Barbed Suture Anchoring Strength: Applicability to Dissimilar Polymeric Materials

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Introduction:
A new method of closing wounds using bi-directional barbed sutures made from polydioxanone monofilaments has been successfully demonstrated in an *in vivo* canine model.[1,2] These devices rely on the ability of barbs to anchor securely in tissues and obviate the need for surgical knots.[2] The goal of this study was to: 1) develop an in vitro suture pull-out strength test, and 2) measure and compare the anchoring strength of barbed polymeric suture materials with that of polydioxanone.

Materials and Methods:
Six polymeric suture monofilaments were selected that span a range of absorption profiles and mechanical properties. The chemical compositions of these absorbable and non-absorbable polymers, and their diameter measurements, are detailed below in the following table.

Suture	Polymer Composition	Diameter (mm)
Biosyn	PGA-PTMC-PDO (60%:26%:14%)	0.440 ± 0.002
Maxon	PGA-PTMC (67.5% : 22.5%)	0.443 ± 0.002
Monocryl	PGA-PCL (75% : 25%)	0.448 ± 0.002
PDS II	p-Dioxanone (100%)	0.443 ± 0.001
Ethilon	Nylon 6 (100%)	0.459 ± 0.002
Prolene	Isotactic polypropylene (100%)	0.459 ± 0.005

PGA: Polyglycolic acid; PTMC: Poly- tri-methylene-carbonate
PDO: Poly-1,4-dioxane-2-one; PCL: Poly-caprolactone

Barbed sutures were fabricated using the current technology.[3] The barb geometry was controlled within the range of 160 ± 3° cut angle, 0.16 ± 0.02 mm cut depth and 0.49 ± 0.01 mm cut length, which corresponds to the dimensions used previously to prepare successful barb suture design.[2] The suture anchoring strength was measured using a pull-out method as depicted in Figure 1: A uni-directional barbed suture (only one half of the bi-directional suture design was employed) was inserted into the middle layer of a tissue simulant (Miracle Towel, Turtle Wax, Inc.), 60 mm x 47.5 mm x 2 mm, using a curved needle (1/2 circle, 22 mm length). This resulted in a distance of 15 mm between suture entry and exit points, burying an arc of 22 mm.

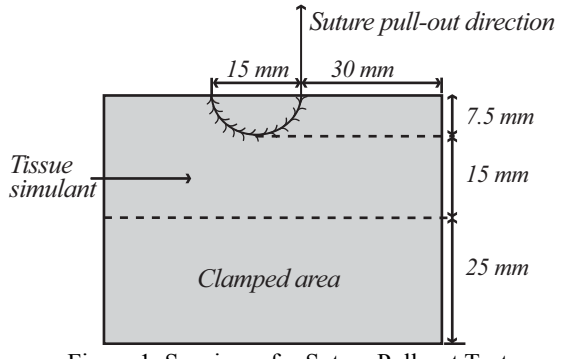

Figure 1: Specimen for Suture Pull-out Test.

This set-up served as an empirical test to mimic one of the multiple curves that would be typically employed in a clinical stitching method.[1,2] The bottom portion of the tissue simulant and the free suture end were clamped between the jaws of a mechanical testing machine (MTS, Model 1122, 500N load cell), with a 12 cm gauge length, and loaded at a rate of 1.0 mm/sec. The suture anchoring strength was determined as the peak force recorded by pulling the suture from the tissue. Ten replicate tests were performed for each suture type, and for comparison purposes, unbarbed sutures were also tested.

Results and Discussion:
The average barbed suture anchoring strengths and standard errors are plotted with their unbarbed counterparts in Figure 2.

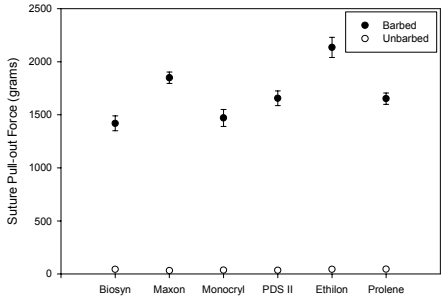

Figure 2: Barbed Suture Anchoring Strength

The pull-out forces for the barbed sutures were in the range of 1.4-2.1 kg. Values for the unbarbed sutures were 0.02-0.04 kg, showing the significant anchoring contribution provided by the barbs. Previous animal studies have shown that barbed polydioxanone sutures, which exhibited 1.65 kg in this study, can effectively close wounds with an *in vivo* pull-out force in a similar range (1.1-1.7 kg).[4] Hence it would appear that satisfactory wound closure performance might be expected from other suture polymers that give similar *in vitro* pull-out values. Further, the fact that all the barbed sutures eventually broke within the tissue simulant suggests that the barbs on all six types of sutures appear capable of providing significant tissue anchoring.

Conclusions:
The results of this study indicate that: 1) an *in vitro* suture pull-out strength test method, capable of measuring barbed suture anchoring strength, was successfully developed; and 2) barbed suture technology is applicable to a range of different absorbable and non-absorbable polymers.

References:
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