

Principles of Veterinary Suturing

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PURPOSE OF THIS DOCUMENT

This is a handout that accompanies a hands-on rodent surgery workshop in the Laboratory Animal Resources Center

OBJECTIVES

Participants will be instructed on...

- A. Properties, selection and use of the suture.
- B. Properties, selection and use of the suturing needle.
- C. Proper knot tying.
- D. Some of the most common suture patterns and wound closure techniques.
- E. Proper suture removal.

INTRODUCTION

Development of good technique requires a knowledge and understanding of the rational mechanics involved in suturing. Many experienced investigators, even those that have performed surgeries for many years, have developed poor surgical technique. Don't be misled by your loyalty to the judgement of superiors. You may just end up acquiring their bad suturing habits.

Your criteria for determining the best method should be **Accuracy and Security**. These should be your prime concern when suturing. Speed and ease of performance are by-products that will be achieved with lots of practice. However, once accuracy and security have been mastered the surgeon should begin focusing on speed, as time in surgery is trauma. The longer tissues are exposed, the greater the trauma. Thus, with enough practice, the ideal scenario would be one of **Accuracy, Security and Speed**.

PROPERTIES OF SUTURE

Physical Construction of Suture

Suture is any strand of material used to approximate the tissue edges and give artificial support while the tissue heals naturally. When considering a type of suture, there are three things that you need to consider. This information should be indicated somewhere on the packaging of the suture:

1. **Absorbable or Non-absorbable**
2. **Natural or Synthetic**
3. **Braided (Multifilament) or Monofilament**

ABSORBABLE

Absorbable sutures are designed to break down over a specific time frame and be absorbed by the body. They are used when temporary support is required and the healing tissue will eventually support itself. Absorption occurs by:

- Phagocytosis and proteolysis in natural suture.
- Hydrolysis in synthetic suture.

NON-ABSORBABLE:

Non-absorbable sutures are designed to either be left permanently in the body or are to be removed after a certain healing period. Permanently placed, non-absorbable sutures are generally used in tissue where even though healing may occur; the new tissue may never have the needed strength to support itself. The effective tensile strength of such sutures remains high over time. When used to close skin, non-absorbable sutures are usually removed in 10-14 days, but this may vary by location and situation.

NATURAL SUTURE MATERIALS

Natural sutures are made from animal or plant materials. Their protein composition can elicit the most pronounced tissue reaction (inflammation) of any suture material. Their useful strength in tissue varies from a few days with Plain Catgut to several months for Silk, and can vary with the individual.

SYNTHETIC SUTURE MATERIAL

Sutures can be made from synthesizing a wide variety of polymers. Synthetic materials cause less tissue reaction than natural fibers, therefore their strength and absorption rate (for absorbable suture) is more uniform and predictable in all individuals.

BRAIDED (MULTIFILAMENT)

This construction involves several filaments or strands being braided or twisted together. This results in a strong suture that is flexible and easy to handle. Multifilament sutures pass less easily through tissue than smooth monofilaments and the resulting "tissue drag" can cause tissue trauma. Suture manufacturers have addressed this issue by coating many of the braided sutures, thus reducing the degree of "tissue drag."

The surface of a suture must be compatible with specific tissue application and have the desired knotting characteristics and capabilities. A rough suture surface can cause trauma and cutting of surrounding tissues, both of which are undesirable. Therefore, selection of materials should consider both the structure of the tissue and the surface of the suture. In principle, a suture with a rough surface can be tied with fewer knots than one with a smooth surface as knots are less likely to slip. Care must be exercised with the tying of all types of suture.

MONOFILAMENT

This type of suture construction results in a single strand or filament. The surface is very smooth and passes easily through tissue. However, they can be difficult to handle and tie as they are less flexible than braided sutures. Most monofilaments also have “memory.” This memory results in a suture that holds the shape it had in the package, making it more difficult to work with. Some memory can be relaxed, but is not effective in all sutures.

CHOOSING THE SUTURE

The following principles should guide the surgeon in suture selection:

1. WHEN A WOUND HAS REACHED MAXIMAL STRENGTH, SUTURES ARE NO LONGER NEEDED. THEREFORE

- a. Tissues that ordinarily heal slowly, such as fascia and tendons, should usually be closed with non-absorbable sutures. An absorbable suture with extended (up to 6 months) wound support may also be used.
- b. Tissues that heal rapidly, such as stomach, colon, and bladder, may be closed with absorbable sutures.

2. FOREIGN BODIES IN POTENTIALLY CONTAMINATED TISSUES MAY CONVERT CONTAMINATION TO INFECTION. THEREFORE

- a. Avoid multifilament sutures, which may convert a contaminated wound into an infected one.
- b. Use monofilament or absorbable sutures in potentially contaminated tissues.

3. WHERE COSMETIC RESULTS ARE IMPORTANT, CLOSE AND PROLONGED APPPOSITION OF WOUNDS AND AVOIDANCE OF IRRITANTS WILL PRODUCE THE BEST RESULT. THEREFORE

- a. Use the smallest inert monofilament suture materials such as nylon or polypropylene.
- b. Avoid skin sutures and close subcuticularly, whenever possible.
- c. Under certain circumstances, to secure close apposition of skin edges, a topical skin adhesive such as Dermabond Topical Skin Adhesive, or Vetbond may be used.

4. FOREIGN BODIES IN THE PRESENCE OF FLUIDS CONTAINING HIGH CONCENTRATIONS OF CRYSTALLOIDS MAY ACT AS A NIDUS FOR PRECIPITATION AND STONE FORMATION. THEREFORE

- a. In the urinary and biliary tract, use rapidly absorbed sutures.

5. REGARDING SUTURE SIZE

- a. Use the finest size, commensurate with the natural strength of the tissue.
- b. If the postoperative course of the patient may produce sudden strains on the suture line, reinforce it with retention sutures. Remove them as soon as the animal's condition is stabilized.

In summary, when choosing the suture, consider that many factors contribute to the choice of materials and techniques for wound closure. The final choice is often a compromise of several of those factors and may be combined with personal preference based on past experience.

Thus, consider...

- How long is the suture to be wholly or partially responsible for the strength of the wound?
- How does the suture material affect the tissue and the process of healing?
- How great is the risk of infection?
- Is absolute fixation needed or is certain mobility acceptable, or even desirable?
- What dimension of suture is necessary to obtain the desired degree of fixation?
- What strength of suture is required?
- Is the material flexible enough for the given purpose and is it possible to knot it in the space provided?

