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Feasibility of Medial Pectoral Nerve to Musculocutaneous Nerve Transfer Using Medial Antebrachial Cutaneous Nerve of Forearm Graft: Histopathologic and Anatomical Evaluation

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ABSTRACT

AIM: To evaluate the compatibility of medial antebrachial cutaneous nerve of the forearm (MACN) with medial pectoral (MPN) and musculocutaneous (MCN) nerves for the anastomosis from anatomical and histopathologic aspects.

MATERIAL and METHODS: Ten brachial plexus specimens from five cadavers were dissected. The distances of the distal ends of MPN and MACN and proximal ends of MACN and MCN were measured from coracoid. Histopathologic slides from the four mentioned nerve ends were provided. The number of fascicles, cross-section diameter, and area of each nerve ends were measured.

RESULTS: The distance of proximal and distal ends of MACN were adjacent to MPN and MCN. The mean number of fascicles (4.5 ± 1.2 vs. 2.9 ± 1.0), area (6.0 ± 2.5 vs. 2.8 ± 2.4) and diameter (2.7 ± 0.6 vs. 1.8 ± 0.7) of the distal end of MACN was significantly more than MCN. The mean number of fascicles (4.4 ± 1.4 vs. 2.6 ± 0.5), area (5.6 ± 2.4 vs. 2.0 ± 1.0) and diameter (2.6 ± 0.6 vs. 1.6 ± 0.4) of the proximal end of MACN was significantly more than MPN. The mentioned parameters were similar between MCN and MPN.

CONCLUSION: Our study reveals that MACN is not a proper graft for MCN and MCN anastomosis due to the incompatibility of its diameter, area, and number of fascicles.

KEYWORDS: Nerve graft, Medial antebrachial cutaneous nerve of forearm, Medial pectoral nerve, Musculocutaneous nerve

ABBREVIATIONS: MACN: Medial antebrachial cutaneous nerve of forearm, **MCN:** Musculocutaneous nerve, **MPN:** Medial pectoral nerve

INTRODUCTION

Elbow flexion is an important motion that is impaired in patients with upper (C5 & C6 or C5 –C7 roots) brachial plexus injuries. There are some treatment options available for brachial plexus injuries such as direct nerve repair, neurotization, and nerve graft (4,5). Nerve graft is suggested for mixed nerve injuries and nerve gaps which are more than three centimeters. Some pre-requisites should be considered to choose a proper nerve as autograft, including its length, diameter, and topography of the its nerve fascicles (10,12). In cases with root avulsion injuries, the musculocutaneous nerve should be innervated with a healthy alternative nerve in order to return the elbow flexion (14). Medial pectoral nerve (MPN), which originates from the inferior trunk (C8 & T1 roots), can be considered for intra plexus transfer as a donor. However, the

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length of the mentioned nerve is not enough to be transferred to MCN without tension. The medial antebrachial nerve of forearm (MACN) is a branch of the medial cord (directly from the inferior trunk) that originates from C8 & T1 roots that are intact in upper and middle trunk brachial plexus injuries. Previous studies revealed favorable results from using MACN as the nerve graft (6,11,19). To the best of our knowledge, there is no previous studies available to investigate the compatibility of MACN with MCN and, or MPN regarding their histopathologic features. To examine our hypothesis, we decided to evaluate the feasibility of MACN as an autograft from histopathologic and anatomical aspects.

MATERIAL and METHODS

Ten specimens from five fresh cadavers without any gross scar or deformity in the arm or chest wall were obtained. An orthopedic surgeon dissected all the specimens. The experiments were performed in accordance with Human Tissue Storage and Use Policy.

Cadaver Preparation and Dissection

Upper extremity specimens, which were fixed in formalin, were placed in the supine position. In order to find MACN, we made a ten centimeter (cm) longitudinal incision on the medial aspect of the arm. The incision was started 3 cm proximal to medial epicondyle, which was extended proximally. After exploring the basilic vein, we followed it to the basilic hiatus where both the basilic vein and MACN pass through the deep fascia of the arm. After finding the MACN, it was traced proximally to its origin (medial cord). The MACN was followed until it was divided into smaller branches. The MCN was explored on the middle third part of the medial aspect of the arm. We also approached MPN below the middle third of the clavicle. MPN was found near to the sternocostal head of the pectoralis major muscle after retracting it (Figure 1).

