

THE WOUND

Injury to any of the tissues of the body, especially that caused by physical means and with interruption of continuity, is defined as a *wound*.¹ Though most often the result of a physical cause, a burn is also considered a wound. Both follow the same processes towards the restoration to health—otherwise known as *healing*.¹

Wound healing is a natural and spontaneous phenomenon. When tissue has been disrupted so severely that it cannot heal naturally (without complications or possible disfigurement) dead tissue and foreign bodies must be removed, infection treated, and the tissue must be held in apposition until the healing process provides the wound with sufficient strength to withstand stress without mechanical support. A wound may be approximated with sutures, staples, clips, skin closure strips, or topical adhesives.

Tissue is defined as a collection of similar cells and the intercellular substances surrounding them. There are 4 basic tissues in the body: 1) epithelium; 2) connective tissues, including blood, bone and cartilage; 3) muscle tissue; and 4) nerve tissue. The choice of wound closure materials and the techniques of using them are prime factors in the restoration of continuity and tensile strength to the injured tissues during the healing process.

The parameters for measuring the strength of normal body tissue are:

- **Tensile Strength**—The load per cross-sectional area unit at the point of rupture, relating to the nature of the material rather than its thickness.
- **Breaking Strength**—The load required to break a wound regardless of its dimension, the more clinically significant measurement.
- **Burst Strength**—The amount of pressure needed to rupture a viscus, or large interior organ.

The rate at which wounds regain strength during the wound healing process must be understood as a basis for selecting the most appropriate wound closure material.

RECOVERY OF TENSILE STRENGTH

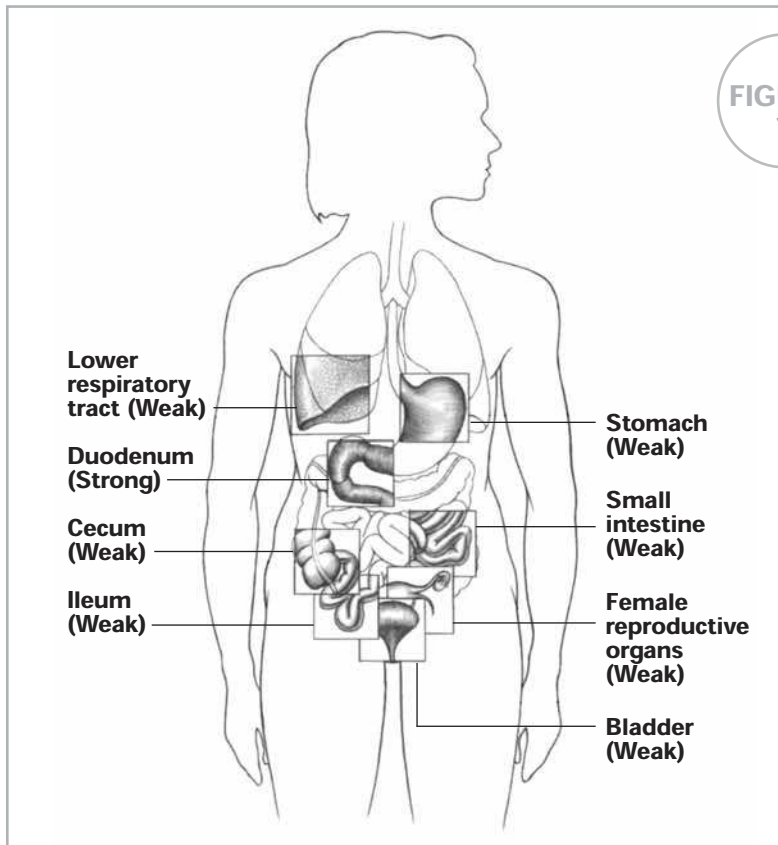
Tensile strength affects the tissue's ability to withstand injury but is not related to the length of time it takes the tissue to heal. As collagen accumulates during the reparative phase, strength increases rapidly, but it is many months before a plateau is reached.² Until this time, the wound requires extrinsic support from the method used to bring it together—usually sutures. While skin and fascia (the layer of firm connective tissue covering muscle) are the strongest tissues in the body, they regain tensile strength slowly during the healing process. The stomach and small intestine, on the other hand, are composed of much weaker tissue but heal rapidly. Variations in tissue strength may also be found within the same organ. Within the colon, for example, the sigmoid region is approximately twice as strong as the cecum—but both sections heal at the same rate. Factors that affect tissue strength include the size, age, and weight

of the patient, the thickness of tissue, the presence of edema, and duration (the degree to which the tissue has hardened in response to pressure or injury).

PATIENT FACTORS THAT AFFECT WOUND HEALING

The goal of wound management is to provide interventions that efficiently progress wounds through the biologic sequence of repair or regeneration. The patient's overall health status will affect the speed of the healing process. The following are factors that should be considered by the surgical team prior to and during the procedure.²⁻⁴

- ◆ **AGE**—With aging, both skin and muscle tissue lose their tone and elasticity. Metabolism also slows, and circulation may be impaired. But aging alone is not a major factor in chronic wound healing. Aging and chronic disease states often go together, and both delay repair processes due to delayed cellular response to the stimulus of injury, delayed collagen deposition, and decreased tensile strength in the remodeled tissue. All of these factors lengthen healing time.
- ◆ **WEIGHT**—Obese patients of any age have excess fat at the wound site that may prevent securing a good closure. In addition, fat does not have a rich blood supply, making it the most vulnerable of all tissues to trauma and infection.
- ◆ **NUTRITIONAL STATUS**—Overall malnutrition associated with chronic disease or cancer,



or specific deficiencies in carbohydrates, proteins, zinc, and vitamins A, B, and C can impair the healing process. Adequate nutrition is essential to support cellular activity and collagen synthesis at the wound site.

◆ **DEHYDRATION**—If the patient's system has been depleted of fluids, the resulting electrolyte imbalance can affect cardiac function, kidney function, cellular metabolism, oxygenation of the blood, and hormonal function. These effects will not only impact upon the patient's overall health status and recovery from surgery but may also impair the healing process.

◆ **INADEQUATE BLOOD SUPPLY TO THE WOUND SITE**—Oxygen is necessary for

cell survival and, therefore, healing. Skin healing takes place most rapidly in the face and neck, which receive the greatest blood supply, and most slowly in the extremities. The presence of any condition that compromises the supply of blood to the wound, such as poor circulation to the limbs in a diabetic patient or arteriosclerosis with vascular compromise, will slow and can even arrest the healing process.

◆ **IMMUNE RESPONSES**—Because the immune response protects the patient from infection, immunodeficiencies may seriously compromise the outcome of a surgical procedure. Patients infected with HIV, as well as those who have recently undergone chemotherapy or who have taken prolonged high

dosages of catabolic steroids, may have debilitated immune systems. Some patients have allergies to specific suturing materials, metal alloys, or latex. These, on the other hand, will cause a heightened immune response in the form of an allergic reaction. This may also interfere with the healing process. Therefore, the surgeon should always check beforehand on a patient's allergies.

◆ **CHRONIC DISEASE**—

A patient whose system has already been stressed by chronic illness, especially endocrine disorders, diabetes, malignancies, localized infection, or debilitating injuries will heal more slowly and will be more vulnerable to post-surgical wound complications. All of these conditions merit concern, and the surgeon must consider their effects upon the tissues at the wound site, as well as their potential impact upon the patient's overall recovery from the procedure. Malignancies, in addition, may alter the cellular structure of tissue and influence the surgeon's choice of methods and closure materials.

◆ **RADIATION THERAPY**—Radiation therapy to the surgical site prior to or shortly after surgery can produce considerable impairment of healing and lead to substantial wound complications. Surgical procedures for malignancies must be planned to minimize the potential for these problems.

SURGICAL PRINCIPLES

Many factors that affect the healing process can be controlled by the surgical team in the operating room, by the obstetrical team in labor and delivery, or by the emergency team in the trauma center. Their first priority is to maintain a sterile and aseptic technique to prevent infection. Organisms found within a patient's own body most commonly cause postoperative infection, but microorganisms carried by medical personnel also pose a threat. Whatever the source, the presence of infection will deter healing. In addition to concerns about sterility, the following must be taken into consideration when planning and carrying out an operative procedure.³

◆ **THE LENGTH AND DIRECTION OF THE INCISION**—A properly planned incision is sufficiently long to afford sufficient optimum exposure. When deciding upon the direction of the incision, the surgeon must bear the following in mind:

- The direction in which wounds naturally heal is from side-to-side, not end-to-end.
- The arrangement of tissue fibers in the area to be dissected will vary with tissue type.
- The best cosmetic results may be achieved when incisions are made parallel to the direction of the tissue fibers. Results may vary depending upon the tissue layer involved.