COMMON SUTURES

<u>ABSORBABLE</u>	<u>COMPOSITION</u>	<u>CONSTRUCTION</u>
Plain Gut	Natural - made from cattle intestine	Multi - 4 strands only
Chromic Gut	Natural - treated with chromic salts to strengthen & delay absorption rate	Multi
CAPROSYN+	Synthetic – Polyglytone 6211	Mono
DEXON^	Synthetic - Polyglycolic Acid	Multi
VICRYL*	Synthetic - Polyglactin 910	Multi
POLYSORB+	Synthetic – Lactomer	Multi
MONOCRYL*	Synthetic - Poliglecaprone 25	Mono
BIO-SYN+	Synthetic – Glycomer 631	Mono
PDS*	Synthetic - Polydioxinone	Mono
MAXON^	Synthetic - Polyglyconate	Mono
<u>NON-ABSORBABLE</u>	<u>COMPOSITION</u>	<u>CONSTRUCTION</u>
Silk	Natural	Multi
Ethibond*/Ti-cron^/Surgidac+	Synthetic - Coated Polyester	Multi
Ethilon*/Dermalon^	Synthetic - Nylon	Mono
Nurolon*/Surgilon^	Synthetic - Nylon	Multi
Prolene*/Surgilene^/Surgipro+	Synthetic - Polypropylene	Mono
Novafil+	Synthetic - Polybutester	Mono
Stainless Steel	Natural	Mono
Flexon^	Natural - Coated Steel	Multi

* ETHICON Trademark

^ D&G, Sherwood Davis & Geck, or USS&DG Trademark,

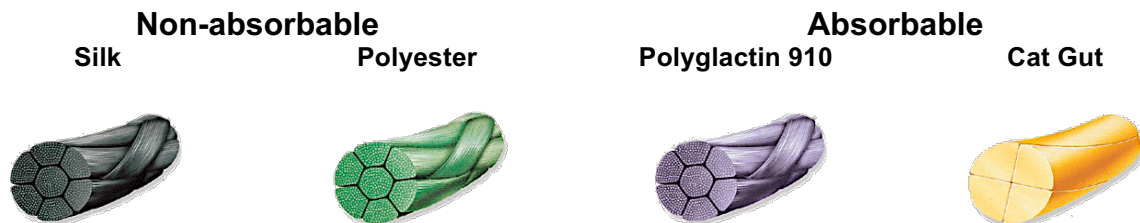
+ USSC, SYNATURE

ADDITIONAL INFORMATION ON SUTURE MATERIAL

Category	Material	Comments
Non-absorbable		Preferred for cutaneous repair
<i>Monofilament</i>		
	Nylon	Strong; stiff, moderately, hard to work with
	Polypropylene	Poorest knot security, most difficult to work with
	Polybutester	Somewhat elastic, so lengthens with wound edema and contracts as edema resolves
<i>Braided</i>		
	Polyester	Low reactivity; not preferred to monofilament for cutaneous use
	Silk	Soft; easy to work with; good knot security; high tissue reactivity. Generally limited to mouth, lips, eyelids, intraoral. Where patient comfort is significantly better. Should not be used for skin closure
Absorbable		Preferred for subcutaneous sutures.
<i>Monofilament</i>		
	Polydioxanone	Very strong and long lasting (absorption 180 days); stiffer, more difficult to handle than other absorbable sutures
<i>Natural</i>		
	Gut, chromic gut	From sheep intima. Weak; poor knot security; rapidly absorbed (1wk); high tissue reactivity. Not preferred
<i>Braided</i>		Easy handling; good knot security, mild reactivity
	Polyglycolic acid	Original absorbable; most strength gone in 1 wk
	Polyglactic acid	Probably current preference

SUTURE SAMPLES

Multifilament



Monofilament



SUTURE

ABSORBABLE



NON-ABSORBABLE



SUTURE SIZING

Suture is available from a "7" (Heaviest) to "12-0" (Finest). The important factor in deciding suture size is the relationship between the tensile strength of the suture, and the tissue to be sutured. Tensile strength of the wound need only match or slightly exceed the holding power of the tissue to be sutured. For example, you don't need a rope to tie your shoes... it might work, but its overkill. A shoelace would do. Finer diameter sutures make smaller knots, provide less tissue reaction, and result in minimal scar formation. Finer strands are very flexible, easy to handle, but do require gentle tying. Closely placed, fine sutures create a stronger suture line than widely spaced, heavy sutures. Tissue drag is also closely related to gauge; the finer the gauge, the less tissue trauma is caused by the passage of the suture.

Finest <<<<----->>>> Largest

12-0 11-0 10-0 9-0 8-0 7-0 6-0 5-0 4-0 3-0 2-0 0 1 2 3 4 5 6 7

Weakest <<<<----->>>> Strongest

SKIN SUTURE SELECTION

The skin is one area where the final result, based on your selection of suture and your technical skill, will be the most evident to your patient (or client if it is a pet). Make informed choices that will give the best result possible. Stitches that are tied **too tight** and are left in **too long** may leave "hatch marks" on either side of the scar. The hole made by the stitch may rip and become larger with increased tension on the wound (i.e. swelling). Sometimes, these marks are more noticeable long term than the scar itself.

PERCUTANEOUS (TRANSCUTANEOUS) SUTURE (e.g. simple, interrupted pattern)

Recommendation: SYNTHETIC, NON-ABSORBABLE, MONOFILAMENT

Example: NOVAFIL, PROLENE, SURGI-PRO, SURGILENE, DERMALON, STAINLES STEEL

Possible Alternative: SYNTHETIC, ABSORBABLE, MONOFILAMENT

Example: MONOCRYL, MAXON, PDS, BIO-SYN

Unsuitable: Organic or synthetic, **braided** absorbable materials

Example: SILK, DEXON, VICRYL

SIZE: Suggest 4-0 or 5-0 for rats, 5-0 or 6-0 for mice depending on size but will vary
NEEDLE: Reverse cutting, 3/8 curve

Comments: Percutaneous sutures should be **tied loosely to barely appose (touch) wound edges**; otherwise, postoperative swelling may cause the suture to be too tight, strangle cutaneous vessels and lead to pain, infection and wound failure.

INTRACUTANEOUS (SUBCUTICULAR) SUTURE

Recommendation: Continuous (generally **preferred**) or interrupted pattern with SYNTHETIC, ABSORBABLE (uncoloured) MONO or MULTIFILAMENT

Example: MONOCRYL, MAXON, PDS (Monofilament); DEXON, VICRYL (Multifilament)

Possible Alternative: A continuous pattern with **SYNTHETIC, NON-ABSORBABLE, MONOFILAMENT** (to be removed)

Example: NOVAFIL, PROLENE, SURGILENE

SIZE: Suggest 4-0 or 5-0 for rats, 5-0 or 6-0 for mice depending on size but will vary
NEEDLE: Reverse cutting, 3/8 curve

Comments: Intra-cutaneous suturing has the advantage of completely avoiding stitch marks. It can be used with advantage where cosmetic aspects are especially important. If synthetic absorbable materials are used, it is quite common that temporary nodules appear under the scar a couple of weeks after suturing. These tend to disappear spontaneously in the course of months as the suture breaks down and absorbs.

