Tools of the Trade and Rules of the Road: A Surgical Guide
Selected Chapters: Knot Tying & Sutures and Needles
Edited by Edwin A. Deitch
1997:287-309

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Knot Tying.

You have not learned all that art has to teach you, but you are safer practitioners today than were many of those names we hardly hear mention without a genuflection.
—Oliver Wendell Holmes (1809–1894)

INTRODUCTION

Surgery consists of the basic skills of cutting, tying knots, and suturing. This appendix deals with the art of tying secure knots. To avoid confusion, all of the maneuvers will be shown with the right hand being the dominant hand.

TYPES OF KNOTS

The first step in learning knot tying is to know what each throw and knot should look like (Fig. 1).

Simple Knots (Half Hitch)

The suture material is looped and one end is completely twisted around the other creating a half hitch. This is the first maneuver in creating a square or granny knot.

Square Knot

This is the basic knot used in surgery and is also known as the reef or flat knot. In this knot, the two half hitches are in the opposite directions, i.e., are mirror images of each other. Its advantage is that once tied, it cannot be loosened. This is the most secure knot used in surgery.
Granny Knot

This knot superimposes one simple knot on the other without reversing the half hitch (both throws in the same direction). This type of knot is insecure, liable to slip, and is usually not intentionally used in surgery. However, in deep wounds, a granny knot may be used as it takes less space to tie, and in this situation it is always followed by a half hitch in the opposite direction, creating a square knot.

Slip Knot

This knot is produced by pulling one end of the suture the whole time that the knot is being tied and by failing to cross the ends of the suture or hands during subsequent throws. That is, applying pressure to only one side of a square knot while it is being tied, or by failing to cross the hands or ends of the suture, converts a square knot into a slip knot. When the first knot has become loose during tying, the square knot can be converted to a slip knot by apply pressure on one end of the suture. The two half hitches are then pushed down on the straight segment until the knot is tight. The knot is then resquared by reversing the direction of tension on the segments. The main disadvantage of a slip knot
is that unless it is resquared, the slip knot yields with internal pressure and may come loose.

The most common mistake in knot tying is to convert a flat half hitch into a sliding half hitch by not maintaining equal tension on both strands of the ligature.

**Surgeon’s Knot**

This knot is made by producing two primary turns in the first half hitch and then placing the second half hitch in the opposite direction so that a square knot results. The double turn on the first throw helps prevent the knot from slipping, and this is helpful in some situations where there is increased tension on what is being tied. That is, using a surgeon’s knot for the first throw allows the second half hitch to be placed without having to maintain tension on the suture. Its main disadvantage is that the knot is bulky, difficult to tighten, and in the hands of the novice results in increased breakage of the suture while tying.

**PRACTICAL TIPS**

When attempting to tie knots for the first time always have someone show you how to tie knots; it’s easier to follow someone’s hand movements than trying to read and coordinate your hand movements.

When practicing, use a thick string or suture so that you can see if you are placing the knots correctly.

Always start with a crossed suture. Not only is it easier to cross the suture than your hands when initiating a knot, it is also important when tying a vessel that is clamped that the surgeon does not obstruct the view of the assistant who is holding the clamp (Fig. 2).

One end of a suture is frequently attached to a needle holder or reel, leaving a free and a fixed end. When practicing your ties, place a clamp on one end of the suture. This will help you to get accustomed to holding the short segment in the correct hand and increase your efficiency in the OR.

For tying tissues under tension, prevent the first half hitch from loosening by (a) holding continuous tension on both ends of the suture; (b) using a surgeon’s knot and locking it.

In surgery, a third half hitch is always added for security. Places where four or five hitches are placed are: (a) tissues under tension; (b) suture on moving structures, e.g., heart, diaphragm; (c) where smooth (monofilament) slippery suture material is used, such as Prolene or nylon; (d) large bleeder.