◆ **DISSECTION TECHNIQUE**—

When incising tissue, a clean incision should be made through the skin with one stroke of evenly applied pressure on the scalpel. Sharp dissection should be used to cut through remaining tissues. The surgeon must preserve the integrity of as many of the underlying nerves, blood vessels, and muscles as possible.

◆ **TISSUE HANDLING**—

Keeping tissue trauma to a minimum promotes faster healing. Throughout the operative procedure, the surgeon must handle all tissues very gently and as little as possible. Retractors should be placed with care to avoid excessive pressure, since tension can cause serious complications: impaired blood and lymph flow, altering of the local physiological state of the wound, and predisposition to microbial colonization.

◆ **HEMOSTASIS**—Various mechanical, thermal, and chemical methods are available to decrease the flow of blood and fluid into the wound site. Hemostasis allows the surgeon to work in as clear a field as possible with greater accuracy. Without adequate control, bleeding from transected or penetrated vessels or diffused oozing on large denuded surfaces may interfere with the surgeon's view of underlying structures.

Achieving complete hemostasis before wound closure also will prevent formation of postoperative hematomas. Collections of

blood (hematomas) or fluid (seromas) in the incision can prevent the direct apposition of tissue needed for complete union of wound edges. Furthermore, these collections provide an ideal culture medium for microbial growth and can lead to serious infection.

When clamping or ligating a vessel or tissue, care must be taken to avoid excessive tissue damage. Mass ligation that involves large areas of tissue may produce necrosis, or tissue death, and prolong healing time.

◆ **MAINTAINING MOISTURE IN TISSUES**—

During long procedures, the surgeon may periodically irrigate the wound with warm physiologic (normal) saline solution, or cover exposed surfaces with saline-moistened sponges or laparotomy tapes to prevent tissues from drying out.

◆ **REMOVAL OF NECROTIC TISSUE AND FOREIGN MATERIALS**—

Adequate debridement of all devitalized tissue and removal of inflicted foreign materials are essential to healing, especially in traumatic wounds. The presence of fragments of dirt, metal, glass, etc., increases the probability of infection.

◆ **CHOICE OF CLOSURE MATERIALS**—

The surgeon must evaluate each case individually, and choose closure material which will maximize the opportunity for healing and minimize the likelihood of infection. The proper closure

material will allow the surgeon to approximate tissue with as little trauma as possible, and with enough precision to eliminate dead space. The surgeon's personal preference will play a large role in the choice of closure material; but the location of the wound, the arrangement of tissue fibers, and patient factors influence his or her decision as well.

◆ **CELLULAR RESPONSE TO CLOSURE MATERIALS**—

Whenever foreign materials such as sutures are implanted in tissue, the tissue reacts. This reaction will range from minimal to moderate, depending upon the type of material implanted. The reaction will be more marked if complicated by infection, allergy, or trauma.

Initially, the tissue will deflect the passage of the surgeon's needle and suture. Once the sutures have been implanted, edema of the skin and subcutaneous tissues will ensue. This can cause significant patient discomfort during recovery, as well as scarring secondary to ischemic necrosis. The surgeon must take these factors into consideration when placing tension upon the closure material.

◆ **ELIMINATION OF DEAD SPACE IN THE WOUND**—

Dead space in a wound results from separation of portions of the wound beneath the skin edges that have not been closely approximated, or from air or fluid trapped between layers of tissue. This is especially true in the fatty layer which tends to lack

blood supply. Serum or blood may collect, providing an ideal medium for the growth of microorganisms that cause infection. The surgeon may elect to insert a drain or apply a pressure dressing to help eliminate dead space in the wound postoperatively.

◆ **CLOSING TENSION**—

While enough tension must be applied to approximate tissue and eliminate dead space, the sutures must be loose enough to prevent exaggerated patient discomfort, ischemia, and tissue necrosis during healing.

◆ **POSTOPERATIVE DISTRACTION FORCES**—

The patient's postoperative activity can place undue stress upon a healing incision. Abdominal fascia will be placed under excessive tension after surgery if the patient strains to cough, vomit, void, or defecate.

Tendons and the extremities may also be subjected to excessive tension during healing. The surgeon must be certain that the approximated wound is adequately immobilized to prevent suture disruption for a sufficient period of time after surgery.

◆ **IMMOBILIZATION**—

Adequate immobilization of the approximated wound, but not necessarily of the entire anatomic part, is mandatory after surgery for efficient healing and minimal scar formation.

CLASSIFICATION OF WOUNDS

The Centers for Disease Control and Prevention (CDC), using an adaptation of the American College of Surgeons' wound classification schema, divides surgical wounds into 4 classes: clean wounds, clean-contaminated wounds, contaminated wounds, and dirty or

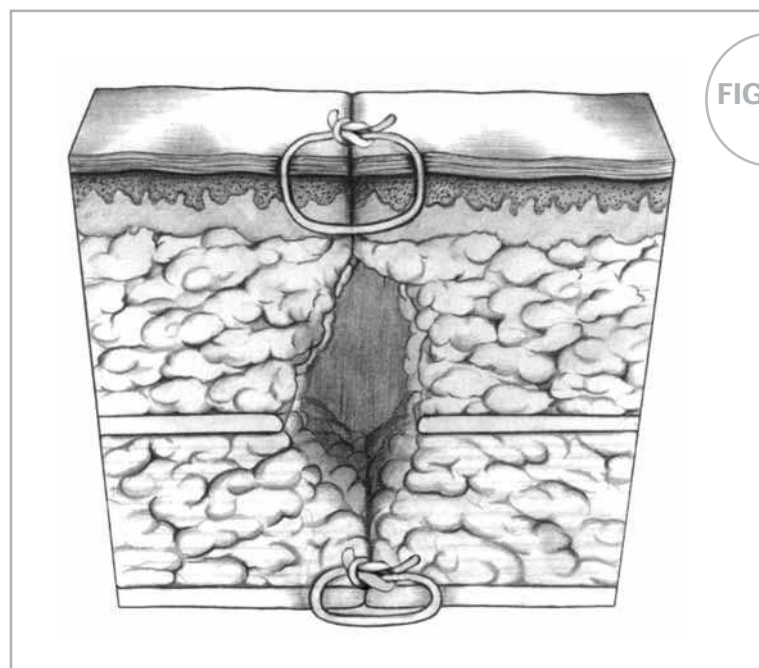


FIGURE 2

DEAD SPACE IN A WOUND

infected wounds.⁵ A discussion of each follows.

Seventy-five percent of all wounds (which are usually elective surgical incisions) fall into the *clean wounds* category—an uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tracts are not entered. These elective incisions are made under aseptic conditions and are not predisposed to infection. Inflammation is a natural part of the healing process and should be differentiated from infection in which bacteria are present and produce damage.

Clean wounds are closed by primary union and usually are not drained. Primary union is the most desirable method of closure, involving the simplest surgical procedures and the lowest risk of postoperative complications. Apposition of tissue is maintained until wound tensile strength is sufficient so that sutures or other forms of tissue apposition are no longer needed.

Clean-contaminated wounds are operative wounds in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category provided no evidence of infection or major break in technique is encountered.

Appendectomies, cholecystectomies, and hysterectomies fall into this category, as well as normally clean wounds which become

contaminated by entry into a viscus resulting in minimal spillage of contents.

Contaminated wounds include open, traumatic wounds or injuries such as soft tissue lacerations, open fractures, and penetrating wounds; operative procedures in which gross spillage from the gastrointestinal tract occurs; genitourinary or biliary tract procedures in the presence of infected urine or bile; and operations in which a major break in aseptic technique has occurred (as in emergency open cardiac massage). Microorganisms multiply so rapidly that within 6 hours a contaminated wound can become infected.

Dirty and infected wounds have been heavily contaminated or clinically infected prior to the operation. They include perforated viscera, abscesses, or neglected traumatic wounds in which devitalized tissue or foreign material have been retained. Infection present at the time of surgery can increase the infection rate of any wound by an average of 4 times.

TYPES OF WOUND HEALING

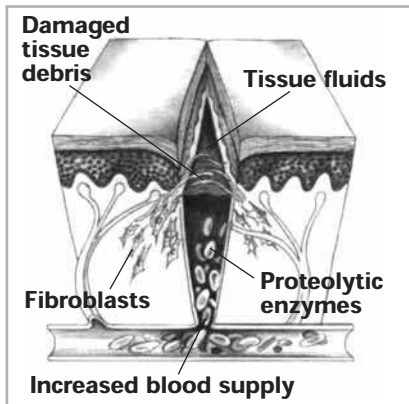
The rate and pattern of healing falls into 3 categories, depending upon the type of tissue involved and the circumstances surrounding closure. Time frames are generalized for well-perfused healthy soft tissues, but may vary.