SUBCUTANEOUS (FAT LAYER) SUTURE

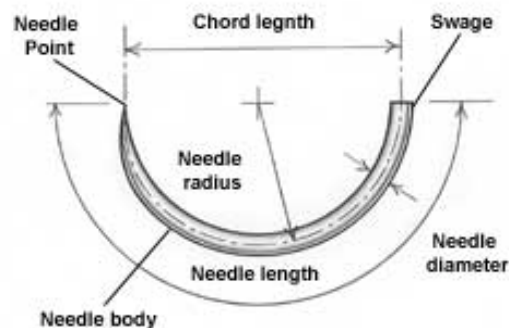
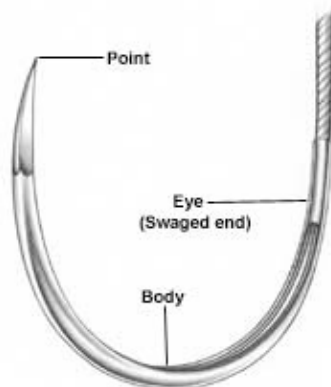
Recommendation: Generally no suture but may be warranted if excess skin tension. Continuous (generally **preferred**) or interrupted pattern with SYNTHETIC, ABSORBABLE (uncoloured) MONO or MULTIFILAMENT

Example: MONOCRYL, MAXON, PDS (Monofilament); DEXON, VICRYL (Multifilament)

SIZE: Suggest 4-0 or 5-0 for rats, 5-0 or 6-0 for mice depending on size but will vary
NEEDLE: Taper, 3/8, 1/2, 5/8 curve

Comments: The subcutaneous fat is the tissue with the least resistance to infection and so, it's best to avoid introduction of foreign materials, like suture. If the tissue is reasonably elastic, good apposition is obtained spontaneously. However, do not leave a DEAD SPACE as this can cause greater problems. This tissue must be gently approximated.

THE SURGICAL NEEDLE



Regardless of its intended use, every surgical needle has three basic components:

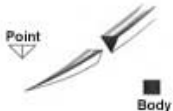
- a. The **eye**.
- b. The **body**.
- c. The **point**.

The measurements of these specific components determine, in part, how they will be used most efficiently. Needle size may be measured in inches or in metric units. The following measurements determine the size of a needle.

- a. **CHORD LENGTH**--The straight line distance from the point of a curved needle to the swage.
- b. **NEEDLE LENGTH**--The distance measured along the needle itself from point to end.
- c. **RADIUS**--The distance from the center of the circle to the body of the needle if the curvature of the needle were continued to make a full circle.
- d. **DIAMETER**--The gauge or thickness of the needle wire. Very small needles of fine gauge are needed for microsurgery.

Large, heavy gauge needles are used in large animals to penetrate the sternum and to place retention sutures in the abdominal wall. A broad spectrum of sizes are available between the two extremes.

THE NEEDLE POINT

Conventional Cutting  skin, sternum	CS ULTIMA Ophthalmic Needle  eye (primary application)
Reverse Cutting  fascia, ligament, nasal cavity, oral mucosa, pharynx, skin, tendon sheath	Taper  aponeurosis, biliary tract, dura, fascia, gastrointestinal tract, laparoscopy, muscle, myocardium, nerve, peritoneum, pleura, subcutaneous fat, urogenital tract, vessels, valve
Precision Point Cutting  skin (plastic or cosmetic)	TAPERCUT Surgical Needle  bronchus, calcified tissue, fascia, laparoscopy, ligament, nasal cavity, oral cavity, ovary, perichondrium, periosteum, pharynx, sternum, tendon, trachea, uterus, valve, vessels (sclerotic)
PC PRIME Needle  skin (plastic or cosmetic)	Blunt  blunt dissection (friable tissue), cervix (ligating incompetent cervix), fascia, intestine, kidney, liver, spleen.
MICRO-POINT Reverse Cutting Needle  eye	Side-Cutting Spatula  eye (primary application), microsurgery, ophthalmic (reconstructive)

THE NEEDLE BODY

Straight		gastrointestinal tract, nasal cavity, nerve, oral cavity, pharynx, skin, tendon, vessels
Half-curved (ski needle)		skin (rarely used) laparoscopy
1/4 Circle		eye (primary application) microsurgery
3/8 Circle		aponeurosis, biliary tract, cardiovascular system, dura, eye, gastrointestinal tract, muscle, myocardium, nerve, perichondrium, periosteum, pleura, skin tendon, urogenital tract, vessels
1/2 Circle		biliary tract, cardiovascular system, eye, fascia, gastrointestinal tract, muscle, nasal cavity, oral cavity, pelvis, peritoneum, pharynx, pleura respiratory tract, skin, subcutaneous fat, urogenital tract
5/8 Circle		anal (hemorrhoidectomy), nasal cavity, oral cavity, pelvis, urogenital tract (primary application)

CHOOSING THE NEEDLE

One basic assumption must be made in considering the ideal surgical needle for a given application, namely, that the tissue being sutured should be altered as little as possible by the needle since the only purpose of the needle is to introduce the suture into the tissue for apposition. While there are no hard and fast rules governing needle selection, the following principles should be kept in mind:

- a. Consider the tissue in which the surgeon will introduce the needle. Generally speaking, taper point needles are most often used to suture tissues that are easy to penetrate. Cutting or TAPERCUT needles are more often used in tough, hard-to-penetrate tissues. When in doubt about whether to choose a taper point or cutting needle, choose the taper point for everything except skin sutures.
- b. Select the length, diameter, and curvature of the needle according to the desired placement of the suture and the space in which the surgeon is working.
- c. When using eyed needles, try to match needle diameter to suture size. Swaged needles, where the needle is already attached to the suture strand, eliminate this concern.

