

Barbed, Bi-directional Medical Sutures: Biomechanical Properties and Wound Closure Efficacy Study

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INTRODUCTION

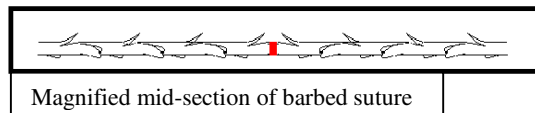
Medical sutures are used in tens of millions of surgical procedures performed each year. They are used to hold tissues together indefinitely, until healing is complete, or when the repaired wounds possess enough strength to withstand tensions during normal activities. To provide varying duration intervals, numerous absorbable and nonabsorbable sutures have been developed to address diverse repair applications. To close a wound, sutures must be knotted. And because the knot increases local stress, suture failure occurs most frequently at the knot. For this reason, The US Pharmacopeia (USP) specifies minimum knot-pull tensile strength requirements for sutures.

Several self-anchoring suture concepts, particularly barbed, one-way sutures,^{1,2} have been published in the patent literature. These have the ability to put tension in the tissue with less suture slippage in the wound. They spread out the holding forces evenly thereby significantly reducing tissue distortion. Nevertheless, usage of these sutures have only been reported scantily,³ most likely due to manufacturing intricacy.

The goal of this study was to evaluate the biomechanical properties of a newly developed barbed, bi-directional absorbable suture, as well as to test its wound closure efficacy in vivo.

MATERIALS AND METHODS

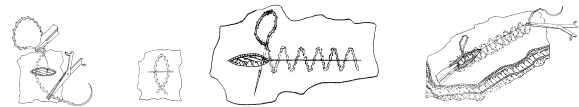
Barbed Suture: A bi-directional barbed suture was fabricated from a monofilament fiber made of polydioxanone (PDO). The suture is 7" long and 0.018" in diameter (size '0' per USP). The middle 3" of the suture contains 78 barbs that are escarped into the fiber. The barbs are positioned in a spiral pattern around the circumference of the monofilament. They are divided into two equal groups that face each other in opposing directions from the suture midpoint. Extending beyond the barbed sections are unbarbed sections of the monofilament that are each 2" long. Depending on the stitch technique, a straight or curved needle can be attached to either end of these sections.



Tensile Strength Measurement: Testing was performed using a Test Resources Universal Tester, Model 200Q. Barbed sutures were held by two serrated jaws padded with cork gasket materials, whereas regular sutures were held by two capstan roller grips. The length of the suture specimen between the two grips was 5" (which in case of barbed sutures, contained all barbed sections). The specimen was pulled at a rate of 10 in./min

until breakage occurred. The peak load was recorded as the straight-pull tensile strength. The average reading of at least 10 measurements was reported.

In Vivo Study: Three Mongrel dogs, each about 14 kg, were used. Seven incisions were made at the thorax (twice), thigh (twice), flank, ventral midline, and paramedian on each animal. The length of the incisions ranged from 1/2" to 4" and the depth of the incisions from the dermis to muscular level. The incisions were closed with barbed sutures and conventional sutures (2-0 silk, 2-0 nylon, and 3-0 PDO) according to a premeditated randomized scheme. Three stitch methods—'alpha', zigzag, and coil—were used with barbed sutures. All animals were monitored daily and maintained for 14 days.



At necropsy, the incisions were evaluated macroscopically.

RESULTS AND DISCUSSION

Escarment of barbs into a '0' size PDO monofilament reduced the straight-pull tensile strength by approximately 60% (7.03 lb vs. 17.72 lb). However, in view of the different failure mechanisms of the two suture types, the '0' barbed suture, with a smaller "effective" diameter, compares favorably with 2-0 or 3-0 sutures.

Suture	Straight-pull (lb.)	USP Knot-pull (lb.)
PDO '0'	17.72	8.60
PDO 2-0	11.86	5.91
PDO 3-0	8.82	3.90
Barbed '0'	7.03	NA

The in vivo performance of the '0' barbed sutures was efficacious when compared to 2-0 and 3-0 control sutures. In various tissues, incision sizes and locations on the dogs, all incisions apposed with the barbed sutures stayed closed and appeared to be healing normally throughout the observation period (14 days). No dehiscence occurred. Three out of the six topical skin sites closed with nylon sutures experienced partial or complete suture loss, apparently due to the dogs' self-mutilation. Our findings suggest that a barbed, bi-directional suture may provide for significantly improved strength and tissue repair in comparison to currently available sutures.

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References [1] Alcamo, J.H. Surgical suture. *US Patent* 3,123,077, 1964. [2] Buncke, H.J. Surgical methods using one-way suture. *US Patent* 5,931,855, 1999. [3] McKenzie, A.R. An experimental multiple *barbed suture* for the long flexor tendons of the palm and fingers. *J Bone Joint Surg [Br]*, 49(3):440-7, 1967.