HEALING BY PRIMARY INTENTION

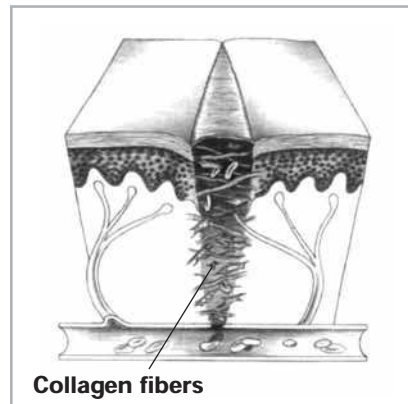
Every surgeon who closes a wound would like it to heal by primary union or first intention, with minimal edema and no local infection or serious discharge. An incision that heals by primary intention does so in a minimum of time, with no separation of the wound edges, and with minimal scar formation. This takes place in 3 distinct phases:^{2,3}

Inflammatory (preparative)—During the first few days, an inflammatory response causes an outpouring of tissue fluids, an accumulation of cells and fibroblasts, and an increased blood supply to the wound. Leukocytes and other cells produce proteolytic enzymes which dissolve and remove damaged tissue debris. These are the responses which prepare the site of injury for repair. The process lasts 3 to 7 days. Any factor which interferes with the progress, may interrupt or delay healing. During the acute inflammatory phase, the tissue does not gain appreciable tensile strength, but depends solely upon the closure material to hold it in approximation.

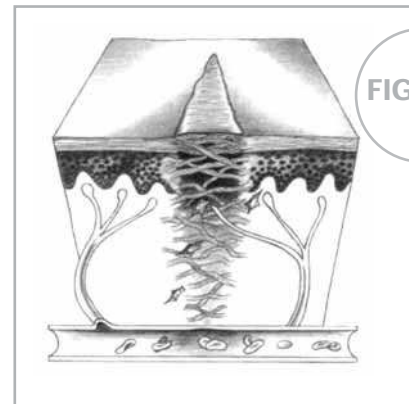
Proliferative—After the debridement process is well along, fibroblasts begin to form a collagen matrix in the wound known as granulation tissue. Collagen, a protein substance, is the chief constituent of connective tissue. Collagen fiber formation determines the tensile strength and pliability of the healing wound. As it fills with new blood vessels, the granulation becomes bright, beefy, red tissue. The thick capillary bed which fills

**PHASE 1–**

Inflammatory response and debridement process

**PHASE 2–**

Collagen formation (scar tissue)

**PHASE 3–**

Sufficient collagen laid down

FIGURE 3

PHASES OF WOUND HEALING

the matrix, supplies the nutrients and oxygen necessary for the wound to heal. This phase occurs from day 3 onward.

In time, sufficient collagen is laid down across the wound so that it can withstand normal stress. The length of this phase varies with the type of tissue involved and the stresses or tension placed upon the wound during this period.

Wound contraction also occurs during this phase. Wound contraction is a process that pulls the wound edges together for the purpose of closing the wound. In essence, it reduces the open area, and if successful, will result in a smaller wound with less need for repair by scar formation. Wound contraction can be very beneficial in the closure of wounds in areas such as the buttocks or trochanter but can be very harmful in areas such as the hand or around the neck and face, where it can cause disfigurement and excessive scarring.³

Surgical wounds that are closed by primary intention have minimal contraction response. Skin grafting is used to reduce avoided contraction in undesirable locations.

Remodeling—As collagen deposition is completed, the vascularity of the wound gradually decreases and any surface scar becomes paler. The amount of collagen that is finally formed—the ultimate scar—is dependent upon the initial volume of granulation tissue.²

HEALING BY SECOND INTENTION

When the wound fails to heal by primary union, a more complicated and prolonged healing process takes place. Healing by second intention is caused by infection, excessive trauma, tissue loss, or imprecise approximation of tissue.³

In this case, the wound may be left open and allowed to heal from the inner layer to the outer surface. Granulation tissue forms and contains myofibroblasts. These specialized cells help to close the wound by contraction. This process is much slower than primary intention healing. Excessive granulation tissue may build up and require treatment if it protrudes above the surface of the wound, preventing epithelialization.

DELAYED PRIMARY CLOSURE

This is considered by many surgeons to be a safe method of management of contaminated, as well as dirty and infected traumatic wounds with extensive tissue loss and a high risk of infection. This method has been used extensively in the military arena and has proven successful following excessive trauma related to motor vehicle accidents, shooting incidents, or infliction of deep, penetrating knife wounds.³

The surgeon usually treats these injuries by debridement of nonviable tissues and leaves the wound open, inserting gauze packing which is changed twice a day. Patient sedation or a return to the operating room with general anesthesia generally is only required in the case of large, complex wounds. Wound approximation using adhesive strips, previously placed but untied sutures, staples after achieving local anesthesia can occur within 3 to 5 days if the wound demonstrates no evidence of infection and the appearance of red granulation tissue. Should this not

occur, the wound is allowed to heal by secondary intention. When closure is undertaken, skin edges and underlying tissue must be accurately and securely approximated.

IN THE NEXT SECTION

The materials, devices, and techniques used to repair wounded tissue will be discussed at length. As you will see, the number of options available is extensive. But no matter how many choices the surgeon has, his or her objective remains singular: to restore the patient to health with as little operative trauma as possible and an excellent cosmetic result.

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WHAT IS A SUTURE?

The word "suture" describes any strand of material used to ligate (tie) blood vessels or approximate (bring close together) tissues. *Sutures* are used to close wounds. Sutures and ligatures were used by both the Egyptians and Syrians as far back as 2,000 BC. Through the centuries, a wide variety of materials—silk, linen, cotton, horsehair, animal tendons and intestines, and wire made of precious metals—have been used in operative procedures. Some of these are still in use today.

The evolution of suturing material has brought us to a point of refinement that includes sutures designed for specific surgical procedures.

Despite the sophistication of today's suture materials and surgical techniques, closing a wound still involves the same basic procedure used by physicians to the Roman emperors. The surgeon still uses a surgical needle to penetrate tissue and advance a suture strand to its desired location.

Successful use of suture materials depends upon the cooperation of the suture manufacturer and the surgical team.

The *manufacturer* must have a thorough knowledge of surgical procedures, anticipate the surgical team's needs, and produce suture materials that meet these stringent criteria:

- They must have the greatest tensile strength consistent with size limitations.
- They must be easy to handle.

- They must be secured in packaging which presents them sterile for use, in excellent condition, and ensures the safety of each member of the surgical team.

The *nurse* must maintain the sterility of sutures when storing, handling, and preparing them for use. The integrity and strength of each strand must remain intact until it is in the surgeon's hands.

The *surgeon* must select suture materials appropriate for the procedure and must place them in the tissues in a manner consistent with the principles that promote wound healing.

With the manufacturer and surgical team working in concert, the patient reaps the final benefit—*the wound is closed in a manner that promotes optimum healing in minimum time.*

PERSONAL SUTURE PREFERENCE

Most surgeons have a basic "suture routine," a preference for using the same material(s) unless circumstances dictate otherwise. The surgeon acquires skill, proficiency, and speed in handling by using one suture material repeatedly—and may choose the same material throughout his or her entire career.

A number of factors may influence the surgeon's choice of materials:

- His or her area of specialization.
- Wound closure experience during clinical training.
- Professional experience in the operating room.
- Knowledge of the healing characteristics of tissues and organs.
- Knowledge of the physical and biological characteristics of various suture materials.
- Patient factors (age, weight, overall health status, and the presence of infection).

Surgical specialty plays a primary role in determining suture preference. For example, obstetrician/gynecologists frequently prefer Coated VICRYL* *RAPIDE* (polyglactin 910) Suture for episiotomy repair and Coated VICRYL* (polyglactin 910) Suture, Coated VICRYL* Plus Antibacterial (polyglactin 910) Suture and MONOCRYL* (poliglecaprone 25) Suture for all tissue layers, except possibly skin. Most orthopedic surgeons use Coated VICRYL Suture, Coated VICRYL Plus Antibacterial Suture, PDS* II (polydioxanone) Suture, and ETHIBOND* *EXCEL* Polyester Suture. Many plastic surgeons prefer ETHILON* Nylon Suture, VICRYL* (polyglactin 910) Knitted Mesh, or MONOCRYL Suture. Many neurosurgeons prefer Coated VICRYL Suture or NUROLON* Nylon Suture. *But no single suture material is used by every surgeon who practices within a specialty.*

The surgeon's knowledge of the physical characteristics of suture material is important. As the requirements for wound support vary

with patient factors, the nature of the procedure, and the type of tissue involved, the surgeon will select suture material that will retain its strength until the wound heals sufficiently to withstand stress on its own.

