Synthesis and Analysis of Electrospun Suture for Localized Infection Prevention

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Statement of Purpose

Sutures are used in roles ranging from organ repair to incision closure, and are a crucial part of any surgery. Coincidentally, 66% of all surgical site infections (SSIs) occur at the incision, and intravenous antibiotics often do not penetrate the interstices where sutures are implanted. While antimicrobial sutures have been developed (Vicryl® Plus) to prevent infection of the suture material itself, the space surrounding the suture remains vulnerable. The goal of this study is to develop a novel, non-degradable, nanofibrous infection-resistant suture with antimicrobial agents loaded throughout. We hypothesize that this novel suture will prevent bacterial infection of the incision, maintain wound closure, and promote a healing response comparable to or better than current antimicrobial sutures.

Methods

Suture Fabrication: A broad-spectrum fluoroquinolone antibiotic (moxifloxacin, "Moxi") was combined at two concentrations (1.5% and 3% w:v ratio) with polyethylene terephthalate (PET) and an organic solvent to create two polymer solutions. The solutions were electrospun at room temperature onto a proprietary mechanical collection surface to synthesize a suture. PET polymer was electrospun without Moxi to act as control nanofibrous suture. All sutures were given a proprietary treatment while under tension to remove residual solvent and maximize crystallinity of the nanofibers.

SEM Analysis: Segments were collected from the electrospun sutures randomly and examined via a JEOL JSM 5900LV electron microscope (gold sputter coated for 30 seconds followed by SEM at 20kV, at 200x and 1,500x) to qualitatively assess fiber size and distribution.

Tensile Testing: Control and drug-loaded sutures were tested for tensile strength using a Q-Test Tensile Strength Apparatus (MTS Systems, Cary, NC; crosshead speed = 50mm/min, gauge length = 20mm).

In Vitro Wash Studies: Vicryl® Plus 4-0 sutures (industry standard for infection-resistant sutures) and electrospun control and Moxi-loaded sutures were washed in sterile PBS to study the duration and activity of drug release. At the start of the wash study, 20 mg segments (n = 3 segments/test group) were washed in a 1.5ml Eppendorf tube with 1ml PBS/segment. Tubes were placed onto an inversion mixer at 33RPM, 37°C. After each time period (1hr, 4hr, 1 day, daily through day 7), the wash solution and 10mm segments were collected, replaced with fresh PBS, and tested for drug concentration and activity.

Antibiotic Release and Activity Assay: Moxi release into the wash solution was measured using UV/VIS spectroscopy and spectrofluorometry. Antibiotic activity for unwashed and washed suture materials was determined using a zone of inhibition (ZOI) Assay. A standard moxifloxacin disk was used as a positive control.

Results

SEM analysis revealed the control and Moxi-loaded suture materials (**Figure 1)** were highly aligned and nanofibrous **(Figure 2)**. Mechanical testing for the 1.5% and 3% Moxi sutures revealed tensile strengths of 100±9.8 and 84±7.3 MPa, respectively. After an experimental 70°C heat treatment, however, 1.5% Moxi suture's material strength increased to 380±119MPa, which exceeds USP strength requirements. This treatment would be expected to cause a similar improvement on the 3% Moxi suture as well. Absorbance testing showed a bolus release of 5.32±1.13 µg Moxi/ml PBS/mg suture in the first hour of PBS wash, dropping down to 0.72±0.17 µg Moxi/ml PBS/mg suture on day 3 with a steady release for each remaining day of the wash study. ZOI studies for the unwashed and washed sutures showed that the 3% Moxi suture was capable of eradicating *S. Aureus* within a 7mm radius at all times throughout the 7-day wash **(Figure 3)**. The 1.5% Moxi suture was also successful for all time intervals, but to a lesser degree, and its efficacy diminished over the course of the 7-day wash study. In contrast, both Vicryl® Plus and the non-drug loaded control suture failed to provide antimicrobial activity at any time period, even before washing. Full ZOI results can be seen below in **Figure 4.**

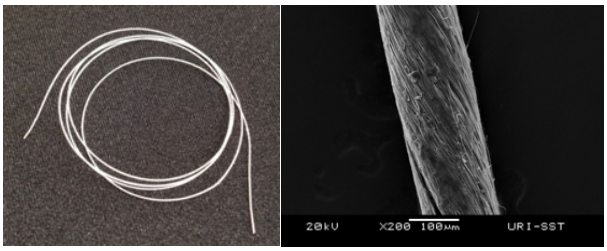

Fig 1: Photo of e-spun suture

Fig 2: SEM image of e-spun suture

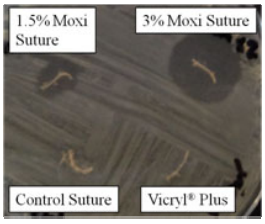

Fig 3: Photo of ZOI plate for samples washed for 7 days

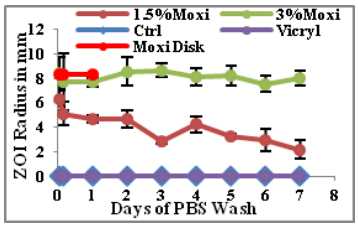

Fig 4: ZOI size for all materials over the course of the 7-day wash study

Conclusions

We have produced a nanofibrous suture with the strength, morphology, and antimicrobial efficacy needed to provide localized infection resistance. This is a significant improvement over the current industry standard for infection-resistant sutures according to these *in vitro* studies. Future studies will focus on surgical implantation of these sutures into an infected zone in an animal model to evaluate infection-resistance and healing *in vivo*.