CHAPTER **43**

INNOVATIONS IN SUTURE MATERIALS: An Update

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The use of suture in medicine dates back to 3000 BC in ancient Egypt (1). Since that time, advents such as sterilization and synthetic materials have advanced the science of tissue closure significantly. The study of biomaterials and the ability to use polymers to match the half-life of a material with the rate of healing of varying tissues has greatly advanced reconstructive surgery (2). This update will serve as a review of recent advents in suture materials and their implication in foot and ankle surgery.

BARBED SUTURE

Barbed suture first received US Food and Drug Administration (FDA) approval for soft tissue approximation in 2005 (3). The uses of the new material configuration have since multiplied in the fields of plastic, obstetrics-gynecology, orthopaedic, and general surgeries. This new suture consists of material with tiny barbs cut into the length of the filament in a helical array set in opposite directions from an unbarbed segment (4). Its use in foot and ankle surgery is seen as being possible; however, few studies have detailed its practicality. Currently, three companies distribute barbed suture in the US: Stratafix (Ethicon, Johnson & Johnson), Quill (Surgical Specialties Corporation), and VLoc (Covien). All three make a wide range of suture sizes from 5-0 to 2 and in absorbable and non-absorbable variations.

Barbed suture has been used for almost all types of tissue closure, from closure of deep capsule in total joint arthroplasties, to use in plastic approximation of the dermis (3). The proposed advantages include the ability to create a uniform tension across a skin closure by relying on the barbed segments to hold tension in between passes of the suture instead of an assistant following with varied tension (3). With interrupted stitches, the barbed suture can be used without tying a knot, thus decreasing operating time (4). However, orthopedic studies have found the decrease in surgical time to be minimal (2.3 minutes) and therefore calling in to question the financial efficacy of barbed suture (5). One of the other findings supporting the use of barbed suture comes from another orthopedic study in which it was found that bacteria adhere less to barbed monofilament than braided sutures (6).

Barbed suture has also been recommended for its use in small tendon approximations (7). The largest advantage is the ability to approximate tendons in areas where a knot may become prominent such as the hand or foot. Two of the existing barbed PDO sutures, Stratafix (Ethicon, Johnson & Johnson) and V-Loc (Covidien) were examined in a porcine tendon model. The V-Loc held an advantage by demonstrating a higher maximum load in the tendon model (7). It is conceivable that barbed suture could enhance tendon repair or approximations in podiatric surgery by using a knotless configuration such as the one depicted here by Jordan et al (Figure 1).

Kanz et al evaluated the strength properties of barbed suture versus fiberwire in a cadaveric study of Achilles tendon repair. For the same reasons as listed above, the knotless barbed suture was tested as a novel knotless approximation of the Achilles. They found a significant decrease in failure strength from the fiberwire to the barbed suture, which may deter its use in large tendon approximations (8).

Barbed suture has been shown to decrease application times when used to apply graft material to a wound. The knotless technique as well as the ability of the barbed suture to hold the graft in place while applying makes this a conceivable option for wound care (9).

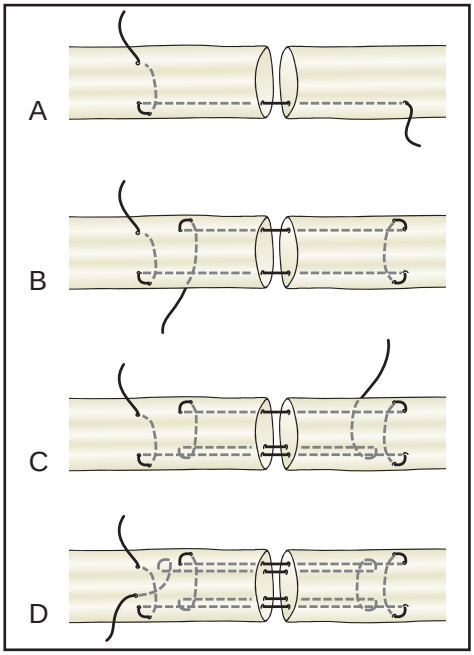

Figure 1. Small tendon approximation using barbed suture.

POLY-4-HYDROXYBUTYRATE (P4HB)

P4HB is a thermoplastic linear polyester, produced by recombinant fermentation that can be converted into a wide range of absorbable medical devices. Since receieiving clearance from the FDA in 2007, P4HB has been used as suture for tendon and ligament repair, surgical mesh devices, and other plastic and reconstructive materials. In foot and ankle surgery, this material holds promise in tendon and ligament repair as it has a tensile strength at the time of surgery equal to non-absorbable suture but will completely resorb over 12-18 months (10).

P4HB is a chemical structure similar to other existing synthetic absorbable polymers such as polyglycolide (PGA) and poly-e-caprolactone (PCL). However, unlike PGA and PCL, P4HB is difficult to synthesize chemically. Instead, P4HB belongs to a class of polyesters called polyhydroxyalkanoates (PHAs) that are produced naturally by microorganisms. P4HB is currently produced by means of a recombinant Escherichia coli fermentation process.

Once implanted in the body P4HB degrades primarily by bulk hydrolysis to produce 4HB, which is a constituent of the mammalian body and is found within a variety of tissues including brain, heart, kidney, liver, long muscle, and brown fat (11). The half-life of 4HB is approximately 27 minutes and is eliminated from the body primarily by metabolism via the Krebs cycle and is ultimately converted to carbon dioxide and water (11).

The P4HB polymer is a semi-crystalline material that can be readily processed by methods used for thermoplastic polymers. Due to its ability to be oriented, P4HB is ductile and does not exhibit brittle fracture characteristics like PGA and PLA. This allows the P4HB to retain 50% of its tensile strength after 3 months but achieve full resorption by 12-18 months (10). This allows for an absorbable suture to have near the same tensile strength properties of a permanent suture at the time of surgery but allow for full resorption after the tendon or ligament has healed.

Currently there are three companies that carry a P4HB suture in the US. Tornier has both suture (Phantom Fiber) as well as tendon scaffold (BioFiber) available. The Tepha Corporation carries the TephaFlex suture. B. Braun Melsungen AG also distributes a monofilament P4HB (MonoMax) however; they market it more towards abdominal wall closure as well as plastic surgery.

Advances in suture material in the past 15 years have brought to market products that could be beneficial in foot and ankle surgery. Currently, barbed suture use has merits in small tendon and ligament approximation where a knotless construct could be preferred. P4HB has not been aggressively marketed to the foot and ankle surgical world until recently. Its strength coupled with delayed absorbability make it a viable option in foot and ankle tendon and ligament repair.

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