SUTURE CHARACTERISTICS

The choice of suture materials generally depends on whether the wound closure occurs in one or more layers. In selecting the most appropriate sutures, the surgeon takes into account the amount of tension on the wound, the number of layers of closure, depth of suture placement, anticipated amount of edema, and anticipated timing of suture removal.

Optimal suture qualities include:

1. High uniform tensile strength, permitting use of finer sizes.
2. High tensile strength retention *in vivo*, holding the wound securely throughout the critical healing period, followed by rapid absorption.
3. Consistent uniform diameter.
4. Sterile.
5. Pliable for ease of handling and knot security.
6. Freedom from irritating substances or impurities for optimum tissue acceptance.
7. Predictable performance.

SIZE AND TENSILE STRENGTH

Size denotes the diameter of the suture material. The accepted surgical practice is to use the smallest diameter suture that will adequately hold the mending wounded tissue. This practice minimizes trauma as the suture is passed through the tissue to effect closure. It also ensures that the minimum mass of foreign material is left in the body. Suture size is stated numerically; as the number of 0s in the suture size increases, the diameter of the strand decreases. For example, United States Pharmacopeia (USP) size 5-0, or 00000, is smaller in diameter than size 4-0, or 0000. The smaller the size, the less tensile strength the suture will have.

Knot tensile strength is measured by the force, in pounds, which the suture strand can withstand before it breaks when knotted. The tensile strength of the tissue to be mended (its ability to withstand stress) determines the size and tensile strength of the suturing material the surgeon selects. The accepted rule is that the tensile strength of the suture need never exceed the tensile strength of the tissue. However, sutures should be at least as strong as normal tissue through which they are being placed.

MONOFILAMENT VS. MULTIFILAMENT STRANDS

Sutures are classified according to the number of strands of which they are comprised. *Monofilament sutures* are made of a single strand of material. Because of their simplified structure, they encounter less resistance as they pass through tissue than multifilament suture material. They also resist harboring organisms that may cause infection.

These characteristics make monofilament sutures well suited to vascular surgery. Monofilament sutures tie down easily. However, because of their construction, extreme care must be taken when handling and tying these sutures. Crushing or crimping of this suture type can nick or create a weak spot in the strand. This may result in suture breakage.

Multifilament sutures consist of several filaments, or strands, twisted or braided together. This affords greater tensile strength, pliability, and flexibility. Multifilament sutures may also be coated to help them pass relatively smoothly through tissue and enhance handling characteristics. Coated multifilament sutures are well suited to intestinal procedures.

METRIC MEASURES AND USP SUTURE DIAMETER EQUIVALENTS

TABLE 1

USP Size	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
Natural Collagen	---	0.2	0.3	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	7.0	8.0	---	---
Synthetic Absorbables	---	0.2	0.3	0.4	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	6.0	7.0	---
Nonabsorbable Materials	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0	6.0	7.0	8.0

The metric gauging system of suture materials indicates the actual diameter of materials. It has been adopted and approved by both the European and the United States Pharmacopeia. The metric number represents the diameter of the suture in tenths of a millimeter.

ABSORBABLE VS. NONABSORBABLE SUTURES

Sutures are classified according to their degradation properties. Sutures that undergo degradation and absorption in tissues are considered *absorbable* sutures. Sutures that generally maintain their tensile strength and are resistant to absorption are *nonabsorbable* sutures.

Absorbable sutures may be used to hold wound edges in approximation temporarily, until they have healed sufficiently to withstand normal stress. These sutures are prepared either from the collagen of healthy mammals or from synthetic polymers. Some are absorbed rapidly, while others are treated or chemically structured to lengthen absorption time. They may also be impregnated or coated with agents that improve their handling properties, and colored with an FDA-approved dye to increase visibility in tissue. Natural absorbable sutures are digested by body enzymes which attack and break down the suture strand. Synthetic absorbable sutures are hydrolyzed—a process by which water gradually penetrates the suture filaments, causing the breakdown of the suture's polymer chain. Compared to the enzymatic action of natural absorbables, hydrolyzation results in a lesser degree of tissue reaction following implantation.

During the first stage of the absorption process, tensile strength diminishes in a gradual, almost linear fashion. This occurs over the first several weeks postimplantation. The second stage often follows with

SUTURE	RAW MATERIAL
Surgical Gut Plain Chromic Fast-Absorbing	Submucosa of sheep intestine or serosa of beef intestine
Polyglactin 910 Uncoated (VICRYL Suture) Coated (Coated VICRYL Suture, Coated VICRYL Plus Antibacterial Suture, Coated VICRYL RAPIDE Suture)	Copolymer of glycolide and lactide with polyglactin 370 and calcium stearate, if coated
Polyglycolic Acid	Homopolymer of glycolide
Poliglecaprone 25 (MONOCRYL Suture)	Copolymer of glycolide and epsilon-caprolactone
Polyglyconate	Copolymer of glycolide and trimethylene carbonate
Polydioxanone (PDS II Suture)	Polyester of poly (p-dioxanone)

TABLE 2

ABSORBABLE SUTURES: BASIC RAW MATERIALS

considerable overlap, characterized by loss of suture mass. Both stages exhibit leukocytic cellular responses that serve to remove cellular debris and suture material from the line of tissue approximation.

The loss of tensile strength and the rate of absorption are separate phenomena. A suture can lose tensile strength rapidly and yet be absorbed slowly—or it can maintain adequate tensile strength through wound healing, followed by rapid absorption. In any case, the strand is eventually completely dissolved, leaving no detectable traces in tissue.

Although they offer many advantages, absorbable sutures also have certain inherent limitations. If a patient has a fever, infection, or protein deficiency, the suture absorption process may accelerate,

causing too rapid a decline in tensile strength. In addition, if the sutures become wet or moist prior to use, the absorption process may begin prematurely. Similarly, patients with impaired healing are often not ideal candidates for this type of suture. All of these situations predispose to postoperative complications, as the suture strand will not maintain adequate strength to withstand stress until the tissues have healed sufficiently.

Nonabsorbable sutures are those which are not digested by body enzymes or hydrolyzed in body tissue. They are made from a variety of nonbiodegradable materials and are ultimately encapsulated or walled off by the body's fibroblasts. Nonabsorbable sutures ordinarily remain where they are buried

within the tissues. When used for skin closure, they must be removed postoperatively. Nonabsorbable sutures may be used in a variety of applications:

- Exterior skin closure, to be removed after sufficient healing has occurred.
- Within the body cavity, where they will remain permanently encapsulated in tissue.
- Patient history of reaction to absorbable sutures, keloidal tendency, or possible tissue hypertrophy.
- Prosthesis attachment (ie, defibrillators, pacemakers, drug delivery mechanisms).

Nonabsorbable sutures are composed of single or multiple filaments of metal, synthetic, or organic fibers rendered into a strand by spinning, twisting, or braiding. Each strand is substantially uniform in diameter throughout its length, typically conforming to the USP limitations for each size. Nonabsorbable sutures have been classified by the USP according to their composition. In addition, these sutures may be uncoated or coated, uncolored, naturally colored, or dyed with an FDA-approved dye to enhance visibility.

SPECIFIC SUTURING MATERIALS

The materials and products described here embody the most current advances in the manufacture of surgical sutures. They are grouped as either *absorbable* or *nonabsorbable* for easy reference.

SUTURE	RAW MATERIAL
Surgical Silk	Raw silk spun by silkworm
Stainless Steel Wire	Specially formulated iron-chromium-nickel-molybdenum alloy
Nylon (ETHILON Suture, NUROLON Suture)	Polyamide polymer
Polyester Fiber Uncoated (MERSILENE* Polyester Fiber Suture) Coated (ETHIBOND EXCEL Suture)	Polymer of polyethylene terephthalate (may be coated)
Polypropylene (PROLENE Suture)	Polymer of propylene
Poly(hexafluoropropylene-VDF) (PRONOVA* poly(Hexafluoropropylene-VDF) Suture)	Polymer blend of poly(vinylidene fluoride) and poly(vinylidene fluoride-cohexafluoropropylene)

TABLE 3

NON-ABSORBABLE SUTURES: RAW MATERIALS

ABSORBABLE SUTURES SURGICAL GUT

Absorbable surgical gut is classified as either *plain* or *chromic*. Both types consist of processed strands of highly purified collagen. The percentage of collagen in the suture determines its tensile strength and its ability to be absorbed by the body without adverse reaction. Noncollagenous material can cause a reaction ranging from irritation to rejection of the suture. The more pure collagen throughout the length of the strand, the less foreign material there is introduced into the wound.