Do not tie the knots with excessive tension, since tissues only need to be approximated. Remember that edema of the tissues always occurs following surgery. Thus, a knot that is tied too tightly will strangulate the tissue and can potentially cause the suture to cut through the tissue.
FIG. 2. An important concept in knot tying is to be sure that the suture is crossed before the first throw of the knot is made. For this to occur, do not pass your hand behind the clamp to grasp the loose end of the suture. Instead, the right hand passes the short end of the suture around the clamp, which is grasped by the left hand. The short end of the suture is then returned to the right hand and the first throw of the knot is made.

METHODS OF TYING A SQUARE KNOT

The best method of tying is a square knot. A square knot may be tied one-handed, two-handed, or with an instrument. The two-handed method of tying a square knot is the best method to use when firm and continuous pressure is required during the entire process of tying. In right-handed tying, the long or fixed segment of the suture is held in the left hand, whereas the right hand holds the short or free end of the suture and does most of the maneuvering by holding, letting go, and regrasping the suture. The first half hitch of a two-handed tie is illustrated in Fig. 3 and the second half hitch is illustrated in Fig. 4. Subsequent throws are made by repeating these steps, being sure to place each throw in the direction opposite the previous throw.

In one-handed ties, all the maneuvering, including releasing and regrasping of the suture, is done with one hand while the other hand merely holds the long or fixed end of the suture taut. One can use either the right or left hand to perform
FIG. 3. The first half hitch of a square knot. Grasp the long end of the ligature with the flexed middle, fourth, and little fingers of the left hand (A). Holding the short end of the ligature between the thumb and index finger of the right hand, bring it back between the extended thumb and index finger of the left hand (B). Cross the left thumb over the short and under the long end of the suture (C). Hook the left thumb around the long end of the suture and pull it across the short end by extending the thumb—a loop is made (D). See Following Page for E through I.
Place the free short end of the suture between the tips of the left thumb and the index finger (E). Grasp the short end of the suture (F) and rotate the short end of the suture through the loop (G). Grasp the short end of the suture with the right hand (H). Tighten the first half hitch by crossing the hands to lay the knot flat (I). Pull the two ends so that they form a straight angle. It is important to pull both ends equally to avoid forming a slip knot.
FIG. 4. The second half hitch of a square knot. Start the second half hitch by uncrossing your hands and grasping the long end of the ligature between flexed middle, fourth, and little fingers of the left hand (A). Hook the left thumb over the long end of the suture (B). Bring the short end of the suture, which is being held in the right hand, across the left thumb (C). Create a loop by bringing the thumb and index finger of the left hand together (D).
Fig. 4. Continued. Push the index finger through the loop, and place the free short end of the suture between the tips of the left thumb and index finger (E). Rotate the free short end of the suture through the loop by moving the thumb and index finger through the loop (F). Grasp the short end of the suture with the right hand (G). Tighten and square the knot (H).

A one-handed tie. Left-handed tying avoids unnecessary movement when suturing is done with the right hand. This method of tying is quick, and speed can be increased further by alternating ties with the left and right hands rather than crossing hands when two free ends are available (e.g., as in interrupted suturing). An advantage of the one-handed tie is that it can be used in deep cavities. Also, with the one-handed tie, it is not necessary to put the needle holder down to tie this knot. However, the knot of a one-handed tie is less secure than a two-handed knot and the first hitch has an increased chance of coming loose.

As a rule, have your two-handed tying perfected before attempting one-handed tying. Remember that it is more important to have a secure, slowly tied knot than trying to tie a quick one-handed knot that promptly becomes loose! The technique of tying a one-handed knot is illustrated in Figs. 5 and 6.