GRASPING THE NEEDLE



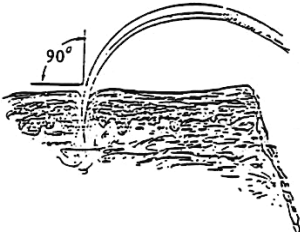
Grasp the needle one-third to one half of the distance from the swaged end to the point --- in the middle third of the needle

PLACING THE NEEDLE IN TISSUE

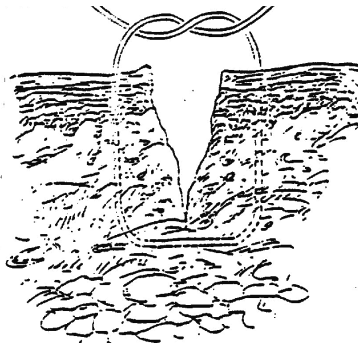
The actual placement of the needle in tissue can cause unnecessary trauma if done incorrectly. Keep the following in mind during suturing:

- a. Apply force in the tissue to be sutured in the same direction as the curve of the needle.
- b. Do not take excessively large bites of tissue with a small needle.
- c. Do not force a dull needle through tissue. Use a new needle.
- d. Do not force or twist the needle in an effort to bring the point out through the tissue. Withdraw the needle completely and then replace it in the tissue, or use a larger needle.
- e. Avoid using the needle to bridge or approximate tissues for suturing.
- f. Do not damage taper points or cutting edges when using the needle holder to pull the needle through tissue. Grasp as far back on the body as possible.
- g. Depending upon the patient, the tissue may be tougher or more fibrous than anticipated and require the use of a heavier gauge needle. Conversely, a smaller needle may be required when tissue is more friable than usual.
- h. In a deep, confined area, ideal positioning of the needle may not be possible. Under these circumstances, proceed with caution. A heavier gauge needle or a different curvature may help.
- i. If a glove is punctured by a needle, the needle must be discarded immediately and the glove must be changed for the safety of the patient, as well as the surgical team.

TECHNIQUES TO HELP ENSURE GOOD WOUND EDGE EVERSION



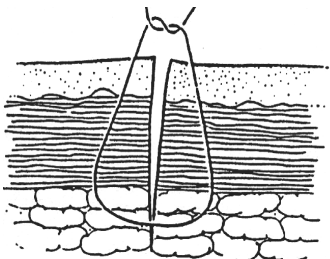
Needle entry angle: The needle must enter and exit the tissue at a minimum of **90°** or greater



This will ensure that the edges have been **approximated** correctly and will not cause the edges to invert, which is not desirable.



If the needle is driven at an entry angle of **45°**, or less, it will cause the edges to **invert**. If you want to drive at this angle, you **must** manipulate the tissue to achieve a 90° drive.



Needles driven at **greater than 90°** will help to obtain good wound edge eversion.

TISSUE HANDLING

Minimal trauma to tissues is fundamentally important for optimal wound healing. This requires that:

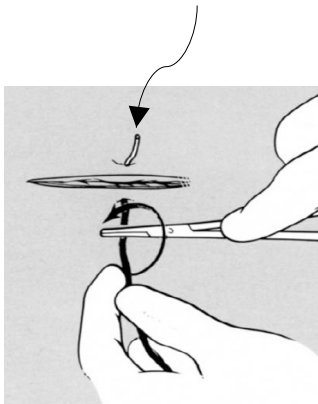
- Tissues are handled carefully using delicate instruments.
- Tissues are not strangulated and made ischemic by sutures.
- Wound edges are loosely coapted since there is always some postoperative swelling.
- Dead space is avoided.

KNOT TYING

The general principles of knot tying which apply to all suture materials are:

- a. The completed knot must be firm to virtually eliminate slippage. The simplest knot for the material used is the most desirable.
- b. Tie the knot as small as possible and cut the ends as short as possible. This helps to prevent excessive tissue reaction toward absorbable sutures and to minimize foreign body reaction to non-absorbable sutures.
- c. Avoid friction. "Sawing" between strands may weaken suture integrity.
- d. Avoid damage to the suture material during handling, especially when using surgical instruments in instrument ties.
- e. Avoid excessive tension, which may break sutures and cut tissue. Practice will lead to successful use of finer gauge materials.
- f. Do not tie sutures used for tissue approximation too tightly, as this may contribute to tissue strangulation. Approximate--do not strangle.
- g. Maintain traction at one end of the strand after the first loop is tied to avoid loosening of the throw.
- h. Make the final throw as nearly horizontal as possible.
- i. Do not hesitate to change stance or position in relation to the patient in order to place a knot securely and flat.
- j. Extra throws do not add to the strength of a properly tied knot, only to its bulk. Some procedures involve tying knots with the fingers, using one or two hands; others involve tying with the help of instruments. Perhaps the most complex method of knot tying is done during endoscopic procedures, when the surgeon must manipulate instruments from well outside the body cavity.

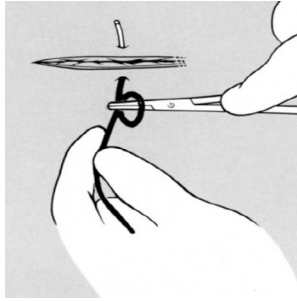
Free End ~ 2 cm



SQUARE KNOT INSTRUMENT TYING

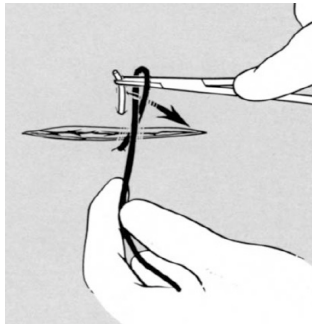
STEP 1. POSITION THE NEEDLE HOLDER

The instrument tie is performed with a needle holder held in the surgeon's right hand. The left hand holds the fixed suture end between the tips of the thumb and index finger. The needle holder is positioned perpendicular to and above the fixed suture end. By keeping the length of the free suture end relatively short (<2 cm), it is easy to form (arrow) suture loops as well as to save suture material. Because the needle holder passes the free suture end through the suture loop, knot construction can be safely accomplished without detaching the needle from the fixed suture end.



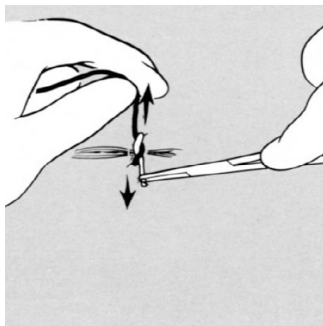
STEP 2. FORM THE FIRST SUTURE LOOP

The fixed suture end held by the left hand is wrapped over and around the needle holder jaws to form the first suture loop. If the suture is wrapped twice around the needle holder jaws, the first, double-wrap throw of the surgeon's knot square will be formed. A double wrap, first throw displays a greater resistance to slippage than a single-wrap throw, accounting for its frequent use in instrument ties in wounds subjected to strong, static skin tensions and for slippery sutures.



