# Laser Assisted Barbed Suture for Wound Closures during Plastic Surgery

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**Statement of Purpose:** Based on the American Society for Plastic Surgery 2020 annual report, there are about 23 million plastic surgical procedures performed in the US each year. Conventional monofilament and braided sutures are being replaced by barbed sutures. Barbed sutures are sutures with barbs projecting from the main suture filament which, when used during wound closure, will interact with the surrounding tissues. Due to the presence of these barbs, these knotless sutures become self-anchored to the surrounding tissues without slippage, which can be problematic with conventional sutures which require knots.[1],[2]

The purpose of this research is to use an Excimer laser source to cut barbs in order to maximize the production of barbed sutures and use them commercially in place of conventional sutures.[3] Monofilaments of natural biomaterials, like collagen and catgut, are being used to fabricate these barbed sutures. Collagen sutures are of growing clinical interest, not only because of their biocompatibility and biodegradability, but because they mimic the natural extra-cellular matrix present in the body. The process of barbing in this study is performed on the monofilaments of collagen and catgut using both a mechanical cutting device as well as a laser source. The barbs are produced in both techniques so as to understand how laser technology can influence on the properties of the barbed suture.

**Methods:** The mechanical technique for barbing involves applying a series of straight blades inclined at a fixed angle of 165° (cut angle) to produce barbs at a fixed depth (cut depth) which is 20% of the diameter of the suture. Size 0 and 2-0 catgut sutures were selected with reference to the USP size chart. A pulsed laser source is used for cutting barbs on the suture monofilaments. After cutting barbs, the initial tensile modulus, breaking strength and elongation at break of the barbed sutures were tested on an MTS Q-tester mechanical tester operating at a constant-rate-of-extension (CRE) principle. The test specimen had a gauge length of 125 mm (5 inch) with a crosshead speed of 150 mm/min.

**Results:** Bidirectional barbed sutures were cut mechanically in both directions using a series of straight blades. The barbs were cut on catgut sutures (both 0 and 2-0) in three planes around the suture, with the angular distance between each plane being 120°. Figure 1 shows individual barbs cut on two catgut size 2-0 sutures. From the tensile test results, it was observed that after barbing, in the case of the size 0 sutures, there was about a 12% increase in the initial elastic modulus compared to the un-barbed control sutures, and about an 11% increase in the initial tensile modulus for the 2-0 sutures. In order to explain the increase in elastic modulus and the corresponding reduction in stress, cross-sectional analysis was performed, and the area lost due to barbing was determined. Figure 1 represents the cross-sectional view of two size 2-0 catgut sutures viewed under the Evos FL Auto2 imaging system at 4x magnification.

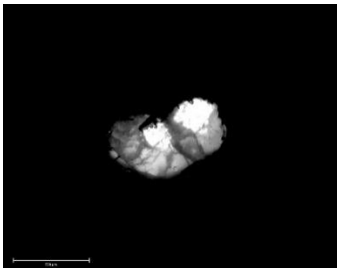

*Figure 1. Cross-sectional view of two catgut 2-0 sutures*

**Conclusions:** The conclusion from these preliminary results indicate that when the suture filaments are barbed there is a reduction in the local tensile stress, which is attributed to the loss in cross-sectional area since the barbs are cut from the surface of the filament. The observed increase in the initial elastic modulus for both suture sizes suggests that the structure of the catgut suture is not uniform or homogeneous across its diameter, and that the internal core of the suture has a stiffer structure than the outside surface material.

**Future Work:** Future work will evaluate the mechanical properties of the barbed sutures cut using laser irradiation compared to the barbed sutures fabricated through mechanical cutting. Along with analysis of mechanical performance the suture-tissue pull out strength will also be evaluated so as to understand the anchoring performance of the sutures in different types of tissue.

**References:**

[1] J. C. Leung, G. L. Ruff, M. W. King, and P. P. Dattilo, “Barbed bi-directional surgical sutures” *Medical Textiles and Biomaterials for Healthcare*, (2006; 395-403)
[2] A. P. Murtha “Evaluation of a Novel Technique for Wound Closure Using a Barbed Suture,” *Plast. Reconstr. Surg.*,(2006;117:1769-1780)
[3] H. J. Buncke and F. Hoffman, “[54] Surgical methods using one-way sutures”(1999; 17)