Instrument ties are used for wound closure or when the free end of the suture is too short for a hand tie and are illustrated in Fig. 7. An easy way to remember the rules for an instrument ties are as follows. Always roll the suture over the needle holder toward the short end and tighten the knot in the opposite direction by pulling away from the short end of the suture.
FIG. 5. The first half hitch is begun by grasping the free short end of the suture with the thumb and index finger of the left hand and wrapping it around the palmar surface of the middle and fourth fingers of the same hand. The long end of the suture is placed over the short end with the right hand creating a loop (A). The middle finger is flexed over the long end of the suture and the long end of the suture is pushed under the short end of the suture (B). Simultaneously, the middle finger is straightened, the thumb and index finger release the end of the suture, and the short end of the suture is pulled through the loop with the middle and ring fingers (C). The half hitch is set by crossing the hands and pulling on both ends of the suture as previously illustrated in Fig. 3.
FIG. 6. The second half hitch. Continue to hold the free end of the suture between the left thumb and index finger. With the right hand bring the long end of the suture around the ring finger of the left hand, crossing the palmar surfaces of the middle and ring fingers. Then grasp the long end of the suture with the flexed middle finger (A). Move the grasped long end of the suture under the short end with the flexed middle finger (B). Grip the suture end of the suture with the extended middle and ring fingers, pulling the short end of the suture through the loop (C). Then set the second half hitch by crossing your hands to square the knot.
FIG. 7. The needle holder is placed parallel with the incision (or vessel) being tied. The long end of the suture is wrapped around the tip of the needle holder in a clockwise direction forming a loop (A). The short end of the suture is grasped with the needle holder (B) and pulled through the loop. Bring the short end of the suture toward oneself (C).

Role of the Assistant

When suturing is being performed or knots are being tied, the assistant has several potential roles. During suturing, it is the assistant's job to maintain tension on the suture, to keep the suture from getting tangled or in the way of the surgeon, and to expose the field for the next stitch. The assistant generally ties the knots while the surgeon is getting ready to place the next stitch. When called upon to cut sutures, remember to hold the suture perpendicular to the scissors, to cut with the tips, and to keep the scissors tips in view to avoid inadvertent injury to underlying structures. The sutures should be cut short enough that the ends will not become entangled in the next stitch but long enough that the suture does not come unraveled.
FIG. 7. Continued. This creates the first hitch of a square knot. The second half hitch is formed by wrapping the long end of the suture around the instrument in a counterclockwise direction (D). The short end of the suture is then grasped and pulled through the loop (E). The needle holder is then pulled away from oneself, thus squaring the knot (F).
Sutures and Needles

INTRODUCTION

Surgeons will perform the same operation with sutures that differ widely in their properties and yet produce much the same results. This is undoubtedly the consequence of nature's ability to overcome many of our deficiencies and the relative margin of safety common to most suture materials. Though surgeons choose suture materials for individual tasks on the basis of pragmatism and traditions, some fundamental considerations concerning suture choice are important and will be covered in this chapter.

SUTURES AND SUTURE MATERIALS

General Concepts

Sutures are used to hold tissues together until the natural process of wound healing has taken place. There are a variety of suture materials with different characteristics available. They may be absorbable, e.g., catgut, chromic catgut, Vicryl, and PDS, or nonabsorbable, e.g., silk, cotton, wire, nylon, Prolene, Mersilene, and Ethibond. Each type can be further subdivided into natural, synthetic, monofilaments, and multifilaments. Nonetheless, all sutures are foreign bodies and therefore impart the same implications regarding wound healing as do other foreign bodies. Absorbable sutures generally excite more of a foreign body type of reaction in the tissues than nonabsorbable sutures. Also, natural sutures that are degraded by tissue enzymes induce more reaction than the synthetics that are dissolved through hydrolysis. The reaction persists until the suture is encapsulated (nonabsorbable material) or absorbed (absorbable material). In recent years synthetic sutures have gained popularity because of their increased strength in a finer suture. Of the commonly used synthetic nonabsorbable sutures, polyesters are considered to have the highest tensile strength. Another characteristic is the filamentous nature of the suture. Monofilaments are single stranded and generally require more knots to prevent slippage. Multifilaments have the advantages
of secure knotting and easy handling but the disadvantage of possibly harboring bacteria within the braided structure.