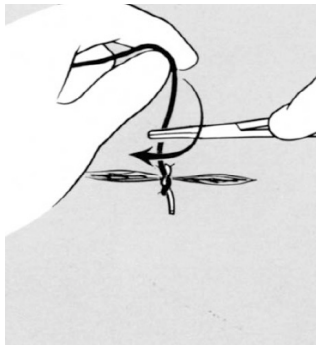
STEP 3. CLAMP FREE SUTURE END AND WITHDRAW IT THROUGH THE SUTURE LOOP TO FORM THE FIRST, SINGLE-WRAP THROW

The tips of the needle holder jaws grasp the suture end and withdraw (arrow) it through the first suture loop. The resulting first throw will have a figure "8" shape.



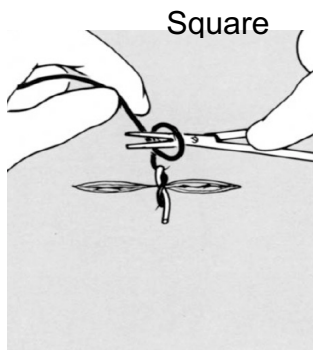
STEP 4. ADVANCE THE FIRST SINGLE-WRAP THROW TO WOUND SURFACE

The figure "8" shape throw will be converted into a rectangular-shaped throw by reversing the direction of the hand movement. The left hand moves away from the surgeon, while the needle holder held in the right hand advances toward the surgeon. This single wrap throw is advanced to the wound surface by applying tension in a direction (arrows) that is perpendicular to that of the wound. Once the first throw of the square knot contacts the skin, the edges of the mid-portion of the wound are approximated.



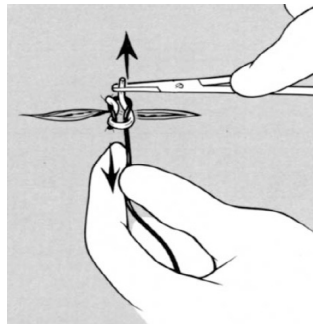
STEP 5. POSITION THE NEEDLE HOLDER

The needle holder releases the free suture end. The right hand holding the needle holder moves away from the surgeon to be positioned perpendicular to and above the fixed suture end. A second throw will be formed by the left hand as it wraps the fixed suture end over and around (arrow) the needle holder jaws. If the surgeon were to place the needle holder beneath the fixed suture end, the ultimate knot construction would be a granny knot.



STEP 6. FORM THE SECOND SUTURE LOOP

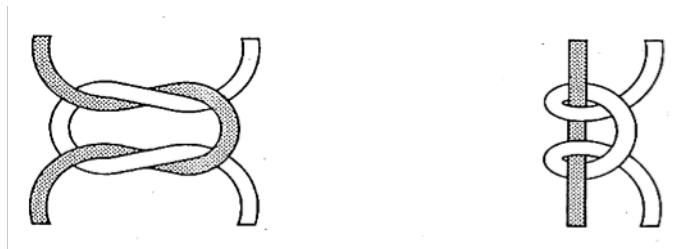
The fixed suture end held by the left hand is wrapped over and around the needle holder to form the second suture loop. With the suture wrapped around the needle holder jaws, the needle holder is moved to grasp the free suture end, after which it is withdrawn through the suture loop.



STEP 7. CLAMP SUTURE END AND WITHDRAW IT THROUGH THE SUTURE LOOP TO FORM THE SECOND, SINGLE-WRAP THROW

The tips of the needle holder jaws grasp the free suture end and withdraw (arrow) it through the second suture loop. By withdrawing the free suture end through the loop, a rectangular-shaped second throw is formed. The surgeon will apply tension to the suture ends in a direction perpendicular to that of the wound.

The Square vs. the Slip Knot



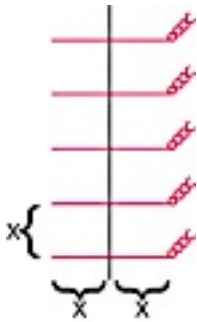
When suturing...DO

- a. Pass the surgical needle swaged to a suture through the wound edges in a direction toward you.
- b. Construct a two-throw square knot that can be advanced to the wound edge, providing a preview of the ultimate apposition of the wound edges.
- c. Approximate the edges of the divided tissue without strangulating the tissue encircled by the suture loop.
- d. Once meticulous apposition of the wound edges is achieved, construct a knot that has sufficient number of throws that allow it to fail by breakage rather than by slippage.
- e. Position your hands on each side and parallel to the suture loop.
- f. Apply opposing forces to the knot "ears" that are equal in magnitude and in a plane parallel to that of the wound surface.
- g. After each throw, reverse the position of your hands that apply tension to the suture ends.
- h. Apply constant force slowly to the "ears" of each throw of the knot.
- i. Use the two-hand tie technique to maintain continuous tension on suture ends.
- j. During an instrument tie, position the needle holder parallel to the wound.
- k. Position the needle holder above the fixed suture end to form the first and second suture throws of a square (1=1) knot.
- l. Clamp only the free end of the suture during the instrument tie.

When suturing...DON'T

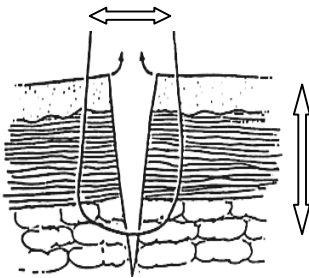
- a. Pass the surgical needle swaged to a suture through the wound edge in a direction away from you.
- b. Construct a secure knot that cannot be advanced to the wound edges.
- c. Apply frictional forces (sawing) between the suture "ears" during knot construction that damage the suture and reduce its strength.
- d. Add further throws to a knot that has the required number of throws for knot security.
- e. Position your hands perpendicular to the suture loop.
- f. Exert unequal levels of tension to the suture ends that convert the knot into a slip knot.
- g. Maintain the same position of your hands after each additional throw.
- h. Apply a constant force rapidly to the "ears" of each throw of the knot.
- i. Use the one-hand tie technique to maintain continuous tension of the suture ends.
- j. During an instrument tie, position the needle holder perpendicular to the wound.
- k. Position the needle holder above the fixed suture end to form the first throw, and then below the fixed suture end to form the second throw of the square knot (1=1).
- l. Clamp the suture loop with an instrument because it will crush the suture, reducing its strength.

SUTURE SPACING

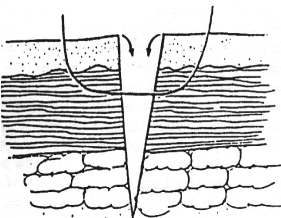
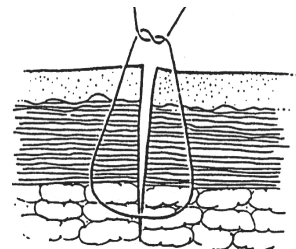


Spacing between sutures is typically equal to the distance from needle entry to wound margin. Although not an absolute formula, in general sutures should enter and exit at an equal distance from the wound margin, where $X = X = X$.

