PURPOSE: Despite extensive research efforts, neuroma formation remains a persistent challenge in the treatment of peripheral nerve injuries. Targeted muscle reinnervation (TMR) has emerged as a promising approach for prevention and treatment of painful neuromas. However, the significant size-mismatch inherent to TMR contributes to substantial axonal escape from the coaptation site and consequently patients rarely achieve full resolution of symptoms. To address this limitation, we developed a funnel shaped conduit to mechanically guide the regenerating axons across the repair site and thereby prevent axonal escape. The conduit is modified from a biodegradable nerve wrap that has demonstrated excellent biocompatibility and anti-inflammatory properties in prior studies by our group. Given the limited capacity of the distal nerve stump to accept the axons regenerating from the larger proximal nerve, we incorporated chondroitin sulfate proteoglycans (CSPGs) within the lumen of the conduits to inhibit the majority of the regenerating axons. We applied the funnel conduit with and without CSPGs in a TMR model to assess the impact on functional recovery and neuroma formation at the repair site.

METHODS: A conduit device composed of nonwoven poly-ε-caprolactone (PCL) was developed by electrospinning. The conduit walls prevent intraneural macrophage infiltration and inflammation, which limits scarring and fibrosis at the coaptation site. Within the conduit, CSPGs incorporated into a nanofiber hydrogel form an interpenetrating network. Using a TMR rodent hindlimb model, we tested the effects of this device on neuroma formation, axonal growth, muscle reinnervation, pain behaviors, and functional recovery.

RESULTS: Qualitative assessment of the coaptation site showed that the significant size mismatch between the sciatic nerve and tibial branch resulted in neuroma formation in the TMR and neuroma groups, while the use of the conduit resulted in tapered reinnervation of the sciatic nerve, demonstrating the effectiveness of this device in mechanically guiding axonal growth. Neuroma and TMR groups demonstrated more co-labelling of Substance P and SCG10 (regeneration marker) than conduit groups. No significant differences were observed between the Positive Control and CSPG-Conduit groups in gastrocnemius muscle mass, myofibril cross-sectional area, and neuromuscular junction reinnervation. However, the Positive Control group exhibited significantly greater gastrocnemius mass than the TMR and the Negative Control groups, suggesting better axonal guidance and muscle reinnervation was enabled by the conduit. By Week 5, mechanical stimulation of the coaptation site elicited significantly less pain behavior response scores in the CSPG-Conduit group compared with the Neuroma group. Autotomy scores of CSPG-Conduit scores were similar to Positive Control scores, suggesting successful prevention of neuroma formation.

CONCLUSIONS: We introduce a novel engineered device in which mechanical guidance of axons is combined with inhibition of axonal regeneration to prevent neuroma formation. This conduit presents a biologically compatible, noninvasive means by which we could optimize postoperative care of peripheral nerve injury. Built from materials and components currently used in FDA-approved devices, the device is poised for clinical translation. This therapeutic approach has high potential for success as a reliable technique to prevent neuromas and facilitate prosthetic use.

Optimal Irrigant in High Pressure Paint Injection Injuries of the Hand

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INTRODUCTION: High-pressure injection injury (HPII) to the hand with paint leads to amputation rates near 48%. Historically, authors utilized saline irrigation alone, but have high re-operation rates. We conducted a cadaveric study to determine the ideal detergent for effective paint removal from the soft tissue.

METHODS: Two cadaveric hands were amputated from the same cadaver. The left and right hand digits were injected with flat white latex-based paint and flat white oil-based paint, respectively. Each digit received a longitudinal incision and was scrubbed for 120 seconds with 50 mL of a randomly assigned detergent and no detergent (saline) as the control. After achieving a lather, each finger was cleansed with 50 mL saline before being evaluated by two blinded hand surgery faculty. Reviewers assessed the washouts as adequate or inadequate, in order to generate a Kappa statistic and measure inter-rater reliability prior to ranking each digit (1–5) (ie, 1 = most paint-free soft tissue).
RESULTS: The two hand faculty had an inter-rater reliability of 0.70. Both reviewers ranked Povidone-Iodine 10% or Johnson & Johnson baby shampoo as the best irrigant for latex-based paint. In oil-based paint, Povidone-Iodine 10%, Johnson & Johnson, and Techni-care were ranked as top three. All reviewers reported detergents better than saline alone.

CONCLUSIONS: The addition of detergent created an irrigant that removed both latex and oil-based paint better than normal saline alone. Based on these results, surgeons treating HPII should consider using Povidone-Iodine 10% or Johnson & Johnson baby shampoo for latex or oil-based paint.