ETHICON* Surgical Gut Sutures are manufactured from between 97% and 98% pure ribbons of collagen. To meet USP specifications, the serosa layer of beef intestine or processed ribbons of the submucosa layer of sheep intestine are spun and polished into virtually monofilament strands of various sizes, with minimum and maximum limits on diameter

for each size. The ETHICON exclusive TRU-GAUGING process produces a uniform diameter to within an accuracy of 0.0002 inch (0.0175 mm) along the entire length of every strand, eliminating high and low spots. High and low spots can cause the suture to fray or chatter when knots are tied down, resulting in a knot that is not positioned properly or tied securely. Most protein-based absorbable sutures have a tendency to fray when tied.

TRU-GAUGING ensures that ETHICON Surgical Gut Sutures possess uniform high tensile strength, virtually eliminating the possibility of fray or breaking. Their strength and surface smoothness allow the surgeon to "snug down" the suture knot to achieve optimum tension.

The rate of absorption of surgical gut is determined by the type of

gut being used, the type and condition of the tissue involved, and the general health status of the patient. Surgical gut may be used in the presence of infection, although it may be absorbed more rapidly under this condition.

Plain surgical gut is rapidly absorbed. Tensile strength is maintained for only 7 to 10 days postimplantation, and absorption is typically complete within 70 days. The surgeon may choose plain gut for use in tissues that heal rapidly and require minimal support (for example, ligating superficial blood vessels and suturing subcutaneous fatty tissue). Plain surgical gut can also be specially heat-treated to accelerate tensile strength loss and absorption. This fast-absorbing surgical gut is used primarily for epidermal suturing where sutures are required for only 5 to 7 days. These sutures have less tensile strength than plain surgical gut of the comparable USP size. Fast-absorbing plain gut is not to be used internally.

Chromic gut is treated with a chromium salt solution to resist body enzymes, prolonging absorption time over 90 days. The exclusive TRU CHROMICIZING process used by ETHICON thoroughly bathes the pure collagen ribbons in a buffered chrome tanning solution before spinning into strands. After spinning, the entire cross section of the strand is evenly chromicized. The process alters the coloration of the surgical gut from yellowish-tan to brown. Chromic gut sutures minimize tissue irritation, causing less reaction than plain surgical gut

during the early stages of wound healing. Tensile strength may be retained for 10 to 14 days, with some measurable strength remaining for up to 21 days.

SYNTHETIC ABSORBABLE SUTURES

Synthetic absorbable sutures offer the strength needed for a wide range of applications, from abdominal and chest wound closure to ophthalmic and plastic surgery.

COATED VICRYL RAPIDE (POLYGLACTIN 910) SUTURE

This braided suture is composed of the same copolymer as Coated VICRYL Suture—lactide and glycolide—and is coated with a combination of equal parts of copolymer of lactide and glycolide (polyglactin 370) and calcium stearate. However, the absorption rate and tensile strength profile are significantly different from Coated VICRYL Suture, achieved by the use of a polymer material with a lower molecular weight than Coated VICRYL Suture. Coated VICRYL RAPIDE Sutures are only available undyed.

Coated VICRYL RAPIDE Suture is the fastest-absorbing synthetic suture and exhibits characteristics that model the performance of surgical gut suture. However, being a synthetic material, Coated VICRYL RAPIDE Suture elicits a lower tissue reaction than chromic gut suture. Coated VICRYL RAPIDE Suture is indicated only for use in superficial soft tissue approximation of the skin and mucosa, where only short-term wound support (7 to 10 days) is required. It is not to be used in

ligation, in ophthalmic, cardiovascular, or neurological procedures, where extended approximation of tissues under stress is required, or where wound support beyond 7 days is required.

Coated VICRYL RAPIDE Sutures retain approximately 50% of the original tensile strength at 5 days postimplantation. All of the original tensile strength is lost by approximately 10 to 14 days. Absorption is essentially complete by 42 days.

Coated VICRYL RAPIDE Suture is particularly well suited for skin closure, episiotomy repair, and closure of lacerations under casts. In addition, since the suture begins to "fall off" in 7 to 10 days as the wound heals, the need for suture removal is eliminated.

MONOCRYL (POLIGLECAPRONE 25) SUTURE

This monofilament suture features superior pliability for easy handling and tying. Comprised of a copolymer of glycolide and epsilon-caprolactone, it is virtually inert in tissue and absorbs predictably. The surgeon may prefer MONOCRYL Sutures for procedures that require high initial tensile strength diminishing over 2 weeks postoperatively. These include subcuticular closure and soft tissue approximations and ligations, with the exception of neural, cardiovascular, ophthalmic, and microsurgical applications.

MONOCRYL Suture is available dyed (violet) and undyed (natural). Dyed MONOCRYL Suture retains 60% to 70% of its original strength at 7 days postimplantation, reduced to 30% to 40% at 14 days, with all

original strength lost by 28 days. At 7 days, undyed MONOCRYL Suture retains approximately 50% to 60% of its original strength, and approximately 20% to 30% at 14 days postimplantation. All of the original tensile strength of undyed MONOCRYL Suture is lost by 21 days postimplantation. Absorption is essentially complete at 91 to 119 days.

COATED VICRYL (POLYGLACTIN 910) SUTURE

This material fills the need for a smoother synthetic absorbable suture that will pass through tissue readily with minimal drag. Coated VICRYL Sutures facilitate ease of handling, smooth tie down, and unsurpassed knot security.

The coating is a combination of equal parts of copolymer of lactide and glycolide (*polyglactin 370*), plus calcium stearate, which is used extensively in pharmaceuticals and food. Calcium stearate is a salt of calcium and stearic acid, both of which are present in the body and constantly metabolized and excreted. The result of this mixture is an outstandingly absorbable, adherent, nonflaking lubricant.

At 2 weeks postimplantation, approximately 75% of the tensile strength of Coated VICRYL Suture remains. Approximately 50% of tensile strength is retained at 3 weeks for sizes 6-0 and larger. At 3 weeks, 40% of tensile strength is retained for sizes 7-0 and smaller. At 4 weeks, 25% of the original strength is retained for sizes 6-0 and larger. All of the original tensile strength is lost by 5 weeks postimplantation. Absorption of Coated

VICRYL Suture is essentially complete between 56 and 70 days.

Lactide and glycolide acids are readily eliminated from the body, primarily in urine. As with uncoated sutures, Coated VICRYL Sutures elicit only a mild tissue reaction during absorption. Their safety and effectiveness in neural and cardiovascular tissue have not been established. Transcutaneous or conjunctival sutures remaining in place longer than 7 days may cause localized irritation and should be removed as indicated. Coated VICRYL Sutures are available as braided dyed violet or undyed natural strands in a variety of lengths with or without needles.

COATED VICRYL PLUS ANTIBACTERIAL (POLYGLACTIN 910) SUTURE

This synthetic, absorbable, sterile, surgical suture is a copolymer made from 90% glycolide and 10% L-lactide. Coated VICRYL Plus Antibacterial Suture is coated with a mixture composed of equal parts of copolymer of glycolide and lactide (*polyglactin 370*) and calcium stearate. Coated VICRYL Plus Antibacterial Suture contains IRGACARE MP*, one of the purest forms of the broad-spectrum antibacterial agent triclosan.

Coated VICRYL Plus Antibacterial Suture offers protection against bacterial colonization of the suture.

In vivo studies demonstrate that Coated VICRYL Plus Antibacterial Suture creates an *in vitro* zone of inhibition that is effective against the pathogens that most often cause surgical site infection (SSI)—*Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Staphylococcus epidermidis*,

methicillin-resistant *Staphylococcus epidermidis* (MRSE).³ *In vivo* studies demonstrate that Coated VICRYL Plus Antibacterial Suture has no adverse effect on normal wound healing.²

Coated VICRYL Plus Antibacterial Suture performs and handles the same as Coated VICRYL Suture. Coated VICRYL Plus Antibacterial Suture has the same dependable construction as Coated VICRYL Suture. *In vivo* testing by surgeons demonstrates the same excellence in performance and handling.

The suture is available undyed (natural) or dyed. Coated VICRYL Plus Antibacterial Suture is indicated for use in general soft tissue approximation and/or ligation requiring medium support, except for ophthalmic, cardiovascular, and neurological tissues. Frequent uses include general closure, bowel, orthopedic, and plastic surgery.