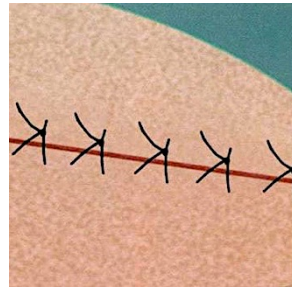
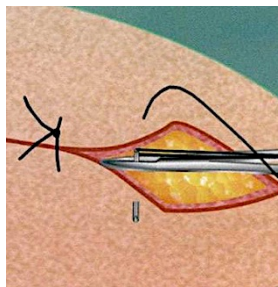
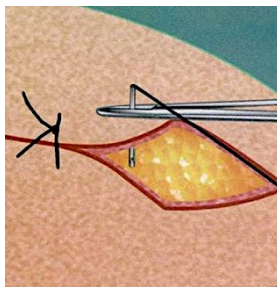
Sutures should be **DEEPER** than they are **WIDE**



CORRECT – will help to create *eversion*



INCORRECT – will cause *inversion*
These bites are wider than they are deep.



EQUAL BITES: The “bite” that is taken on one side of the wound, must be equal to the bite taken on the second side.

EQUAL DEPTHS: The depth that the needle passes through the tissue should be equal on both sides.

PERPENDICULAR: The needle should pass through the tissue perpendicular to the incision. This will help to restore the anatomy correctly. Oblique stitches will result in uneven closing and may result in a “dog ear” effect at the end of the incision.

Remember...

EQUAL BITES

EQUAL DEPTHS

PERPENDICULAR

SQUARE KNOTS!

THE PRIMARY SUTURE LINE

The *primary suture line* is the line of sutures that holds the wound edges in approximation during healing by first intention. It may consist of a continuous strand of material or a series of interrupted suture strands. Other types of primary sutures, such as deep sutures, buried sutures, purse-string sutures, and subcuticular sutures, are used for specific indications. Regardless of technique, a surgical needle is attached to the suture strand to permit repeated passes through tissue.

THE SECONDARY SUTURE LINE

A secondary line of sutures may be used:

- a. To reinforce and support the primary suture line, eliminate dead space, and prevent fluid accumulation in an abdominal wound during healing by first intention. When used for this purpose, they may also be called *retention*, *stay*, or *tension* sutures.
- b. To support wounds for healing by second intention.
- c. For secondary closure following wound disruption when healing by third intention.

NOTE: If secondary sutures are used in cases of non-healing, they should be placed in opposite fashion from the primary sutures (i.e., interrupted if the primary sutures were continuous, continuous if the primary sutures were interrupted).

RETENTION SUTURES

Retention sutures are rarely used in rodents and is more commonly used in large animals. When used, they are placed further away from each edge of the wound (~ 2 cm in large animals). The tension exerted lateral to the primary suture line contributes to the tensile strength of the wound. *Through-and-through* sutures are placed from inside the peritoneal cavity through all layers of the abdominal wall, including the peritoneum. They should be inserted before the peritoneum is closed using a simple interrupted stitch. The wound may be closed in layers for a distance of approximately three-fourths its length. Then the retention sutures in this area may be drawn together and tied. It is important that a finger be placed within the abdominal cavity to prevent strangulation of the viscera in the closure. The remainder of the wound may then be closed. Prior to tightening and tying the final retention sutures, it is important to explore the abdomen again with a finger to prevent strangulation of viscera in the closure. The remainder of the wound may then be closed. Retention sutures utilize non-absorbable suture material. They should therefore be removed as soon as the danger of sudden increases in intra-abdominal pressure is over--usually 2 to 6 weeks, with an average of 3 weeks.

CUTTING SUTURES

Once the knot has been securely tied, the ends must be cut. Before cutting, make sure both tips of the scissors are visible to avoid inadvertently cutting tissue beyond the suture. Cutting sutures entails running the tip of the scissors lightly down the suture strand to the knot. The ends of surgical gut are left relatively long, approximately 1/4" (6mm) from the knot. Other materials are cut closer to the knot, approximately 1/8" (3mm), to decrease tissue reaction and minimize the amount of foreign material left in the wound. To ensure that the actual knot is not cut, twist or angle the blades of the scissors prior to cutting. Make certain to remove the cut ends of the suture from the operative site.

SUTURE REMOVAL

When the wound has healed so that it no longer needs the support of non-absorbable suture material, skin sutures must be removed. The length of time the sutures remain in place depends upon the rate of healing and the nature of the wound. Sutures should be removed before the epithelium has migrated into deeper parts of the dermis, generally between days 10-14 post-op, but this may vary.

Sutures should be removed using clean or aseptic technique. The following steps are recommended:

STEP 1--Cleanse the area with an antiseptic. Hydrogen peroxide can be used to remove dried serum encrusted around the sutures.

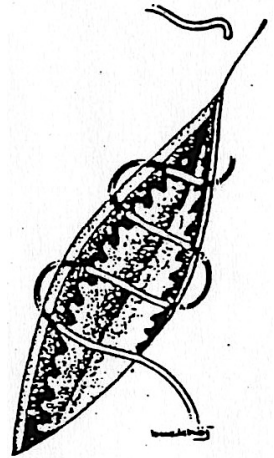
STEP 2--Pick up one end of the suture with thumb forceps or thumb and index finger, and cut as close to the skin as possible where the suture enters the skin.

STEP 3--Gently pull the suture strand out through the side opposite the knot with the forceps. To prevent risk of infection, the suture should be removed without pulling any portion that has been outside the skin back through the skin.

COMMON SUTURE PATTERNS

Subcuticular Sutures

Subcuticular sutures are continuous or interrupted sutures placed in the dermis, beneath the epithelial layer. Continuous subcuticular sutures are best placed using a reverse cutting needle and in a line parallel to the wound. This technique involves taking short, lateral stitches the full length of the wound. After the suture has been drawn taut, the distal end is anchored in the same manner as the proximal end. This may involve tying or any of a variety of anchoring devices. Subcuticular suturing may be performed with absorbable suture, which does not require removal, or with monofilament non-absorbable suture that is later removed by simply removing the anchoring device at one end and pulling the opposite end.



1. Begin at one end of the wound, approximately 1 cm opposite the apex of the ellipse.
2. Make a bite, as if placing an interrupted stitch exactly at the apex of the excision.
3. Select one edge of the wound, and make a subcuticular bite parallel to the skin surface.
4. Make a similar bite, backspacing slightly, in the opposite edge of the wound.
5. Continue this procedure, exiting the skin after you have gone 2 cm, until you reach the other apex of the excision. Remember to backspace slightly, as this is critical to fine, equal eversion of the two wound edges.
6. Make your last bite, with the needle pointing upward, at the apex.
7. Exit the skin approximately 1 cm opposite the apex.
8. Pull gently to approximate the wound.
9. Anchor the ends by tying the suture back on itself.
10. If there is a small gap in the closure line, approximate it using a fine epicuticular interrupted stitch.

