SCIENTIFIC ARTICLE

The Value of the Tender Muscle Sign in Detecting Motor Recovery After Peripheral Nerve Reconstruction

Ellen Y. Lee, MD, Teemu V. Karjalainen, MD, Sandeep J. Sebastin, MBBS, Aymeric Y. T. Lim, MBBS

Purpose Squeezing a denervated muscle a few weeks after nerve repair produces a characteristic response in patients. This response is observed before any clinical evidence of motor recovery. We called this response the tender muscle sign (TMS) and wanted to determine whether this sign was related to the recovery of motor power.

Methods We studied 31 adults with unilateral brachial plexus injuries who underwent 50 procedures for reinnervation of the supraspinatus, deltoid, and biceps. Follow-up was monthly for the first year and at 3-monthly intervals thereafter. Average duration of follow-up was 3.3 years. The TMS was sought at each visit. The presence of the TMS, when it was first observed, and time to Medical Research Council (MRC) grade 1 and 3 recoveries were recorded. The sensitivity, specificity, and predictive values of TMS for motor recovery were calculated.

Results The TMS was always detected earlier than palpable muscle contraction. It was significantly associated with recovery of MRC grade 1 and 3 motor power. The sensitivity of TMS for MRC grade 1 recovery was 96% and specificity was 100%. For MRC grade 3 recovery, it had 97% sensitivity and 27% specificity. The positive predictive value was 100% for MRC grade 1 recovery and 83% for MRC grade 3. The negative predictive value was 50% for MRC grade 1 recovery and 75% for MRC grade 3.

Conclusions Previous studies have demonstrated the presence of nocioceptive receptors in human skeletal muscle. The reinnervation of these receptors by the regenerating axons results in cramp-like tenderness when the muscle is squeezed. This response is specific to a reinnervated muscle and cannot be elicited in denervated or normally innervated muscle. The TMS is a simple, clear, and early indicator of muscle reinnervation that is useful in monitoring motor recovery after nerve regeneration. *(J Hand Surg Am. 2015;40(3):433–437.*

Type of study/level of evidence Diagnostic IV.

Key words Nerve injury, brachial plexus injury, clinical sign, motor recovery, nerve regeneration.

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From the Department of Hand and Reconstructive Microsurgery, National University Health System, Singapore.

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Corresponding author: Sandeep J. Sebastin, MBBS, Department of Hand and Reconstructive Microsurgery, National University Health System, 1E Kent Ridge Road, NUHS Tower Block, Level 11, Singapore 119228; e-mail: sandeepsebastin@hotmail.com.

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During routine follow-up of adult brachial plexus patients after Oberlin transfers, we found that squeezing the paretic biceps muscle resulted in a characteristic pain response. Patients would wince and report a cramp-like pain that they had never felt before. This response was elicited before the patient or examiner could feel any muscle contraction. It was also present in other muscles that had undergone nerve transfer procedures, such as the supraspinatus and the deltoid. A similar pain response

could not be elicited on other denervated muscles on the same side that were not recipients of nerve transfers or on normally innervated, non-injured contralateral muscles. This prompted us to investigate whether this tender muscle sign (TMS) could be used to predict motor recovery in muscles after nerve reconstruction procedures. We hypothesized that patients with a TMS after a nerve transfer procedure would recover at least British Medical Research Council (MRC) grade 1 motor power.

MATERIALS AND METHODS

Patients

We observed 31 adults with brachial plexus injuries between 2002 and 2010. Institutional review board approval was obtained for this retrospective review of prospectively collected data. Patients were predominantly men (90%) and average age was 29 years (range, 19−49 y). Road traffic accidents were responsible for 87% (27 of 31) of the injuries. Twelve patients (39%) had complete C5 to T1 injury, 11 (35%) had injury to C5 to C7 roots, and 5 (16%) had C5 to C6 injury. Patients were referred to our unit an average of 56 days (median, 45 d) after the injury (range, 8−163 d).

Priority was given to restoring elbow flexion and shoulder abduction. For elbow flexion, the transfer of an ulnar nerve fascicle to the biceps branch of the musculocutaneous nerve was preferred.[1] If the ulnar nerve was not available, 3 intercostal nerves (ICNs) were transferred to the musculocutaneous nerve (MCN).[2,3] For shoulder abduction, the spinal accessory nerve (SAN) was transferred to the suprascapular nerve (SSN) and if functional, the branch of the radial nerve innervating the long head of the triceps was transferred to the deltoid branch of the axillary nerve.[3−5]

Each patient underwent an average of 2 operations, with the first operation performed an average of 130 days after injury (range, 12−202 d). At each operation, multiple nerve procedures were done. Most often, 3 nerve reconstructions—2 for the shoulder and 1 for the elbow—were performed in 1 operation. A total of 50 nerve procedures were performed to reinnervate the supraspinatus, deltoid, and/or the biceps (Fig. 1). After surgery, patients were called back for review monthly for the first 12 months and at 3-month intervals thereafter. Patients also attended separate therapy sessions with occupational therapists after the surgery. Average length of follow-up was 3.3 years (range, 2−8 y).

Methods

At each follow-up visit, patients were examined for a TMS by the surgeons and motor recovery by the therapists. The surgeons were not blinded. Surgeons tested for TMS as part of the patient's routine clinical examination. The muscles examined included the biceps, deltoid, and supraspinatus. Patients were unaware of the meaning of the test, and therapists were blinded. Therapists performed an independent assessment of motor power during therapy sessions without knowledge of this study.

The biceps and deltoid were tested for a TMS by squeezing the muscle belly. The supraspinatus was tested by applying moderate to deep pressure using the pulp of index and middle finger. Testing for a TMS was first performed on the contralateral normal side to gauge the patient's reaction to the stimulus. Care was taken to ensure that the muscle belly was squeezed and not just the patient's skin. Then the target muscle was tested. The TMS was positive when the patient showed a characteristic pain reaction that could not be elicited on the normal side (Video 1, available on the *Journal's* Web site at www.jhandsurg.org). Patients described the pain as cramp-like. We recorded the date when TMS was first observed.

Therapists evaluated motor power of the injured limb during independent therapy sessions. They were aware of the procedures performed for each patient but were not informed regarding the presence or absence of a TMS. Motor power was recorded using the MRC grade.[6] Medical Research Council grade 1 (M1) motor recovery was determined by palpating the muscle and feeling for muscle contraction while asking the patient to move the involved joint (flex the elbow or abduct the shoulder). Before palpating the supraspinatus, the trapezius was relaxed by extending and laterally flexing the neck toward the tested side and turning the face toward the opposite side.[7] Medical Research Council grade 3 (M3) motor recovery was recorded as present when patient could initiate shoulder abduction from neutral (supraspinatus), abduct or forward flex the shoulder at least 40° (deltoid), or flex the elbow against gravity (biceps).[7]

Statistical analysis

Fisher exact test was used to determine association between a TMS and M1 and M3 recovery of supraspinatus, deltoid, and biceps nerve reconstruction. Statistical significance was set at $P < .05$. We used a 2×2 table to determine the sensitivity, specificity, and positive and negative predictive values of TMS in predicting motor recovery.

RESULTS

A total of 96% (48 of 50) of nerve transfer procedures resulted in recovery of M1 motor power. A TMS could be elicited in 46 of the 48 (96%) muscles that