Results: Rats with untreated fresh nerve allografts demonstrated very poor nerve regeneration compared to rats with nerve isografts or rats with nerve allografts treated with FK506 (p<0.001). Rats with nerve allografts treated with local FK506 demonstrated significantly better motor and sensory neuron regeneration than rats with untreated nerve allografts (p<0.001) and not significantly different from rats with nerve isografts or rats with nerve allografts treated with systemic FK506 (p>0.05). Histomorphometric analysis of the midgraft and distal common peroneal nerve revealed that rats with local FK506-treated nerve allografts had comparable numbers of myelinated axons as rats with nerve isografts and rats with nerve allografts treated with systemic FK506 (p>0.05). Compared to rats with untreated nerve allografts, serum concentrations of the pro-inflammatory cytokine IL-12 were significantly lower 1 week after surgery in rats with nerve allografts treated with local FK506 (p<0.05) or systemic FK506 (p<0.001); however, unlike rats treated with systemic FK506, rats treated with local FK506 had undetectable serum levels of FK506.

Conclusions: A local FK506 drug delivery system enhances motor and sensory nerve regeneration through fresh nerve allografts comparable to nerve allografts treated with systemic immunosuppression and nerve isografts. These results provide data for future investigations to characterize the neurotrophic and immunosuppressive effects of local FK506 using an immunodeficient transgenic rat, as well as to evaluate functional recovery. Local FK506 drug delivery may have direct clinical application in allotransplantation of peripheral nerve and vascularized composite allografts.

Surface Electromyography-Based Gamification Therapy For Rehabilitation Of Upper Extremity Weakness: An Acceptability Study

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Purpose: Upper extremity weakness may be debilitating and results from a variety of causes, including peripheral nerve and cervical spinal cord injury, stroke, and disuse atrophy. Therapy is critical for regaining function but patients are unable to engage with traditional methods of therapy until evidence of motor recovery is seen on clinical exam. In this study, we have developed an innovative system of gamified therapy that uses signals detected by surface electromyography (EMG), a well-established, noninvasive technique that measures electrical activity generated by muscle contractions from electrodes placed on the overlying skin.

Methods: We constructed a highly sensitive custom surface EMG device and integrated it with multiple gaming platforms. In our system, adhesive electrodes are placed over a muscle of interest, and muscle activation greater than a set threshold triggers a single action in the virtual gaming environment. Patients with upper extremity weakness from any cause were recruited to use the surface EMG device to play games. Acceptability surveys were administered after each gaming session, and additional metrics to assess feasibility were examined, including task learning speed, length of gameplay session, high scores achieved, and technical problems encountered.

Results: The sensitivity of our custom surface EMG device was assessed through simultaneous needle EMG recordings. Our device is capable of detecting muscle activation even during recruitment of a single motor unit, and signals recorded represent activity from the specific muscle of interest and not of opposing muscle groups nearby. Patients quickly learned how to activate their muscles to interact with the virtual gaming environment. Interestingly, patients lacking antigravity muscle strength, scoring as low as 2/5 on manual muscle testing, were still able to engage in reliable gameplay. Responses from acceptability surveys showed that the majority of patients found the surface EMG-based gaming platform to be motivating, enjoyable, easy to understand, and safe.

Conclusion: Gamified therapy represents a novel approach to rehabilitation that promotes patient engagement, motivation, and compliance. The use of surface EMG signals as input for therapeutic gaming has tremendous potential for severe muscle weakness in the earliest stages of recovery, as nascent signals from underlying affected muscles are detectable on EMG before significant movement is observed on clinical exam. This creates the opportunity for earlier initiation of therapy in many patients with upper extremity weakness. In patients with brachial plexus injuries who have undergone nerve transfer surgeries, surface EMG-based therapy may have the added benefit of facilitating cortical retraining by helping patients learn the association between donor nerve activation and recipient muscle movement. Future studies are needed to assess the clinical efficacy of surface EMG-based gamification therapy in these distinct patient populations.