Burying The Final Knot

Buried sutures are placed so that the knot protrudes to the inside, under the layer to be closed. This technique is useful when using large diameter permanent sutures on deeper layers in thin patients who may be able to feel large knots that are not buried.

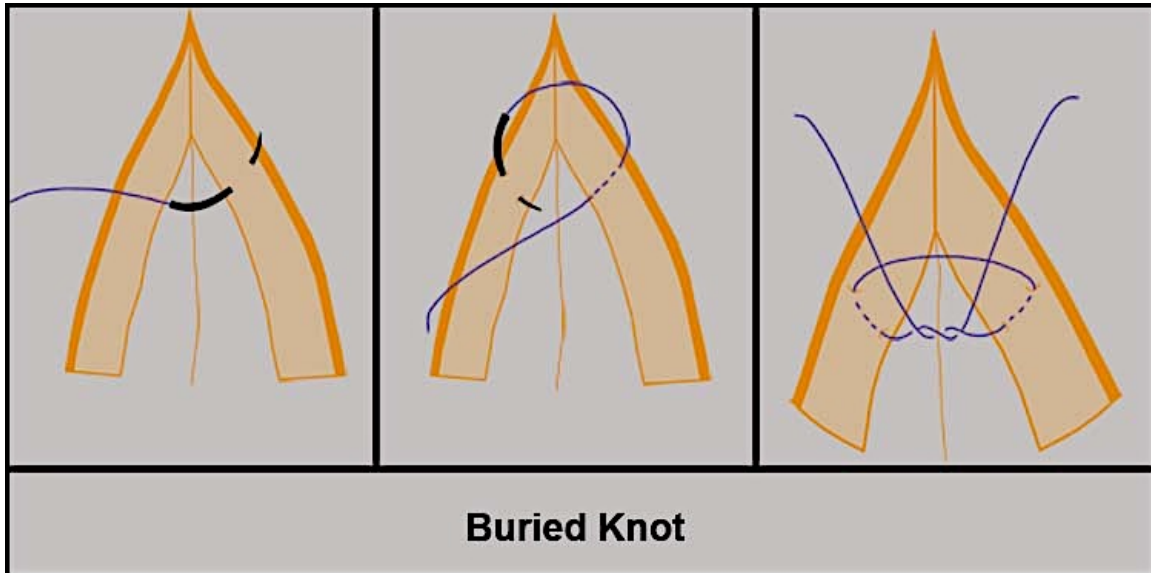
Mastering the technique for burying the end knot is the greatest challenge of the Buried Continuous Subcuticular (BCS) pattern. BCS pattern is recommended for skin closure in most elective surgeries, and MONOCRYL or PDS (polydioxanone) suture is an excellent choice for this suture pattern.

1. After the BCS pattern is completed, the needle is advanced 2-3 mm to the opposite side. A vertical bite is placed from the mid-dermis down to subcutaneous tissue. The needle is then inserted on the opposite side, vertically aiming up from the subcutaneous tissue, exiting at the mid-dermis within 2-3 mm of the commissure. A 2 cm loop of suture is created between the 2 vertical bites.
2. A third vertical bite is taken parallel to the first, initiating in the mid-dermis, but exiting deeper in the subcutaneous layer. The needle is brought up between the exposed loop and final suture crossing the incision.

Simple Cutaneous Continuous

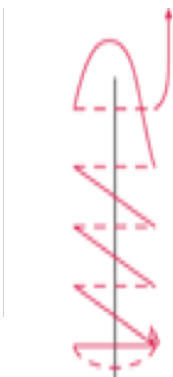
- After tension is applied to the exposed loop to tighten the horizontal sutures and appose the wound margins, the free suture end is tied to the exposed loop with 4-5 throws to complete the knot and close the wound.
- The loop is trimmed 2-3 mm above the knot. The needle is then inserted close to the knot, aimed to exit the dermis at least 1cm lateral to the incision. As tension is applied to the suture, the knot is pulled deeper into the tissue, below the dermis. Finally, under tension, the free end of suture is trimmed flush with the skin.

Start
Here

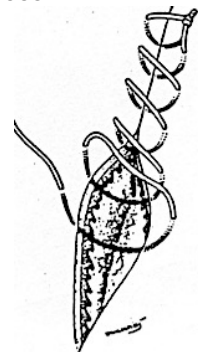


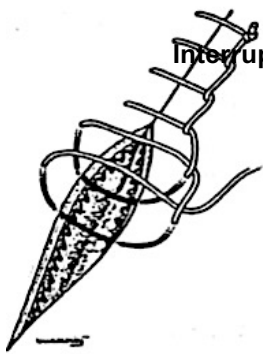
Continuous (Running) Suturing

Also referred to as *running stitches*, continuous sutures are a series of stitches taken with one strand of material. The strand may be tied to itself at each end, or looped, with both cut ends of the strand tied together. A continuous suture line can be placed rapidly. It derives its strength from tension distributed evenly along the full length of the suture strand. However, care must be taken to apply firm tension, rather than tight tension, to avoid tissue strangulation. Excessive tension and instrument damage should be avoided to prevent suture breakage, which could disrupt the entire line of a continuous suture. Continuous suturing leaves less foreign body mass in the wound. In the presence of infection, it may be desirable to use a monofilament suture material because it has no interstices, which can harbor microorganisms. This is especially critical as a continuous suture line can transmit infection along the entire length of the strand. A continuous one layer mass closure may be used on peritoneum and/or fascial layers of the abdominal wall to provide a temporary seal during the healing process.



The most commonly used running suture, the **Simple Continuous** pattern begins with a simple suture at one end of the wound. The tail is cut without the needle, and suturing is continued. Sutures are snugged up as they are done, except for the last one, which is left as a loop. The tail is tied to the loop.

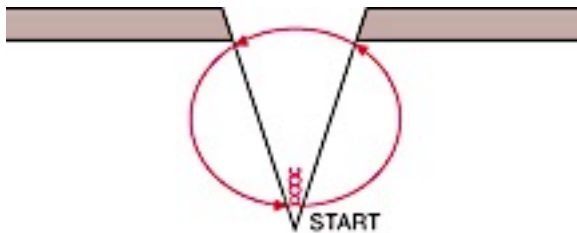




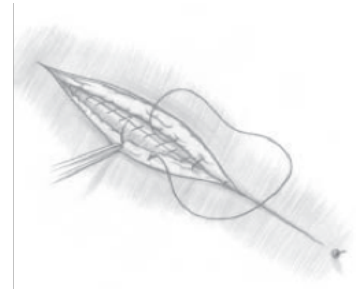
Interrupted Vertical Mattress

Simple Subcutaneous

The **Locking Cutaneous** (a.k.a. **Ford Interlocking**) produces an air and water tight closure.

