Suture selection is a crucial and integral factor to ensuring successful surgical outcomes. Suture material choices must be based on the anticipated wound healing times and tissue types as well as considerations unique to each patient (e.g., age, weight, overall health status, presence of infection). Since many sutures are subject to either absorption, encapsulation or rejection, using the wrong suture type may lead to unintended consequences such as wound dehiscence or the development of draining fistulous tracts. Veterinary technicians well versed in suture types and selection criteria will be more adept at anticipating the needs of the surgeon.

What is a Suture?

The word ‘suture’ is used to describe strands of material used to ligate (tie off) blood vessels or approximate tissues during wound closure. Written Egyptian and Syrian references describing the use of strings and animal sinew as sutures have been discovered as far back as 2,000 B.C. Throughout history, the evolution of suturing materials for operative procedures have included the use of silk, linen, cotton, horsehair, animal tendons and intestines, and wire made from precious metals. In fact, some of these materials as well as the surgical methods used by the Roman emperors’ physicians are still in use today. Modern advancements include the development of easy-to-use sutures designed for specific surgical procedures that can also help decrease the potential for postoperative infections.

Ideal Suture Characteristics

General suture performance may be divided into 3 areas: 1) physical characteristics, 2) handling characteristics, and 3) biological properties. Consequently, the perfect suture would be made of strong, inert materials that resisted shrinking and breaking until completely serving its purpose. It would also have minimal ‘memory’ properties, thereby rendering the suture easy to handle while maintaining good knot security. The perfect suture would also be nontoxic, non-electrolytic, non-capillary, non-allergenic, non-carcinogenic, and avoid bacterial growth.

Other beneficial properties of the ideal suture would employ the use of readily available and inexpensive materials, ability to withstand the sterilization process without alteration, and would be manufactured securely attached to strong, sharp needles that easily and rapidly penetrate tissues.

Surgical Needles and Needleholders

Surgical needles are made of high quality stainless steel alloys that resist corrosion. They are available in a wide variety of shapes and sizes, but there is no standardized sizing system or nomenclature available for them. The length, diameter, and curvature of a needle can influence the surgeon's ability to place the suture material. Since one of the primary goals in needle selection is to minimize tissue trauma, the needle should be as slim as possible while not compromising strength. Therefore, the needle-body diameter should ideally match the suture size. For example, swaged (attached) needles will pass more efficiently through tissues than reusable manually threaded needles.
Needle shapes vary widely and may be straight, half-curved, or any portion of a circle (3/8 circle, 1/2 circle, etc). Choosing the best needle configuration may be based on tissue type, depth, size, and accessibility.\textsuperscript{1,3}

Needle point type is another important consideration during needle selection. Taper, or noncutting (●) needles may be sufficient for tissues that are easy to penetrate, such as viscera, fat and muscle. As a general rule, tapered needles may be used for all tissue closures except skin.

Cutting (▲) needles are honed to create at least 2 opposing sharp edges that can easily penetrate dense tissues such as fascia and skin. The three primary types of cutting needles available are conventional, reverse and tapered. Conventional curved cutting needles have a concave cutting surface with 3 cutting edges. The cutting edge of reverse curved cutting needles is located along the convex edge, which serves to increase the needle strength and minimize cutting areas located outside of the targeted tissue. Tapered cutting needles combine a cutting point with a round shaft. This feature is beneficial when it is necessary to penetrate both delicate and dense tissues.\textsuperscript{3,4}

Another key element in suture performance is the needleholder. Needleholder jaws may be short or flat, concave or convex, and smooth or serrated. Furthermore, needleholder jaws containing embedded tungsten carbide particles offer 2 distinct advantages: 1.) The fine, granular jaw surface has better holding power as compared to its smooth-jawed counterparts and 2.) It is less apt to damage sutures than needleholder jaws containing teeth.\textsuperscript{2,5}

The needleholder choice must be based on the surgical procedure (e.g., deep body cavities such as the chest or abdomen will require longer needleholders) as well as the desire to hold the selected needle securely and without causing damage to the needle or suture. Since needleholders may weaken over time and with repeated use, they should be carefully inspected prior to each procedure to assure proper jaw alignment and a secure grasp of the needle.\textsuperscript{2} To prevent damage to the swage (a needle’s fused connection to suture material) the needle should be securely grasped with the needleholder about 1/3 to 1/2 the distance from the swaged region to the needle point while completely avoiding the region near the swage.\textsuperscript{5}

\textit{Suture Material Overview}

The U.S. Food and Drug Administration categorizes suture material as predominantly a class II medical device. Class II and III medical devices encompass surgically implanted materials that remain as a foreign body inside in the patient’s body upon discharge.\textsuperscript{6}