Coated VICRYL Plus Antibacterial Suture retains approximately 75% of the original tensile strength at 2 weeks postimplantation. At 3 weeks, approximately 50% of the original strength is retained. At 4 weeks, approximately 25% of the original strength is retained. All of the original tensile strength is lost by 5 weeks postimplantation. Absorption of Coated VICRYL Plus Antibacterial Suture is essentially complete between 56 and 70 days.

PDS II (POLYDIOXANONE) SUTURE

Comprised of the polyester poly (p-dioxanone), this monofilament represents a significant advance in suturing options. It combines the features of soft, pliable, monofilament construction with absorbability and extended wound

support for up to 6 weeks. It elicits only a slight tissue reaction. This material is well suited for many types of soft tissue approximation, including pediatric cardiovascular, orthopedic, gynecologic, ophthalmic, plastic, digestive, and colonic surgeries.

Like other synthetic absorbable sutures, PDS II Sutures are absorbed *in vivo* through hydrolysis. Approximately 70% of tensile strength remains 2 weeks postimplantation, 50% at 4 weeks, and 25% at 6 weeks. Absorption is minimal until about the 90th day postoperatively and essentially complete within 6 months. The safety and effectiveness of PDS II sutures in microsurgery, neural tissue, and adult cardiovascular tissue have not been established. PDS II sutures are available clear or dyed violet to enhance visibility.

NONABSORBABLE SUTURES

The USP classifies nonabsorbable surgical sutures as follows:

- **CLASS I**—Silk or synthetic fibers of monofilament, twisted, or braided construction.
- **CLASS II**—Cotton or linen fibers, or coated natural or synthetic fibers where the coating contributes to suture thickness without adding strength.
- **CLASS III**—Metal wire of monofilament or multifilament construction.

SURGICAL SILK

For many surgeons, *surgical silk* represents the standard handling performance by which newer synthetic materials are judged,

especially due to its superior handling characteristics. Silk filaments can be twisted or braided, the latter providing the best handling qualities.

Raw silk is a continuous filament spun by the silkworm moth larva to make its cocoon. Cream or orange-colored in its raw state, each silk filament is processed to remove natural waxes and sericin gum, which is exuded by the silkworm as it spins its cocoon. The gum holds the cocoon together, but is of no benefit to the quality of braided surgical silk sutures.

ETHICON degums the silk for most suture sizes before the braiding process. This allows for a tighter, more compact braid that significantly improves suture quality. After braiding, the strands are dyed, scoured and stretched, and then impregnated and coated with a mixture of waxes or silicone. Each of these steps is critical to the quality of the finished suture and must be carried out in precise order. Surgical silk is usually dyed black for easy visibility in tissue.

Raw silk is graded according to strength, uniformity of filament diameter, and freedom from defects. Only top grades of silk filaments are used to produce PERMA-HAND* Silk Sutures.

Surgical silk loses tensile strength when exposed to moisture and should be used dry. Although silk is classified by the USP 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. Thus, it behaves in reality as a very slowly absorbing suture.

SURGICAL STAINLESS STEEL

The essential qualities of surgical stainless steel sutures include the absence of toxic elements, flexibility, and fine wire size. Both monofilament and twisted multifilament varieties are high in tensile strength, low in tissue reactivity, and hold a knot well. Provided that the sutures do not fragment, there is little loss of tensile strength in tissues. The 316L (low carbon) stainless steel alloy formula used in the manufacture of these sutures offers optimum metal strength, flexibility, uniformity, and compatibility with stainless steel implants and prostheses. Stainless steel sutures may also be used in abdominal wall closure, sternum closure, retention, skin closure, a variety of orthopedic procedures, and neurosurgery.

Disadvantages associated with alloy sutures include difficulty in handling; possible cutting, pulling, and tearing of the patient's tissue; fragmentation; barbing; and kinking, which renders the stainless steel suture useless. When used for bone approximation and fixation, asymmetrical twisting of the wire will lead to potential buckling, wire fracture, or subsequent wire fatigue. Incomplete wire fixation under these circumstances will permit movement of the wire, resulting in postoperative pain and possible dehiscence.

Surgical stainless steel sutures should not be used when a prosthesis of another alloy is

DIAMETER	USP	B & S
.0031 inch	6-0	40
.0040	6-0	38
.0056	5-0	35
.0063	4-0	34
.0080	4-0	32
.0100	3-0	30
.0126	2-0	28
.0159	0	26
.0179	1	25
.0201	2	24
.0226	3	23
.0253	4	22
.0320	5	20
.0360	6	19
.0400	7	18

**TABLE
4**

**SURGICAL
STAINLESS
STEEL: WIRE
GAUGE
EQUIVALENTS**

implanted since an unfavorable electrolytic reaction may occur.

Above all, stainless steel sutures pose a safety risk. They easily tear surgical gloves when handled and may puncture the surgeon's own skin—putting both physician and patient at risk of transmitted immunodeficiency virus or hepatitis. Many surgeons refer to wire size by the Brown & Sharpe (B & S) gauge of 40 (smallest diameter) to 18 (largest diameter). ETHICON labels surgical stainless steel with both the B & S and USP diameter size classifications.

ETHICON packaging of surgical stainless steel maintains the integrity of the product by eliminating kinking and bending of strands. Just as important, it presents the strands in a safe manner for all members of the surgical team who handle them.

**SYNTHETIC
NONABSORBABLE SUTURES**

Nylon sutures are a polyamide polymer derived by chemical synthesis. Because of their elasticity, they are particularly well suited for retention and skin closure. They may be clear, or dyed green or black for better visibility.

ETHILON NYLON SUTURE

These sutures are extruded into noncapillary single or monofilament strands characterized by high tensile strength and extremely low tissue reactivity. They degrade *in vivo* at a rate of approximately 15% to 20% per year by hydrolysis. ETHILON Sutures in sizes 10-0 and 6-0 and larger are produced from a special grade of nylon 6. The medical grade polyamide nylon 6-6 is used for sizes 7-0 and finer. While both grades permit good handling, monofilament nylon sutures have a tendency to return to their original straight extruded state (a property

known as "memory"). Therefore, more throws in the knot are required to securely hold monofilament than braided nylon sutures.

Monofilament nylon in a wet or damp state is more pliable and easier to handle than dry nylon. A limited line of ETHILON Sutures (sizes 3-0 through 6-0) are pre-moistened or "pliable" for use in cosmetic plastic surgery. This process enhances the handling and knot tying characteristics to approximate that of braided sutures.

ETHILON Sutures are frequently used in ophthalmology and microsurgery procedures in very fine sizes. For this reason, sizes 9-0 and 10-0 have an intensified black dye for high visibility.

NUROLON NYLON SUTURE

This suture is composed of filaments of nylon that have been tightly braided into a multifilament strand. Available in white or dyed black, NUROLON Sutures look, feel, and handle like silk. However, NUROLON Sutures have more strength and elicit less tissue reaction than silk. Braided nylon may be used in all tissues where multifilament nonabsorbable sutures are acceptable. Braided nylon sutures generally lose 15% to 20% of their tensile strength per year in tissue by hydrolyzation.

Polyester fiber suture is comprised of untreated fibers of polyester (polyethylene terephthalate) closely braided into a multifilament strand. They are stronger than natural fibers, do not weaken when wetted prior to use, and cause minimal tissue reaction. Available white or

dyed green, polyester fiber sutures are among the most acceptable for vascular synthetic prostheses.

MERSILENE POLYESTER FIBER SUTURE

The first synthetic braided suture material shown to last indefinitely in the body, MERSILENE Sutures provide precise, consistent suture tension. They minimize breakage and virtually eliminate the need to remove irritating suture fragments postoperatively. Because it is uncoated, MERSILENE Suture has a higher coefficient of friction when passed through tissue.

ETHIBOND EXCEL POLYESTER SUTURE

ETHIBOND *EXCEL* Sutures are uniformly coated with polybutylate, a biologically inert, nonabsorbable compound which adheres itself to the braided polyester fiber strand. Polybutylate was the first synthetic coating developed specifically as a surgical suture lubricant. The coating eases the passage of the braided strands through tissue and provides excellent pliability, handling qualities, and smooth tie-down with each throw of the knot. Both the suture material and the coating are pharmacologically inactive. The sutures elicit minimal tissue reaction and retain their strength *in vivo* for extended periods. ETHIBOND *EXCEL* Sutures are used primarily in cardiovascular surgery, for vessel anastomosis, and placement of prosthetic materials.

ETHIBOND *EXCEL* Sutures are also available attached to TFE polymer felt pledgets. Pledgets serve to prevent possible tearing of adjacent friable tissue.

Pledgets are used routinely in valve replacement procedures (to prevent the annulus from tearing when the prosthetic valve is seated and the sutures are tied), and in situations where extreme deformity, distortion, or tissue destruction at the annulus has occurred.