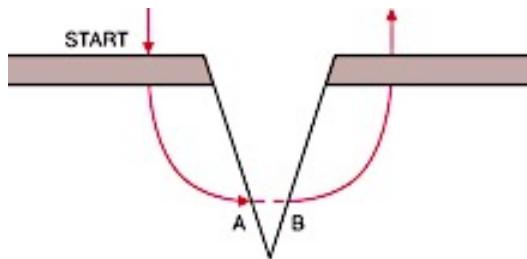


The **Simple Subcutaneous** suture begins and ends at the bottom of the wound so that the knot is deeply buried.

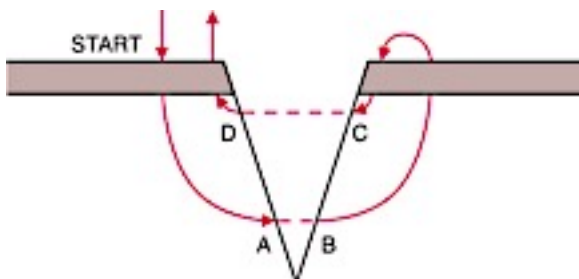
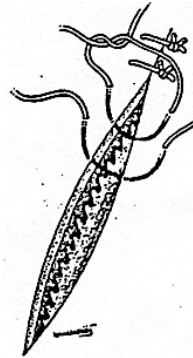


Interrupted Suturing

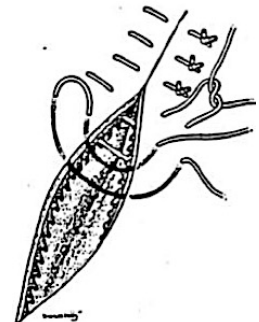
Interrupted sutures use a number of strands to close the wound. Each strand is tied and cut after insertion. This provides a more secure closure, because if one suture breaks, the remaining sutures will hold the wound edges in approximation. Interrupted sutures may be used if a wound is infected, because microorganisms may be less likely to travel along a series of interrupted stitches.



The suture begins and ends equidistant from the wound margins. Points A and B are at the same depth.



With the **Interrupted Vertical Mattress**, the first pass of the needle is the same as a large simple suture, but instead of tying off, another smaller bite is taken back across the wound to end on the starting side. Both ends are



Interrupted Horizontal Mattress

pulled up to approximate the wound. Points A and B must be at the same depth, as must points C and D; this gives proper vertical alignment.

Stick tie

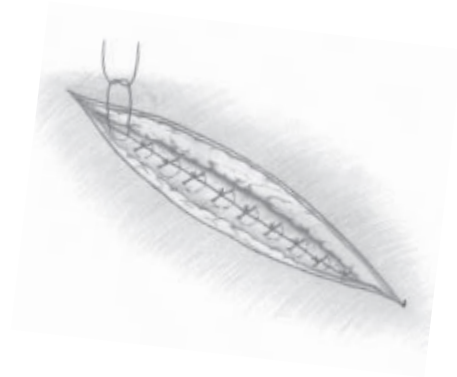
Free tie

Vertical and Horizontal Mattress sutures allow for skin edges to be closed under tension when wound edges have to be brought together over a distance. They provide edge eversion and tension relief



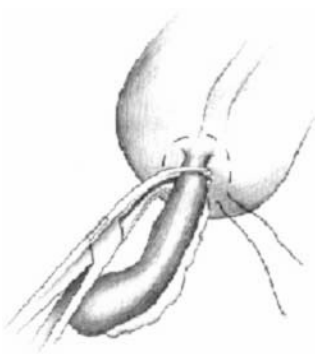
Deep Sutures

Deep sutures are placed completely under the epidermal skin layer. They may be placed as continuous or interrupted sutures and are not removed postoperatively

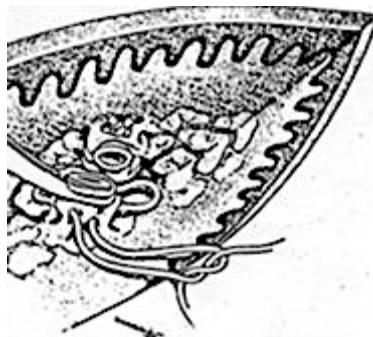


Purse String Sutures

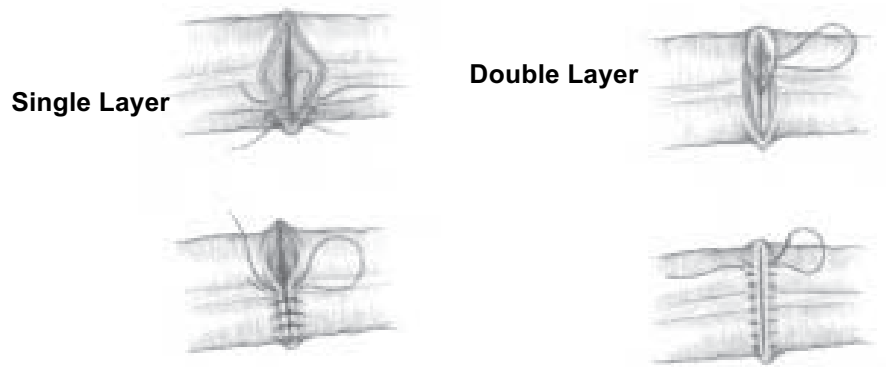
Purse-string sutures are continuous sutures placed around a lumen and tightened like a drawstring to invert the opening. They may be placed around the stump of the appendix, in the bowel to secure an intestinal stapling device, or in an organ prior to insertion of a tube (such as the aorta, to hold the cannulation tube in place during an open heart procedure).



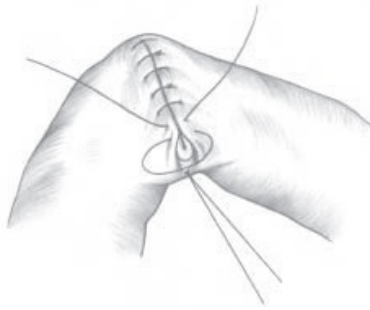
Ligatures



Anastomotic Closure Technique



Inverted Closure Technique



References (adapted from):

1. Surgical Knot Tying Manual (US Surgical Corp)
2. Knot Tying Manual (Ethicon, Inc.)
3. Wound Closure Manual (Ethicon, Inc.)
4. Merck Manual (Merck, Inc.)