Sutures are sized based on metric or United States Pharmacopeia (USP) measurements. Established in 1937, the USP classification system was developed to standardize and compare suture material sizes.\textsuperscript{4} Metric sizes are determined by taking the suture diameter as expressed in tenths of a millimeter, while USP sizes can range from 11-0 (ought) to 7 (largest). Stainless steel wire is sized according to the Brown and Sharpe (B and S) wire gauge measurements, and can range from large, 18-gauge (~ USP 7) to the smallest 41-gauge (~USP 7-0) \textsuperscript{3,4}

Selecting the appropriate suture size can minimize tissue reaction and the presence of excessive foreign material as well as prevent alteration of tissue architecture.\textsuperscript{3} Optimal suture size is determined as the smallest size necessary to achieve a tension-free wound closure. However, if wound tension is high, smaller-diameter sutures may actually damage tissues by cutting through them. Therefore, it is prudent to closely match the tensile strength of the suture with the tissue in which it is being used.\textsuperscript{3,4}
Sutures are classified by the number of strands comprising them. Monofilament sutures are made of a single strand of material, while multifilament sutures consist of several filaments (strands) that are spun, twisted or braided together. The simple structure of monofilament suture decreases resistance when passed through tissues and resists harboring organisms, but is at an increased risk of damage when tied, crimped or crushed. Multifilament sutures have greater tensile strength, pliability and flexibility, but cause more tissue drag and provide increased surface area for microorganisms to adhere. Sutures may be coated with agents to improve handling properties or colored with an FDA-approved dye to enhance visibility.

Sutures are also classified as either absorbable or nonabsorbable. Absorbable sutures undergo degradation and rapid loss of tensile strength in less than 60 days. Absorbable sutures may be classified as natural fiber absorbable (e.g., catgut, collagen) or synthetic absorbable polymers (e.g., polyglycolic acid suture, polyglactin 910, polydioxanone, polyglyconate, and poliglecaprone). Furthermore, some synthetic absorbable sutures may be sub-classified as active sutures based on their ability to inhibit bacterial growth. Nonabsorbable sutures will maintain tensile strength for more than 60 days.

Absorbable suture: Natural fiber absorbable sutures are essentially digested by the body’s enzymes, while synthetic absorbable sutures are broken down by hydrolyzation. Hydrolyzation is a process by which water gradually penetrates the suture filaments, thereby causing a breakdown of the suture’s polymer chain. Hydrolyzation causes less tissue reaction as compared to enzymatic destruction.

Although there are many advantages of using absorbable sutures it should be noted that the absorption process can become altered in patients with a fever, infection or protein deficiency, resulting in an accelerated decline of tensile strength. Furthermore, the absorption process can begin prematurely if the sutures are placed in a moist or fluid filled part of the body, or if the material becomes wet or moist during handling or any other time prior to implantation.

Active sutures are another relatively new option in absorbable suture materials (e.g., Polyglactin 910-, Poliglecaprone 25-, Polydioxanone- Plus Antibacterial). Active suture materials are impregnated with a broad-spectrum antibacterial agent such as Irgacare MP (triclosan) at concentrations less than 572 ug/m. This agent has been shown to inhibit bacterial colonization of microorganisms along the suture line (e.g., Staphylococcus aureus, Staphylococcus epidermidis, Methicillin Resistant S. aureus, Methicillin Resistant S. epidermidis and Escheria Coli) while eliciting minimal tissue reaction during absorption.

Nonabsorbable suture: Nonabsorbable natural fiber materials include stainless steel, silk and cotton, while non-absorbable synthetic materials may include nylon, polyester, and polyolefin plastics (e.g., polypropylene, polyethylene.) The USP classification of nonabsorbable sutures is:

- Class I - Silk or synthetic fibers of monofilament, twisted, or braided construction
- Class II - Cotton or linen fibers or coated natural or synthetic fibers in which the coating contributes to suture thickness without adding strength
- Class III - Metal wire of monofilament or multifilament construction

The most common indications for nonabsorbable sutures includes transient exterior skin closure, patient history of reaction to absorbable sutures (e.g., keloidal tendencies, tissue hypertrophy), permanent use within the body cavity where suture eventually becomes encapsulated in tissue by fibroblasts, or during prosthesis attachment (pacemakers, drug delivery systems.)
Absorbable Suture Materials- Monofilament

Poliglecaprone 25 (Monocryl®): Synthetic material prepared from a copolymer of glycolide and epsilon-caprolactone. Recommended for ligation or tissue approximation during general soft tissue, oral and urinary bladder surgery, and for subcutaneous closures. Not recommended for use in cardiovascular, neurologic, microvascular or ophthalmic surgery.

Glycomer 631 (Biosyn®): THE strongest monofilament suture in this class, second only to stainless steel. Sixty-percent loss of tensile strength at 21 days, with complete absorption by 90-110 days. Dyed (violet) and undyed versions available. Good handling characteristics with low memory and little tissue drag, but tying secure knots requires a good technique.

Polydioxanone (PDS, PDS II®): Synthetic paradioxanone (p-diaxanone) polymer available in dyed (violet) or undyed versions. Slow and predictable absorption rate is essentially complete at 180 days (6 months.) Acceptable to use for abdominal or thoracic wall closure or in the bladder tissue of sterile or infected canine urine. Rarely associated with calcinosis circumscripta in young dogs.