PROLENE POLYPROPYLENE SUTURE

Widely used in general, cardiovascular, plastic, and orthopedic surgery, PROLENE Sutures do not adhere to tissue and are therefore efficacious as a pull-out suture. PROLENE Sutures are relatively biologically inert, offering proven strength, reliability, and versatility. PROLENE Sutures are recommended for use where minimal suture reaction is desired, such as in contaminated and infected wounds to minimize later sinus formation and suture extrusion. They are available clear or dyed blue.

Polypropylene is an isostatic crystalline stereoisomer of a linear hydrocarbon polymer permitting little or no saturation. Manufactured by a patented process which enhances pliability and handling, polypropylene monofilament sutures are not subject to degradation or weakening by tissue enzymes. They cause minimal tissue reaction and hold knots better than most other synthetic monofilament materials.

PRONOVA POLY (HEXAFLUOROPROPYLENE-VDF) SUTURE

This monofilament nonabsorbable suture is a polymer blend of poly (vinylidene fluoride) and poly

(vinylidene fluoride-cohexafluoropropylene). This suture resists involvement in infection and has been successfully employed in contaminated and infected wounds to eliminate or minimize later sinus formation and suture extrusion. Furthermore, the lack of adherence to tissues has facilitated the use of PRONOVA Sutures as a pull-out suture.

This material is well suited for many types of soft tissue approximation and ligation, including use in cardiovascular, ophthalmic, and neurological procedures.

Table 5 gives an overview of the many suturing options that have been discussed in this section.

COMMON SUTURING TECHNIQUES

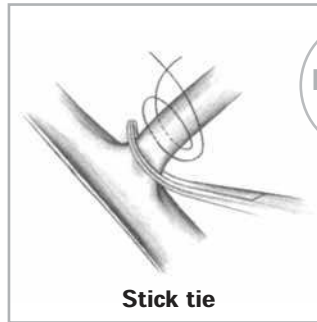
LIGATURES

A suture tied around a vessel to occlude the lumen is called a *ligature* or *tie*. It may be used to effect hemostasis or to close off a structure to prevent leakage. There are 2 primary types of ligatures.

Free tie or *freehand ligatures* are single strands of suture material used to ligate a vessel, duct, or other structure. After a hemostat or other similar type of surgical clamp has been placed on the end of the structure, the suture strand is tied around the vessel under the tip of the hemostat. The hemostat is removed after the first throw and the surgeon tightens the knot using his or her fingertips, taking care to avoid instrument damage to the suture. Additional throws are added



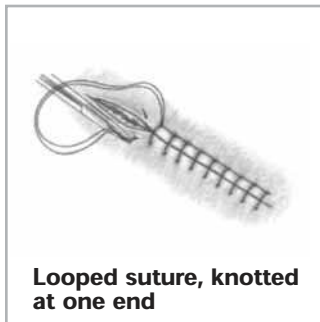
Free tie



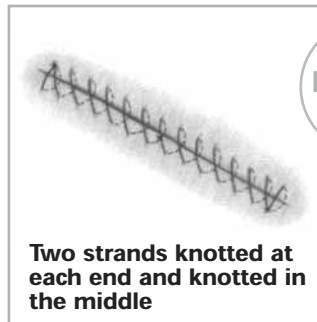
Stick tie

FIGURE 1

LIGATURES



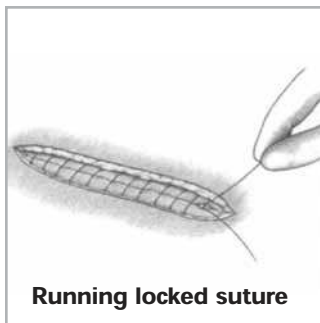
Looped suture, knotted at one end



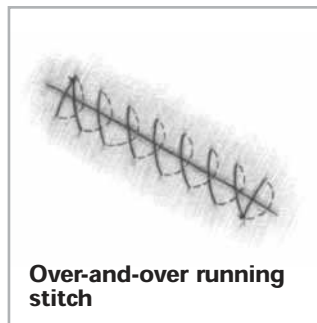
Two strands knotted at each end and knotted in the middle

FIGURE 2

CONTINUOUS SUTURING TECHNIQUES



Running locked suture



Over-and-over running stitch

as needed to square and secure the knot. *Stick tie*, *suture ligature*, or *transfixion suture* is a strand of suture material attached to a needle to ligate a vessel, duct, or other structure. This technique is used on deep structures where placement of a hemostat is difficult or on vessels of large diameter. The needle is passed through the structure or adjacent tissue first to anchor the suture, then tied around the structure. Additional throws are used as needed to secure the knot.

THE PRIMARY SUTURE LINE

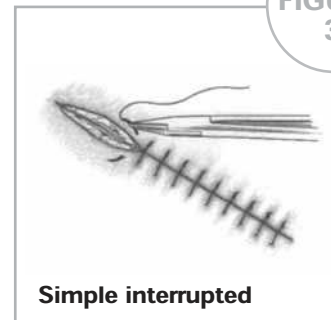
The *primary suture line* is the line of sutures that holds the wound edges in approximation during healing by first intention. It may consist of a continuous strand of material or a series of interrupted suture strands. Other types of primary sutures, such as deep sutures, buried sutures, purse-string 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.

CONTINUOUS SUTURES

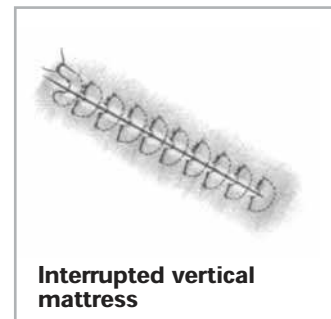
Also referred to as *running stitches*, continuous sutures are a series of stitches taken with one strand of material. The strand may be tied to itself at each end, or looped, with both cut ends of the strand tied together. A continuous suture line can be placed rapidly. It derives its strength from 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

INTERRUPTED SUTURING TECHNIQUES

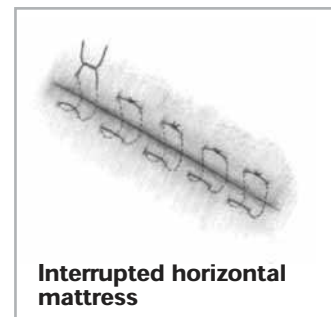
FIGURE 3



Simple interrupted



Interrupted vertical mattress



Interrupted horizontal mattress

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 1 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.

INTERRUPTED SUTURES

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.

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.

BURIED SUTURES

Buried sutures are placed so that the knot protrudes to the inside, under the layer to be closed. This tech-

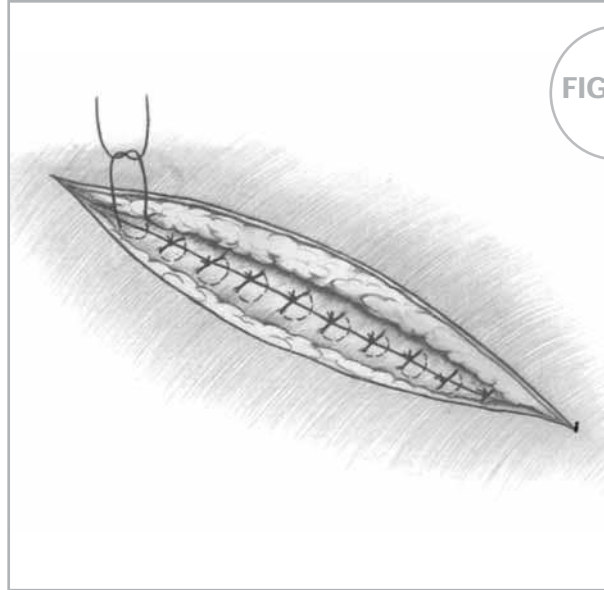


FIGURE 4

DEEP SUTURES

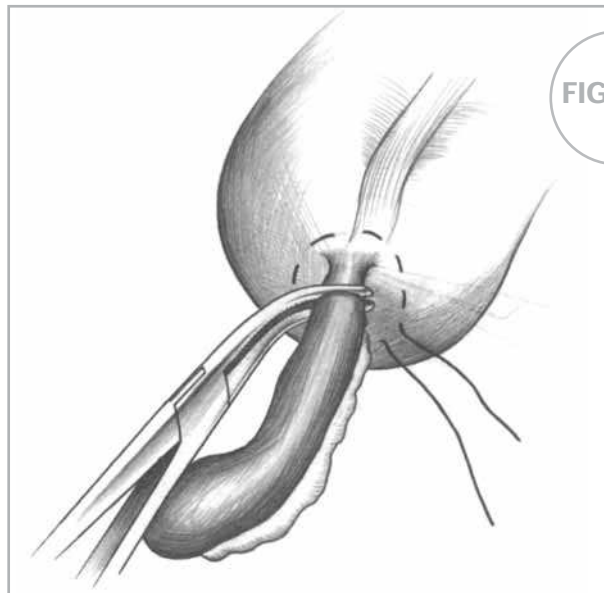


FIGURE 5

PURSE-STRING SUTURES

nique 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.

