Partial Skeletal Muscle Grafts for Prosthetic Control

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Abstract

Background: Nonvascularized partial skeletal muscle grafts are notorious for their limited force-generating capacity and tendency to degenerate in the absence of reinnervation [1-3]. Accompanied by peripheral nerve implantation, however, partial muscle grafts can survive and transmit detectable electromyographic (EMG) signals capable of prosthetic control [4]. Our study investigated partial muscle graft survival in the construction of regenerative peripheral nerve interfaces (RPNIs) and further characterized their electrophysiological properties across various muscle donor sites.

Methods: Twenty F344 rats were assigned to 1 of 5 groups based on muscle graft type used for RPNI construction: 1) control-whole extensor digitorum longus; 2) partial biceps femoris; 3) partial rectus femoris; 4) partial lateral gastrocnemius; and 5) partial vastus medialis. Each graft of approximately 140-mg was transferred to the femur, wrapped in small intestinal submucosa for tissue isolation, and implanted with the transected common peroneal nerve. After 4 months of RPNI recovery, in situ EMG (Figure 1) and force testing were performed.

Results: Twelve of 16 partial muscle RPNIs demonstrated detectable EMG function at 4 months. Significant differences between control RPNIs (n=4) and functional partial muscle RPNIs (n=12) included average mass (118±42 mg vs. 66±25 mg), EMG peak-to-peak amplitude (6.7±2.3 mV vs. 1.5±1.6 mV), and maximum tetanic force (729±666 mN vs. 175±154 mN). Outcomes by group for all RPNIs (n=20) are depicted in Figure 2. RPNI mass was the overriding significant predictor of EMG peak-to-peak amplitude (p<0.001). After adjusting for RPNI mass, donor muscle type showed no correlation with partial muscle EMG signal strength.
Conclusions: Partial muscle graft RPNIs transmit detectable EMG signals with a 75% success rate at 4 months. This proof of concept feasibility underscores the potential to develop and refine partial muscle graft-based interfaces to harness peripheral nerve signals for high-fidelity prosthetic control in amputees. While signal size remains favorable (i.e. 10-50 times larger than signals recorded directly from peripheral nerves) [5], further studies are warranted for optimization of partial muscle graft regeneration and methods of signal acquisition.

References

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