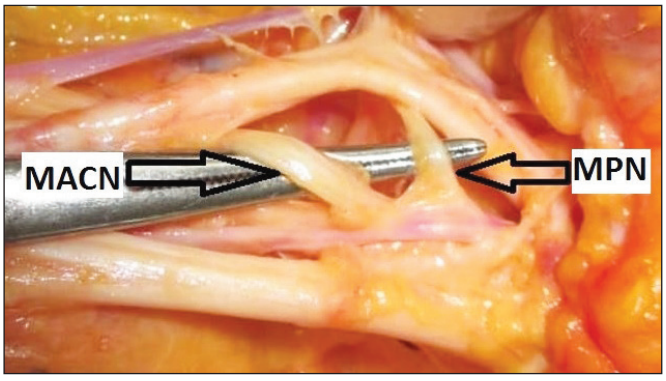

Figure 1: The size discrepancy of the medial antebrachial cutaneous nerve of forearm (MACN) compare to medial pectoral nerve (MPN) is shown.

Anatomical and Histopathologic Evaluation

In order to evaluate the feasibility of MACN length to be used as a graft, we measured the distance of the coracoid bone from its proximal and distal sites of anastomosis, using a ruler. For the histopathological study, MCN, MPN, and MACN tissues were harvested from all ten specimens and fixed with Karnovsky's fixative (paraformaldehyde-glutaraldehyde solution) for 24 hours. After washing it using 0.1 M phosphate buffer for 15 minutes three times it was postfixed with 1% osmium tetroxide that was dehydrated in acidified 2,2 dimethoxypropane for one hour. Semi-thin (1µm) cross-sectional cuts were obtained and embedded in Araldite Epoxy resin then stained with Hematoxylin–eosin and toluidine blue. The slides were read by a pathologist, and the number of fascicles, nerve diameter, and cross section were measured. Histopathologic views were recorded with Olympus DP12 Digital Camera system (Olympus Optical, Tokyo, Japan) (Figure 2A-C).

Statistical Analysis

Statistical significance between the values of each pair of nerves was analyzed by Wilcoxon rank-sum test using SPSS version 11.5 (SPSS, Chicago, Illinois). P-value <0.05 was considered to be statistically significant.