Suture sizes are represented numerically by zeroes. The more zeroes, the smaller the diameter of the suture, a 3-0 suture (000) being smaller than a 2-0 suture (00). On the other hand the suture diameter increases with an increase in the numbers when described without zeroes, e.g., a size 3 suture is bigger than a size 2 suture. With an increase in size comes an increase in tensile strength. The tensile strength of the suture need not be stronger than the tissue being sutured, and the smallest size suture necessary to hold the tissue together will minimize the tissue reaction and result in more rapid wound healing. As a general rule, the tensile strength of a healing wound at 20 days is 20% of normal, at 40 days 40%, at 90 days 60%, and at 1 year 70%. A wound rarely if ever attains the tensile strength of noninjured tissue. Sutures therefore have to provide tensile strength appropriate for the specific tissues sutured until healing has occurred and dehiscence is no longer a problem.

Tissues that are mainly formed of collagen, such as skin, fascia, aponeurosis, or tendon, are the strongest tissues but regain tensile strength slowly; therefore, the use of permanent or longer-lasting nonabsorbable sutures are desirable in these tissues. On the other hand, most absorbable sutures can be used in tissues, such as the stomach, intestines, or bladder, which heal rapidly. Finally when securing prosthetic materials (e.g., mitral valves, vascular grafts, or various meshes), nonabsorbable sutures that can maintain their tensile strength for the duration of patient's life must be used, since these foreign materials never fully heal.

It is important to understand a few terms before discussing the characteristics of individual sutures.

1. *Memory*: This term refers to the inherent capacity of a material to return to its former shape after being manipulated, and is often a reflection of its stiffness. A suture with a high level of memory is stiffer, more difficult to handle, and is more susceptible to becoming untied than a suture with less memory.

2. *Plasticity*: Suture materials that exhibit plasticity expand when stretched, but have a decreased tendency to return to their initial length when the deforming strain (e.g., wound edema) is no longer present. Thus, during regression of wound edema, sutures with a high degree of plasticity may become loose and compromise wound edge apposition.

3. *Elasticity*: Elasticity refers to a suture's intrinsic ability to regain its original form and length after being stretched. This is a useful feature, as it allows the suture to expand in situations of wound edema without leading to strangulation or laceration of tissue. In addition, elasticity allows the suture to recoil during wound contraction, thereby maintaining wound edge apposition.

4. *Fluid absorption and capillarity*: Fluid absorption and capillarity are two important characteristics that can affect complications in case of infection. Fluid absorption is the ability of a suture to take up fluid after being
immerged. Capillarity is the extent to which the absorbed fluid is transferred along the strand. Multifilamentous sutures, like silk, generally have greater capillarity than monofilamentous sutures and for this reason they have a greater potential for complications during infection.

PROPERTIES OF COMMONLY USED ABSORBABLE SUTURES (TABLE 1)

Catgut

This natural product, also called surgical gut, is derived from sheep or cattle intima. Gut retains significant tensile strength for 4 to 5 days only, and after 2 weeks wound security is essentially gone. However, chromic catgut retains its tensile strength for 2 to 3 weeks. Its tendency to produce a tissue reaction is moderate to high and its handling characteristics are fair. It is used for suture ligations of vessels and for epidermal closure where removal may be difficult, such

