Does Motor End Plate Morphometry from Muscle Biopsies Correlate with Electromyography Data for Patients with Brachial Plexus/Peripheral Nerve Injury?

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INTRODUCTION:

The indications for nerve transfer after traumatic peripheral injury remain controversial. For patients who present in a delayed fashion, many surgeons use the presence of fibrillations and positive sharp waves (PSWs) on electromyography (EMG) as a proxy for motor endplate viability and receptivity to reinnervation, indicating the patient for nerve transfer rather than alternatives such as free functional muscle transfer. Although this concept is frequently suggested in the literature, there has not been a rigorous evaluation of a relationship between EMG data and motor endplate (MEP) morphology in affected muscles in humans. Here, we characterize the relationship between fibrillation potentials/PSWs and the quantity of healthy MEPs in muscle biopsy samples taken from patients undergoing nerve transfer.

METHODS: We performed a prospective analysis of 14 patients undergoing nerve transfer. Pre-operative EMG data was obtained by a board-certified neurologist with neuromuscular subspeciality training. Fibrillation potentials and PSWs are institutionally reported as a combined value and rated 0, 1+, 2+, or 3+. Muscle biopsies were obtained at the time of nerve transfer and were stained with acetylcholine receptor-alpha (AchR-α) and neurofilament/synaptophysin to identify MEPs and innervating presynaptic axons. The structure of AchR-α stained MEPs was assessed in 3-dimensions using image stacks collected with Keyence BZ-X810 inverted fluorescence phase contrast microscope to assess motor end plate morphology. Visualized MEPs were morphologically categorized as either pretzel (healthy) or intermediate/plaque (unhealthy). Healthy MEPs were quantified as a percentage of total MEPs present. Partial correlation analysis was utilized to evaluate the relationship between fibrillation potentials/PSWs and MEP morphology, controlling for time from injury to surgery. Spearman's rho correlation was used to define the relationship between the fibrillation potentials/PSWs and MEP morphology.

RESULTS:

The average patient age at the time of nerve transfer was 41.7 years old. The time from injury to operative intervention ranged from 1 week to 492 months, with an average interval of 1 year. Muscle biopsies were acquired from the following muscles: deltoid (10), bicep (2), triceps (2). 12 biopsies were collected from affected muscle and 2 biopsies were collected from adjacent unaffected muscle. The average number of motor end plates present in the muscle biopsies was 19.78. The proportion of healthy MEPs in biopsy samples were compared to fibrillation potentials/PSWs recorded from the corresponding muscle. A significant, moderate negative correlation ($r = -0.56$, $p = 0.035$) was observed between the fibrillation potentials/sharp waves and percentage of healthy pretzel MEPs while controlling for time from injury to muscle biopsy. As fibrillations and PSWs increased, the percentage of MEPs demonstrating healthy pretzel morphology decreased, suggesting an inverse relationship with neuromuscular junction health.

DISCUSSION AND CONCLUSION:

The correlation between biopsy findings and EMG data while controlling for time from injury supports the use of muscle biopsy as an adjunct to electromyography in surgical decision-making. Increased fibrillations correlate with poorer MEP morphology, indicating that EMG data may provide a window into underlying muscle architecture. Such results suggest that combined diagnostic approaches may provide a more robust understanding of motor end plate degeneration and viability so as to better determine patient eligibility for operative intervention following peripheral nerve injury. Finally, these data reinforce surgeons' use of fibrillation potentials/positive sharp waves as a metric of underlying neuromuscular junction health.

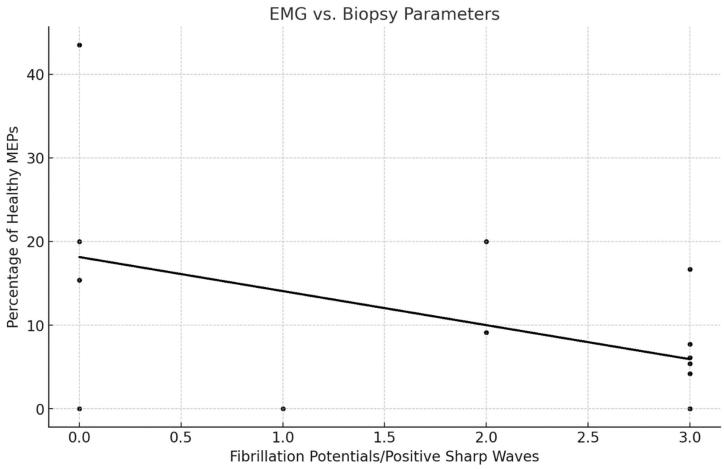

Figure 1 – Scatterplot of Fibrillation Potentials/Positive Sharp Waves vs. Percentage of Healthy Motor End Plates (MEPs). EMG – Electromyography.