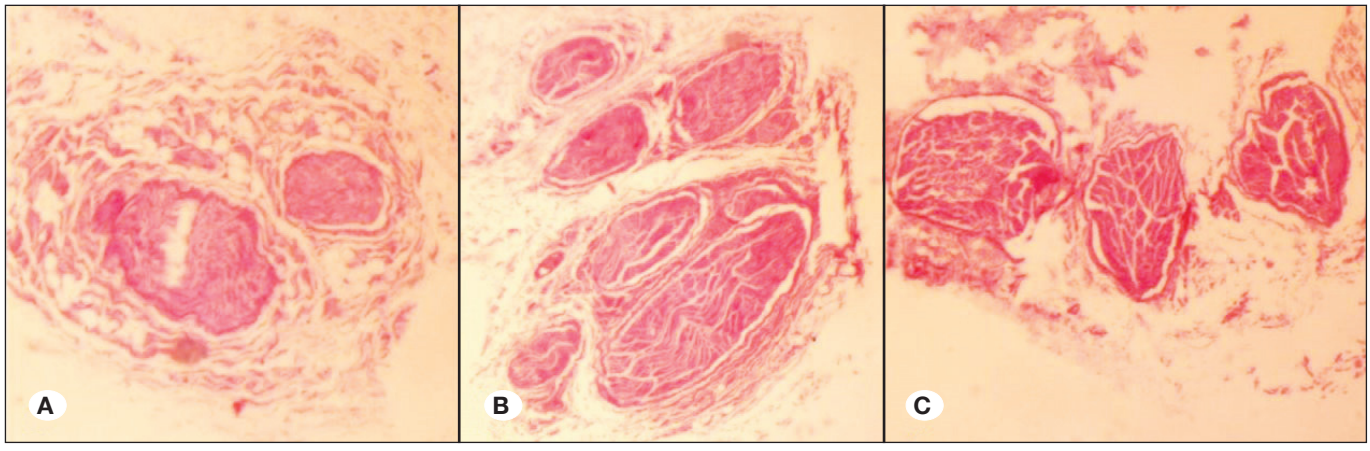

Figure 2: High power microscopy of medial pectoral nerve (MPN), medial antebrachial cutaneous nerve of forearm (MACN), musculocutaneous nerve (MCN) shows the incompatibility of MPN and MCN with MACN, regarding the number of fascicles, diameter, and cross-section area.

RESULTS

Identification of MACN, MCN, and MPN was possible in all cadavers. After dissection of the preferred nerves, the anatomical distances of the preferred nerves were measured from the coracoid bone. The mean ± standard deviation of the distances of the proximal part of MCN, and MACN were 31.8 ± 0.5 and 27.3 ± 0.6, respectively. Also, the mean (± standard deviation) of distances of distal ends of MPN and MACN were 3.6 ± 0.4 and 3.8 ± 0.4, respectively.

After anatomical measurements, the nerves of interest were dissected and underwent histopathologic evaluation. The mean (± standard deviation) number of the fascicles MPN (2.6 ± 0.5) and MCN (2.9 ± 1.0) were similar (p=0.615). However, the mean number of MACN fascicles were not compatible with its adjacent nerve, neither at the proximal (p=0.004) nor at distal (p=0.009) parts. A similar pattern was seen for the diameter and cross-section area of the nerves. While the mean diameter of the MPN (1.6 ± 0.4) and MCN (1.8 ± 0.7) was similar, they were significantly different (p=0.002 and p=0.004) from their adjacent MACN ends (2.6 ± 0.6 and 2.7 ± 0.6, respectively). The mean cross-section area of the MPN was 2.0 ± 1.0 that was similar to MCN (2.8 ± 2.4; p=0.849). The mean cross-section area of the proximal and distal ends of MACN were 5.6 ± 2.4 and 6.0 ± 2.5 that were different from their adjacent nerves (Figure 3). The mean of fascicle count, diameters and cross-section of nerve ends are shown in Table I.

DISCUSSION

Elbow flexion is an essential motion that is impaired in patients with upper brachial plexus injuries. Regarding different origin of the MPN (C8, T1) and those nerves involved in elbow flexion (C5, C6), it can be used to innervated the distal branches of the injured roots. In a recent meta-analysis, the recovery of elbow flexion following nerve transfer and nerve graft surgery was investigated. The results revealed that nerve transfer from the pectoral nerve to MCN was superior to other nerves regarding elbow flexion recovery in brachial plexus injuries (18). However, these nerves are far from each other and tension-free direct anastomosis of the mentioned nerves is not possible. Previous studies suggested MACN as a proper nerve graft due to its long length and minimal morbidity for the donor site (2,3,9). Also, MACN has revealed successful results as a nerve graft for facial nerve palsy (13), digital nerve reconstruction (1,8), and correction of iatrogenic spinal accessory nerve palsy (15). In a retrospective study by Li et

Table I: Comparison of the Histopathologic and Anatomic Parameters of MPN, Distal and Proximal Ends of MACN and MCN Which are Reported as mean ± SD

	MPN	MACN (proximal)	p	MACN (distal)	MCN	p
Number of fascicles	2.6 ± 0.5	4.4 ± 1.4	**0.004**	4.5 ± 1.2	2.9 ± 1.0	**0.009**
Radial diameter (mm)	1.6 ± 0.4	2.6 ± 0.6	**0.002**	2.7 ± 0.6	1.8 ± 0.7	**0.004**
Cross section area (mm²)	2.0 ± 1.0	5.6 ± 2.4	**0.002**	6.0 ± 2.5	2.8 ± 2.4	**0.004**
Distance from coracoid bone (cm)	3.6 ± 0.4	3.8 ± 0.4		31.8 ± 0.5	27.3 ± 0.6	