<table>
<thead>
<tr>
<th>Material</th>
<th>Nature</th>
<th>Tensile strength (TS) and absorption</th>
<th>Handleability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catgut:</td>
<td>has been known to be absorbed under</td>
<td>Plain—TS lost in 4-5 days; chromic—TS lost in</td>
<td>Moderate; becomes wavy when dried up; pliability improved by immersion in water</td>
</tr>
<tr>
<td>type A, plain;</td>
<td>tissue conditions;</td>
<td>10-15 days; complete absorption 70 days</td>
<td></td>
</tr>
<tr>
<td>type C, chromic</td>
<td>sheep submucosa and cattel serosa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dexon (polyglycolic acid)</td>
<td>First synthetic; absorbable;</td>
<td>TS 5% at 28 days; complete absorption 90-120</td>
<td>Stiff in monofilament form; better in braided; smoother knot tying with coat</td>
</tr>
<tr>
<td></td>
<td>monofilament/braided/coated</td>
<td>days</td>
<td></td>
</tr>
<tr>
<td>Vicryl (poligalactic acid)</td>
<td>Second synthetic; absorbable;</td>
<td>TS 8% at 28 days; complete absorption 60-90</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>braided/coated</td>
<td>days</td>
<td></td>
</tr>
<tr>
<td>PDS (polydioxanone)</td>
<td>Synthetic; monofilament</td>
<td>TS 58% at 28 days; complete absorption 180</td>
<td>Stiffer than Dexon and Vicryl; longer memory and decreased knot security</td>
</tr>
<tr>
<td></td>
<td></td>
<td>days</td>
<td></td>
</tr>
<tr>
<td>Maxon (Polyglycomate)</td>
<td>Newest synthetic</td>
<td>TS 59% at 28 days; complete absorption 180-210</td>
<td>60% less rigid than PDS; absorbable suture of choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>days</td>
<td></td>
</tr>
<tr>
<td>Monocryl (poliglecaprone)</td>
<td>Latest synthetic; absorbable;</td>
<td>TS 50-60% at 7 days, 30-40% at 14 days,</td>
<td>Superior pliability, easy handling and tying; new choice for subcuticular closures</td>
</tr>
<tr>
<td></td>
<td>monofilament</td>
<td>0 at 21 days; complete absorption 91-119 days</td>
<td></td>
</tr>
</tbody>
</table>
as for closure of the oral mucosa and tongue. Although used for centuries, it is rapidly fading from use because gut suture material has poor tensile strength, poor *in vivo* knot stability, and high tissue reactivity.

**Glycolic Acid Polymers**

This group of suture materials includes synthetic absorbable sutures, e.g., Dexon, Vicryl, PDS, Maxon, Monocryl, and Polysorb.

**Dexon (Polyglycolic Acid)**

This was the first synthetic absorbable suture to become available, in 1970. It was renowned for its superb tensile and knot strengths in addition to having delayed absorption and diminished tissue reactivity when compared with catgut.

In animal studies, Dexon has been found to have a tensile strength of about 40% after 7 days, 20% after 15 days, and 5% at 28 days. It is completely absorbed by 90 to 120 days. In the monofilament form, it is hard to work with; therefore, it is supplied in braided form for ease of handling. Dexon plus has a synthetic coating for smooth knot tying and passage through tissues. Dexon II is a newer product designed to have improved handling qualities.

**Vicryl (Polyglycolic Acid 910)**

Vicryl was introduced in 1974 and was the next synthetic material to be marketed. It has a lubricant coating, and is provided in a braided form, which gives Vicryl its superb handling and smooth tie-down properties. Vicryl, like Dexon, retains less than 10% of its tensile strength by 28 days; however, complete absorption is more expedient and takes between 60 to 90 days. Although the high tensile strength of Vicryl is advantageous in keeping wound edges approximated, its low elasticity tends to cause some cutting through tissue, particularly when the tissue is soft and pliable.

Vicryl is most useful as a buried intradermal suture. However, if a Vicryl suture is placed too close to the surface of a cutaneous wound, it may be extruded, or spit, before dissolving completely. Another uncommon, untoward complication of Vicryl is the formation of a suture abscess that resolves after removal or extrusion of the suture.

**PDS (Polydioxanone)**

PDS was marketed as having prolonged tensile strength in vivo compared with Vicryl or Dexon. It retains 74% of its original tensile strength at 14 days,
58% at 28 days, and 41% at 42 days. Complete absorption occurs in 180 days. Therefore, it is useful in situations where extended wound strength is required.

Unlike Vicryl or Dexon, PDS is manufactured as a monofilamentous suture and therefore it should have less of a tendency to harbor bacteria. PDS has less of a tendency to produce suture abscesses or cut through tissues than Vicryl. A disadvantage of using PDS is that it is more difficult to use than the braided synthetics because of its intrinsic stiffness and prolonged memory. In addition, it costs about 14% more than either Dexon or Vicryl.

