through a posterior approach. The preliminary results of the clinical application of this procedure also are reported.

Methods: The study was performed on 10 fresh cadavers. The lengths of the third, fourth, and fifth intercostal nerves from the costochondral junction to the midaxillary line were recorded. The distance from the pivot point at the midaxillary line to the anterior branch of the axillary nerve was recorded as the tunnel length. All histomorphometric measurements of the axon number were recorded. Based on the anatomic study, the fourth and fifth intercostal nerves were transferred directly to the anterior branch of the axillary nerve in 2 patients.

Results: The average distances from the costochondral junction of the third, fourth, and fifth intercostal nerves to the pivot points were 12, 15, and 16 cm, respectively. The average tunnel distances of the third, fourth, and fifth intercostal nerves were 11, 13, and 15 cm, respectively. The average numbers of myelinated nerve fibers of the third, fourth, and fifth intercostal nerves were 742, 830, and 1,353, respectively. At the 2-year follow-up evaluation the preliminary clinical results showed that the deltoid recovered against resistance (M4). The range of motion for shoulder abduction and external rotation were both 95° in the first case and 105° and 95°, respectively, in the second case. Useful functional recovery was achieved and classified as a good result in both patients.

Conclusions: This anatomic study with 2 case reports supports the idea that transfer of 2 intercostal nerves to the anterior branch of the axillary nerve through the posterior approach could be an alternative method for reconstruction of the deltoid muscle in C5 through C7 root avulsion injuries. (J Hand Surg 2007;32A:218–224. Copyright © 2007 by the American Society for Surgery of the Hand.)

Type of study/level of evidence: Therapeutic IV.

Key words: Brachial plexus injury, nerve transfer, intercostal nerve, axillary nerve.

The restoration of shoulder abduction and stability after brachial plexus root avulsion injuries represents one of the most complex challenges facing the peripheral nerve surgeon. Since repair of brachial plexus root avulsion injuries is not possible, nerve transfers achieve better results for shoulder abduction and stabilization than arthrodesis or tendon transfer.[1,2]

Recently many surgeons have recommended simultaneous nerve transfers to both the suprascapular and axillary nerves, when adequate donors are available, to achieve better results.[2–6] In 2003, we advocated that nerve transfer to the anterior branch of the axillary nerve using the nerve to the long head of the triceps should be combined with a spinal accessory nerve transfer to the suprascapular nerve to obtain

better shoulder abduction for motor power and range of motion.[7,8] In C5 through C7 root avulsion injuries, however, the nerve to the long head of the triceps could not be used because of the injury to its main components from the C7 root.

There are some donor nerves that can be used for transferring to the axillary nerve, such as the phrenic nerve,[3] spinal accessory nerve,[3] and medial pectoral nerve.[9] Previous results of these nerve transfers to obtain deltoid function, however, have had limited results. Chuang et al[3] reported less than 20° of shoulder abduction using either a phrenic or spinal accessory nerve transfer to the axillary nerve. Samardzic et al[9] reported a medial pectoral nerve transfer to the musculocutaneous or axillary nerves; however, the recovery of deltoid muscle usually cannot attain a level of function comparable with that of the biceps muscle. Previous studies on the anatomy of intercostal nerves have focused mostly on the nerve transfer to the musculocutaneous nerve in elbow flexion restoration.[10] From an English literature review, we found few articles that studied the intercostal nerve transfer to an axillary nerve for shoulder reconstruction.[3,11,12]

We conducted a feasibility study for deltoid function restoration by transferring the third, fourth, and fifth intercostal nerves to the anterior branch of the axillary nerve without nerve grafting through a posterior approach. We also report 2 cases with this nerve transfer technique and the preliminary results of this clinical application.

Materials and Methods

Anatomic Study

This study was performed on 10 fresh cadavers (8 male, 2 female). There were 5 left upper limbs and 5 right upper limbs. We excluded the cadaver that had thoracic trauma. All cadavers were placed in the supine position with a sandbag beneath the dissected shoulder. A curve incision was made along the fifth rib in the male cadavers or along the inframammary fold in the female cadavers from the sternum to the midaxillary line. The dissection of the third, fourth, and fifth intercostal nerves extended from the costochondral junction to the midaxillary line. The emergence of the sensory branch of the intercostal nerve was consistently noted at just anterior to the midaxillary line. The intercostal nerves were dissected posteriorly up to 5 cm after the division of its sensory branch. The length of each intercostal nerve was recorded. A second incision was made along the posterior border of the deltoid. The quadrilateral space was approached to identify the anterior branch of the axillary nerve. The distances between the pivot points of each intercostal nerve to the anterior branch of the axillary nerve were recorded to represent the tunnel length for each nerve (Figs. 1, 2).

The intercostal nerves were processed for histomorphometric evaluation. The nerves were fixed overnight at 4°C in 2.5% gluteraldehyde. On the following day, they were postfixed in 1% osmium tetroxide for 1 hour, dehydrated through a graded alcohol series, and embedded perpendicular to the face of the block in epoxy resin. Semithin transverse sections of 1.5 μm were cut on an ultra-microtome. The sections were stained with 1% solution of toluidine blue and viewed using a light microscope.

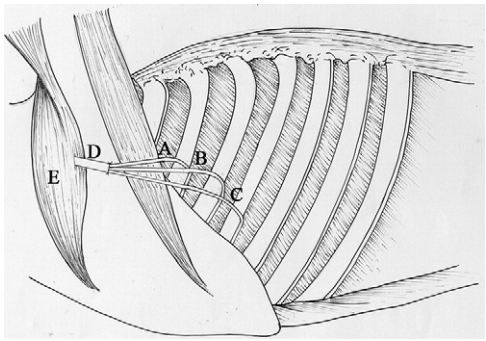

Figure 1. Nerve transfer to the anterior branch of the axillary nerve using the third, fourth, and fifth intercostal nerves: third intercostal nerve (A), fourth intercostal nerve (B), fifth intercostal nerve (C), the anterior branch of the axillary nerve (D), and deltoid muscle (E).

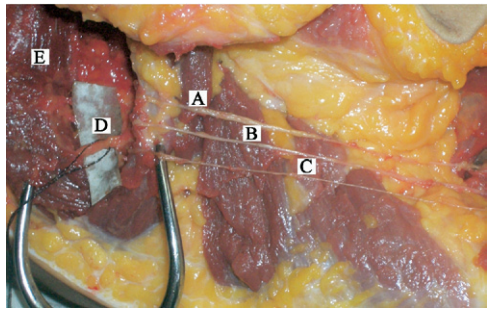

Figure 2. Dissection of the third, fourth, and fifth intercostal nerves to the midaxillary line provides the possibility of direct nerve transfer to the anterior branch of the axillary nerve without nerve grafting via the posterior approach. Third intercostal nerve (A), fourth intercostal nerve (B), fifth intercostal nerve (C), anterior branch of the axillary nerve (D), and deltoid muscle (E). For accurate measurement of the tunnel length, the incision for exposure in the cadaveric specimen was connected to the posterior aspect of the shoulder with the chest-wall incision and is not the same exposure that one would get using the 2 incisions shown in the clinical examples.