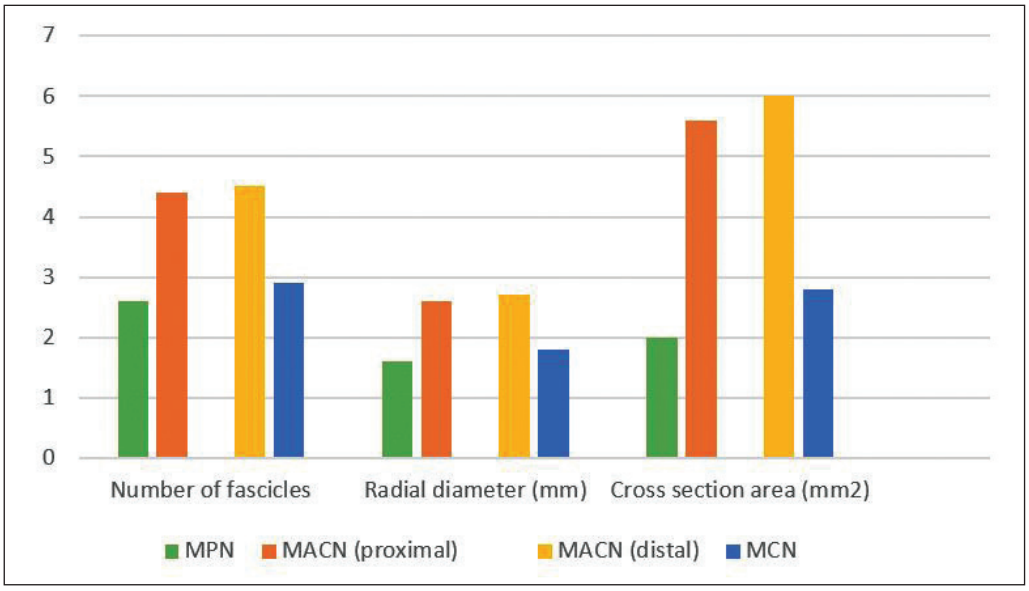

Figure 3: Comparison of the histopathologic parameters of Medial Pectoral Nerve (MPN), distal and proximal ends of Medial Antebrachial Cutaneous Nerve of Forearm (MACN) and Musculocutaneous (MCN).

al. 16 patients with total brachial plexus avulsion underwent contralateral C7 transfer via both the ulnar nerve and MACN in two stages. They anastomosed the proximal end of the ulnar nerve of the injured side to the posterior division of the contralateral C7 and its distal end to the median nerve of the injured side. At the same time, they anastomosed the proximal end of the MACN to the anterolateral portion of the anterior division of contralateral C7 and also the distal part of the MACN of the injured side to the MCN of injured side. They reported that 68.75% of the patients achieved functional recovery of elbow flexion to M3 or better (6).

The reason MACN is considered as a potential nerve graft was anatomical proximity of its proximal and distal ends to the donor and targeting nerves of interest. However, there are other influential characteristics for a potential nerve graft, such as the compatibility of the diameter, area, and number of the fascicles. According to a study carried out by Wellons et al., the result of neurotization of MPN to MCN was excellent (20). However, they did not evaluate the histomorphology of the mentioned nerves. To the best of our knowledge, there is no previous study available to investigate the compatibility of MACN with MCN and, or MPN regarding their histomorphologic features. The present study shows that the histomorphologies of the MCN and MPN are compatible with anastomosis. Also, it reveals that the anatomical position of the proximal and distal end of MACN is adjacent to the mentioned nerves to provide tension-free anastomosis. However, from histomorphologic aspects, MACN is compatible with neither MCN nor MPN. Thus its seems that MACN is not a proper nerve graft for MCN and MPN anastomosis.

One of the considerations in MACN harvesting is to avoid taking its posterior branch since it will lead to numbness of the skin over the olecranon and painful neuroma (7). In spite of superficial course of MACN under the subcutaneous tissue, it has various interpositions due to its high length and arborization that makes its harvesting difficult and time-consuming (16,17).

CONCLUSION

The present anatomical and morphological study reveals that MACN is not a proper graft for MCN and MCN anastomosis due to its incompatibility of its diameter, area, and number of fascicles.

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