**Maxon (Polytrimethylene Carbonate)**

This is the newest synthetic absorbable material. It was developed to combine the excellent tensile strength retention qualities of PDS with improved handling properties. Maxon provides wound support over an extended period of time, like PDS, with an average strength retention of 81% at 14 days, 59% at 28 days, and 30% at 42 days. Complete absorption takes place in 180 to 210 days. It is also much more supple and manageable than PDS, with 60% less rigidity. Although the cost of Maxon is 7% more than Vicryl or Dexon, its improved strength and handling characteristics make it an absorbable suture of choice.

**Monocryl Synthetic (Poliglecaprone 25)**

This suture features superior pliability for easy handling and tying. It is virtually inert in tissue and absorbs predictably. Thus, it is recommended for procedures that require a high initial tensile strength diminishing over 2 weeks postoperatively. These include general surgical subcuticular closures and soft tissue approximations and ligations. At 7 days, 50% to 60% of initial strength remains, reduced to 20% to 30% at 14 days, with all original strength lost at 21 days. Absorption is essentially complete at 91 to 119 days.

**PROPERTIES OF NONABSORBABLE SUTURES (TABLE 2)**

**Silk**

Silk is created from natural protein filaments spun by the silkworm. It is available in braided form. It is perhaps the easiest suture material to handle and is considered the gold standard against which the handling properties of all sutures are compared. However, it has the lowest tensile strength of any suture tested. Although it is classified as a nonabsorbable suture, long-term in vivo studies have shown that it loses most or all of its tensile strength in about 1 year and usually cannot be detected in tissue after 2 years. Dry silk is 20% stronger than wet, therefore it should be used dry. It elicits more tissue reaction than any other
## TABLE 2. Properties of common nonabsorbable surgical sutures

<table>
<thead>
<tr>
<th>Material</th>
<th>Nature</th>
<th>Tensile strength and absorption</th>
<th>Handleability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silk (SofSilk)</td>
<td>Silk worm product; nonabsorbable; braided</td>
<td>Lowest TS of all sutures; complete absorption 2 years</td>
<td>Easiest suture material to handle and tie; dry silk 20% stronger than wet;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>secure knots</td>
</tr>
<tr>
<td>Nylon (Nurolon, Surgilon, Ethilon, Dermalon, Monosof, Bralon)</td>
<td>First synthetic suture; nonabsorbable monofilament/ braided</td>
<td>TS 89% at 1 yr, 72% at 2 yrs, 2/3 at 11 yrs</td>
<td>Poor in monofilament; good in braid; main disadvantage is prominent memory, so needs increased number of knot throws</td>
</tr>
<tr>
<td>Polypropylene (Prolene, Surgilene, Surgipro)</td>
<td>Synthetic nonabsorbable monofilament</td>
<td>As for nylon</td>
<td>As for nylon; extreme smoothness compromises knot security and extra throws are required; especially noted for its plasticity</td>
</tr>
<tr>
<td>Polyester fibers: uncoated—Mersiline, Dacron; coated—Ethibond</td>
<td>Synthetic braided; available in nontreated and coated forms</td>
<td>Greater tensile strength than most synthetic nonabsorbable sutures</td>
<td>Good because of its combination of braid and monofilament coat</td>
</tr>
<tr>
<td>Polybutester (Novafil)</td>
<td>Newest nonabsorbable monofilament</td>
<td>Stronger than nylon or polypropylene</td>
<td>Less stiff, has low coefficient of resistance; unique feature—elasticity; reduced potential of suture marks and suture cut throughs</td>
</tr>
</tbody>
</table>

material except catgut. It has an increased tendency for fluid absorption and capillarity and should be avoided in areas prone to infection. It should also be avoided in biliary or urinary tracts where it could act as a nidus for stone formation.

**Nylon (Nurolon, Surgilon, Ethilon, Dermalon, Monosof, Bralon)**

Nylon was the first synthetic suture to be available. It is popular because of its high tensile strength, minimal tissue reactivity, and low cost. The main disadvantage to using nylon is its prominent memory, which mandates an increased number of knot throws to hold the stitch in place. Although initially produced as a monofilament suture, it is also available in a braided form, which is more pliable. Nylon sutures can also be purchased soaked in alcohol to decrease its memory and increase its pliability.
Nylon is partially degraded in vivo and retains 89% of its original strength at 1 year and 72% at 2 years, at which time the degradation process appears to have stabilized. Studies have shown nylon to retain approximately two-thirds of its tensile strength after 11 years.