Polyglyconate (Maxon®): Monofilament absorbable with properties similar to PDS. Superior effective strength post implantation with absorption complete at 6 months, which is not affected by the presence of infection or inflammation. Versatile material recommended over nylon and polybutester for tendon repair. Ends can be sharp if cut too short.

Absorbable Suture Materials- Multifilament

Surgical gut (Chromic Gut®, Gut®): Natural multifilament material made from purified connective tissue derived from either sheep small intestine (submucosa) or bovine small intestines (serosal layer). Available individually packaged or on multiple use reels, but multiple use reels are associated with an increased contamination risk.

Polyglycolic acid, +/- Polycaprolate coating (Dexon®, Dexon II®): Synthetic braided material made from polyester polymerized from hydroxyacetic acid. Suitable for use during intestinal anastamosis, caesarean section and hernia repair as long as extended approximation of tissues under stress is not required. Tolerated in the presence of infected wounds. Avoid use in the oral cavity or urinary bladder, especially in the presence of an alkaline pH.

Polyglactin 910 (Vicryl Plus®, Vicryl®, Vicryl Rapide®): Synthetic braided material composed of a 9:1 ratio of glycolic and lactic acids. Well tolerated in many wound conditions. Avoid prolonged contact with salt solutions, such as those found in the urinary or biliary tract. Avoid in cardiovascular or neurologic surgery.

Lactomer 9-1 (Polysorb®): Lactomer 9-1 has very similar characteristics to polyglactin 910, but a finer filament diameter results in a very compliant strand with less memory than other synthetic absorbable multifilaments. May cause calculi when used in urinary or gall bladder tissues. Avoid in cardiovascular or neurologic surgery.

Nonabsorbable Suture Materials

Surgical silk (Mersilk®, Perma-Hand®): Comprised of raw silk spun by silkworms. May be coated with beeswax, oil or silicone to decrease capillarity. Superior handling characteristics make this material considered the ‘standard of performance’ by many surgeons. Used in vascular surgery (PDA) or for skin sutures. May cause ulceration when used in hollow viscera (e.g., gastrointestinal tract) or predispose to calculi formation in the urinary or biliary tract. Potentiates wound infection x 10^3 - 10^4.
Polybutester (Novafil®): Synthetic monofilament suture is made from a copolymer of polyglycol terephthalate and polytriethylene terephthalate. Suture exhibits superior elasticity as compared to other materials but returns to its original length once the load is removed. Elastic properties, good tensile strength and knotting characteristics make it suitable for surface closure, repair of tissues such as tendons or when prolonged wound healing is expected.

Polyester fiber (Mersilene®/Surgidac®, Dacron®, [uncoated] and Ethibond®/Ticron®, Ethiflex [coated]): Multifilament braided material comes coated with polybutylate (Ethibond), Teflon (Ethiflex), or silicone (Ticron) to reduce friction and improve pliability. Lasts indefinitely in the body. Can be used in slow healing tissues, vessel anastomosis and during placement of prosthetic materials. Avoid in infected wounds where bacteria entrapped between fibers can cause persistent incisional drainage.

Nylon/Polyamide (Ethilon®, Monosof®, Nurolon®, Dermalon®, Bralon®, Surgilon®): Monofilament (e.g., Ethilon®, Monosof®) and braided [e.g., Nurolon®, Surgilon®] polyamide polymer suture. Braided forms coated with silicone. Stronger than silk and elicits minimal acute inflammatory reaction. Maintains elasticity post implantation, even when moist. Inert and non-capillary. Supramid®, a twisted multifilament suture, is available in large diameters only.

Polymerized caprolactam (Supramid®, Vetafil®): Synthetic multifilament material. Similar to nylon, composed of a ployimide polymer but has a smooth sheath of polyethylene/proteinaceous material. Elasticity properties permit use in areas subject to movement or tension. Not sterile, so few indications other than skin closure. Causes subcutaneous swelling and sinuses.

Polypropylene (Prolene®, Surgipro®, Surgilene®): Synthetic monofilament suture consists of a stereoisomer of polypropylene. Remains biologically inert. May be used as a pull-out suture (e.g., subcuticular or skin closure) since it does not adhere to tissues. Often used in vascular surgery due to being the least thrombogenic. Also good for use during hernia and tendon repair and in contaminated or infected wounds.

Stainless steel (Flexon®): Comprised of monofilament or twisted multifilament iron-chromium-nickel-molybdenum alloy, but also manufactured without toxic elements. Demonstrates excellent knot holding capabilities, high tensile strength with little loss over time and biologically inert. Used in orthopedic, neurosurgical and thoracic (e.g., sternum closure) applications as well as for abdominal wall closure or in contaminated or infected wounds. Visible radiographically but may interfere with magnetic resonance imaging (MRI) and requires special cutting scissors.

References