The Application of Photochemical Tissue Bonding (PTB) for Large Gap Peripheral Nerve Injury

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Aims

1. Determine mechanical properties, seal strength and resistance to biodegradation of candidate biological nerve wraps.
2. Determine efficacy of regeneration in a rat model of large deficit injury as a function of nerve wrap materials and method.

Hypothesis

Photochemical sealing of nerve graft coaptation sites using a durable, biocompatible nerve wrap will create a sutureless water tight seal, leading to superior outcomes compared to conventional methods.

Experimental Approach

Aim 1

• Candidate nerve wrap biomaterials:
  • Processed human amnion (HAM)
  • Swine intestinal submucosa (SIS)
  • Wraps crosslinked with EDC(1-ethyl-3-(3-dimethylaminopropyl) carbodiimide/NHS (N-hydroxysuccinimide)) to improve durability.
  • Mechanical properties of nerve wrap materials determined by tensiometry.
  • Resistance to biodegradation measured using collagenase digestion and fluorescamine assay.
  • Nerve wraps stained with 0.1% Rose Bengal (RB, Fig 1) and bonded to ex-vivo rat sciatic nerves using 532 nm light (0.5 W/cm² for 5 mins per coaptation site).
  • Bond strength between nerve wrap and epineurium tested using tensiometer (Fig 2).

Results

• Tensile strength and Young’s modulus of HAM and SIS increases (stronger) significantly with EDC/NHS concentration.
• Photochemical bond strength of epineurium/wrap interface is maintained until 8mM EDC/2mM NHS.
• Crosslinking HAM and SIS wraps reduces rate of proteolytic degradation (Fig 3).
• 4mM/1mM EDC/NHS selected for in vivo study based on optimal bond strength and resistance to collagenase degradation of HAM and SIS in vitro.

Aim 2

• 110 male Lewis rats
• 1.5cm left sciatic nerve defect created and repaired with isograft (Fig 4).
• 11 treatment combinations (n=10)

Outcome assessment

• Greatest recovery of SFI and muscle mass retention occurred in xHAM+PTB group (Table 1 and 2).

Conclusions

• Photochemical bonding of biological nerve wraps increases strength and resistance to proteolytic degradation.
• Crosslinked amnion wraps photochemically sealed to neuroprosthesis sites of nerve grafts results in superior functional and histological outcomes compared with standard epineurial suture

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