**Polypropylene (Prolene, Surgilene, Surgipro)**

Polypropylene is extremely inert. Tissue reactivity and tensile strength are comparable to nylon. Its extreme smoothness compromises knot security and extra throws are required to compensate for this drawback.

Polypropylene is especially noted for its plasticity. It expands when stretched, as with wound swelling postoperatively, and helps to prevent strangulation of tissue, but has a decreased tendency to return to its initial length when the deforming strain is no longer present. Hence, during regression of wound edema, the suture may become loose and wound edge apposition is compromised. It costs 13% more than monofilament nylon.

**Braided Polyesters (Includes Ethibond, Mersilene, Dacron, and Ethiflex)**

These are braided polymers formed by condensation polymerization. They provide greater tensile strength than most synthetic nonabsorbable sutures but with improved qualities in handling and knot security. Mersilene and Dacron are uncoated and have a rough surface that produces drag when pulled through tissues and when knots are set. To ameliorate this problem, coated polyesters such as Ethibond were developed. However, these sutures are expensive and the coating is susceptible to cracking after knots are tied.

**Polybutester (Novafil)**

This is the newest nonabsorbable suture. It is stronger and less stiff and possesses a lower coefficient of friction than either nylon or polypropylene. However, its unique characteristic is elasticity. It has the capacity to stretch 50% of its length at loads of only 25% of its knot breaking level. At similar loads, a nylon suture elongates only 25%. Polybutester also has the advantage of suture elongation when wound edema occurs and maintenance of tension when the edema recedes. This characteristic reduces the potential for suture marks and suture cut throughs. Its cost is equivalent to that of polypropylene.

**Staples**

Staples have been widely used for skin closure. Staples may be placed more quickly than traditional sutures, resulting in reduced operating time. Furthermore,
tissue handling is minimized during staple placement, so that trauma to the tissue is minimized. Staples are particularly useful on hair-bearing areas such as the scalp. The cosmetic results obtained with staples are comparable with those obtained with sutures. The cost of staples is generally greater than that of sutures.

**Metallic Wires**

The use of wire sutures has decreased with the advent of new synthetic non-absorbable sutures. The most commonly used wire is stainless steel wire. Advantages of wires include virtually no tissue response and indefinite tensile strength, although wire sutures can develop fatigue fractures after 1 year. Disadvantages of wire include troublesome knots and wound pain, capability to prick holes in the gloves, and tendency to kink, which can render it particularly difficult to use. The only common uses of steel wires in modern surgical practice are in reduction of bone fractures and closure of the sternum and skull.

**NEEDLES**

The three basic components of a surgical needle are the eye, the body, and the point (Fig. 1). Most sutures used today have swaged eyes (i.e., the suture mater-

![Diagram of Needle Configuration](image)

**FIG. 1.** Nomenclature of needle configuration. The needle should be grasped by the tip of the needle holder approximately one-half to one-third the distance from the swaged end of the curved needle. Grasping the needle at this point allows proper rotation of the needle with pronation of the wrist. Because the swaged part of the needle is hollow, holding this portion of the needle with the needle holder will result in bending of the needle. Thus, by appropriate placement of the needle in the needle holder, it is possible to avoid unnecessary bending of the needle during suturing.
ial is securely encased within the eye). Because the swaged part of the shank has a diameter larger than that of the suture as well as that of the remainder of the needle, and it is this portion of the needle that determines the size of the suture tract, it is important to select a needle that has a thickness that matches the diameter of the suture material so that the smallest tunnel possible is created within the tissue.

The body of the needle determines the shape of the needle (Fig. 2). Straight needles are no longer as commonly used as they once were and have been largely replaced by curved needles except in a few specialized circumstances. Curved needles have replaced straight needles since they allow greater control of needle placement, especially in difficult areas of access. This is because the curved needle shape requires less space for maneuvering than a straight needle. Curved needles come in various shapes, with the three most commonly used curved needles being the 3/8 circle, 1/2 circle, and 5/8 circle needles. The key principle in selecting a specific curved needle curvature is to be sure that the curvature is great enough that the needle tip can be easily seen.

The 3/8 circle needle is used for most cutaneous procedures. The surgeon can easily manipulate this curvature with slight pronation of the wrist in a relatively large and superficial wound. It is very difficult to use this needle in a deep body cavity or restricted area because a larger arc of manipulation is required. The 1/2 circle needle was designed for use in a confined space, although it requires more pronation and supination of the wrist. But even the tip of this needle may be obscured by tissue deep in the pelvic cavity or when suturing in a body cavity. A 5/8 circle needle may be more useful in this situation, especially in some anal, urogenital, intraoral, and cardiovascular procedures.

FIG. 2. Needles are described based on the shape of the needle body as either straight or curved needles. Curved needles are further classified by the fraction of the arc of a circle that the needle forms (i.e., 1/4, 3/8, 1/2, 5/8).
Although the nomenclature of needle points can be confusing and is not fully standardized (i.e. each manufacturing company uses different names to describe the same needle point), basically needle points are either tapered or cutting (Fig. 3). Tapered point needles, also referred to as round needles, are used in easily penetrated tissues, such as bowel, peritoneum, abdominal viscera, myocardium, dura, and subcutaneous tissues. The advantage of tapered needles is that they pierce and spread rather than cut tissue. Cutting edge needles are used in tougher tissues, such as skin, sclera, periosteum, and perichondrium. Because of the sharpness of the cutting edge, care must be taken in some tissue (tendon sheath or oral mucous membrane) to avoid cutting through more tissue than desired. The most commonly used cutting edge needle is called reverse cutting. Its sharp edge is on the outer curvature and appears as an upended triangle on cross section. When the inner curvature is sharpened, the needle is called conventional or regular cutting. The reverse cutting needle is preferred for cutaneous suturing.

FIG. 3. Schematic illustration of the cross sections and bodies of the commonest types of needles used. See text for description of their use.
TABLE 3. General uses of specific types of needles

<table>
<thead>
<tr>
<th>Needle type</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taper point</td>
<td>Soft tissue closure such as gastrointestinal tract, vascular, fascia, and soft tissue</td>
</tr>
<tr>
<td>Conventional cutting</td>
<td>Skin closure, subcutaneous tissue</td>
</tr>
<tr>
<td>Reverse cutting</td>
<td>Skin closure and subcutaneous ligamentous or fibrous tissue</td>
</tr>
<tr>
<td>Tapercut</td>
<td>Cardiovascular surgery, dense connective tissues, especially tendon</td>
</tr>
<tr>
<td>Blunt point</td>
<td>Suturing of liver and other fragile tissue where neither cutting or piercing properties are desirable; a variant is used in fascia or mass closure of abdominal wall to minimize risk of needle sticks in HIV-positive patients</td>
</tr>
</tbody>
</table>

When it transects the skin lateral to the wound, the outside edge is parallel to the edge of the wound. This cutting action creates less of a tendency for suture to tear through tissues. Reverse cutting needles also have more strength than similar-sized conventional cutting needles.

Tapercut needles combine the features of the reverse cutting edge tip and taper point needles. Although initially designed for cardiovascular surgery on sclerotic or calcified tissue, these needles are widely used for suturing dense, fibrous connective tissue, especially in fascia, periosteum, and tendon, where separation of parallel connective tissue fibers could occur with a conventional cutting needle.

Blunt point needles can literally dissect friable tissue rather than cutting it. They have a taper body with a rounded, blunt point that will not cut through tissue. They may be used for suturing the liver and kidney. Due to safety considerations, surgeons also use blunt point needles in obstetric and gynecologic procedures when working in deep cavities that are prone to space and visibility limitations (Table 3).

SUMMARY

Although there are many suture materials and needles to choose from, in fact most operations are carried out just using a few of the choices discussed above.