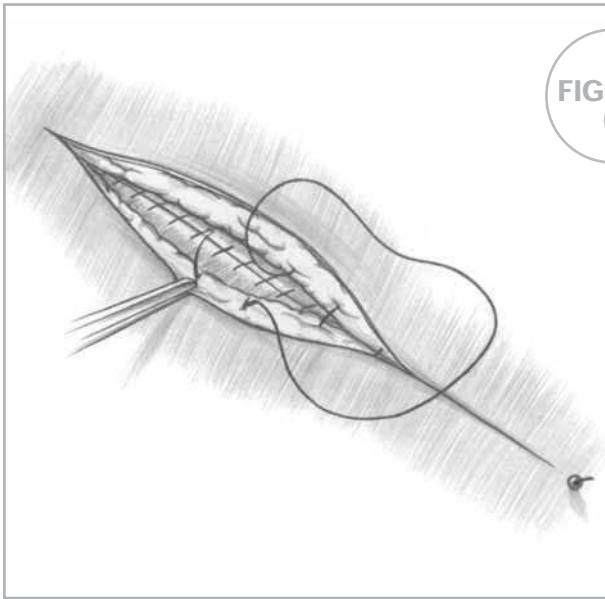
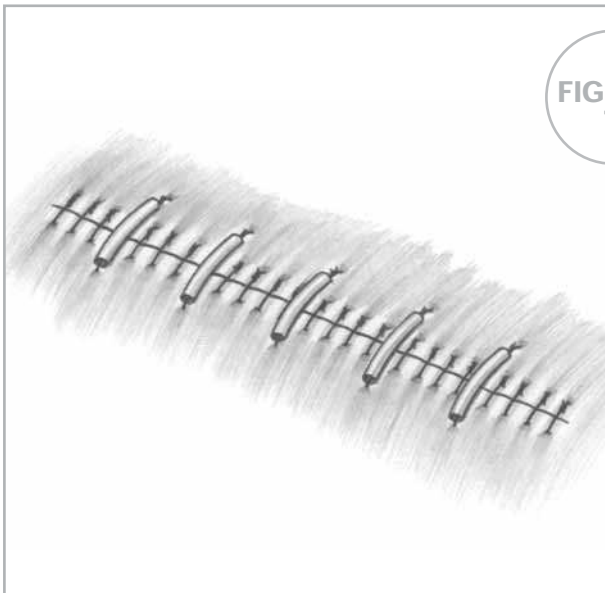
PURSE-STRING SUTURES

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).

SUBCUTICULAR SUTURES

Subcuticular sutures are continuous or interrupted sutures placed in the dermis, beneath the epithelial layer. Continuous subcuticular sutures are placed in a line parallel to the wound. This technique involves taking short, lateral stitches the full length of the wound. After the

FIGURE
6**SUBCUTANEOUS
SUTURES**FIGURE
7**RETENTION
SUTURE
BOLSTER**

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 nonabsorbable suture that is later removed by simply removing the anchoring device at one end and pulling the opposite end.

**THE SECONDARY
SUTURE LINE**

A secondary line of sutures may be used:

- 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.

- To support wounds for healing by second intention.
- For secondary closure following wound disruption when healing by third intention.

NOTE: If secondary sutures are used in cases of nonhealing, they should be placed in opposite fashion from the primary sutures (ie, interrupted if the primary sutures were continuous, continuous if the primary sutures were interrupted).

Retention sutures are placed approximately 2 inches from each edge of the wound. 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 quarters of 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 nonabsorbable 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.

STITCH PLACEMENT

Many types of stitches are used for both continuous and interrupted suturing. In every case, equal "bites" of tissue should be taken on each side of the wound. The needle should be inserted from 1 to 3 centimeters from the edge of the wound, depending upon the type and condition of the tissue being sutured.

KNOT TYING

Of the more than 1,400 different types of knots described in *THE ENCYCLOPEDIA OF KNOTS*, only a few are used in modern surgery. It is of paramount importance that each knot placed for approximation of tissues or ligation of vessels be tied with precision and each must hold with proper tension.

KNOT SECURITY

The construction of ETHICON Sutures has been carefully designed to produce the optimum combination of strength, uniformity, and hand for each material. The term *hand* is the most subtle of all suture quality aspects. It relates to the feel of the suture in the surgeon's hands, the smoothness with which it passes through tissue and ties down, the way in which knots can be set and snugged down, and most of all, to the firmness or body of the suture. *Extensibility* relates to the way in which the suture will stretch slightly during knot tying and then recover. The

stretching characteristics provide the signal that alerts the surgeon to the precise moment when the suture knot is snug.

The type of knot tied will depend upon the material used, the depth and location of the incision, and the amount of stress that will be placed upon the wound postoperatively. Multifilament sutures are generally easier to handle and tie than monofilament sutures, however, all the synthetic materials require a specific knotting technique. With multifilament sutures, the nature of the material and the braided or twisted construction provide a high coefficient of friction and the knots remain as they are laid down. In monofilament sutures, on the other hand, the coefficient of friction is relatively low, resulting in a greater tendency for the knot to loosen after it has been tied. In addition, monofilament synthetic polymeric materials possess the property of memory. *Memory* is the tendency not to lie flat, but to return to a given shape set by the material's extrusion process or the suture's packaging. The RELAY* Suture Delivery System delivers sutures with minimal package memory due to its unique package design.

Suture knots must be properly placed to be secure. Speed in knot tying frequently results in less than perfect placement of the strands. In addition to variables inherent in the suture materials, considerable variation can be found between knots tied by different surgeons and even between knots tied by the same individual on different occasions.

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

1. The completed knot must be firm, and so tied that slipping is virtually impossible. The simplest knot for the material is the most desirable.
2. The knot must be as small as possible to prevent an excessive amount of tissue reaction when absorbable sutures are used, or to minimize foreign body reaction to nonabsorbable sutures. Ends should be cut as short as possible.
3. In tying any knot, friction between strands ("sawing") must be avoided as this can weaken the integrity of the suture.

CONTINUOUS SUTURE	INTERRUPTED SUTURES
To appose skin and other tissue	
Over-and-over Subcuticular	Over-and-over Vertical mattress Horizontal mattress
To invert tissue	
Lembert Cushing Connell	Lembert Halsted Purse-string
To evert tissue	
Horizontal mattress	Horizontal mattress

TABLE
6

**COMMONLY
USED TYPES
OF STITCHES**

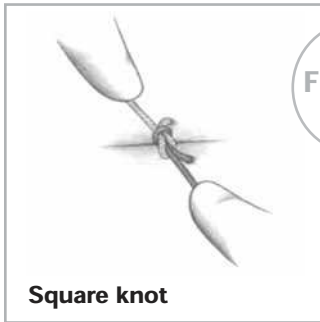
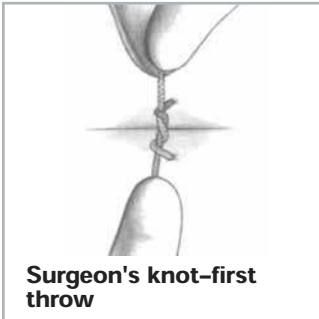
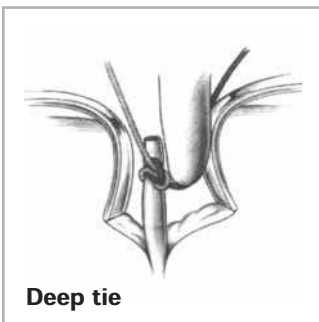
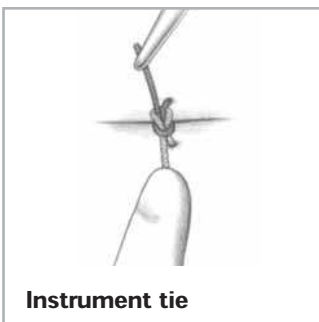


FIGURE 8

FINISHED SUTURE TIES**Square knot****Surgeon's knot—first throw****Surgeon's knot—second throw****Deep tie****Instrument tie**

4. Care should be taken to avoid damage to the suture material when handling. Avoid the crushing or crimping application of surgical instruments, such as needleholders and forceps, to the strand except when grasping the free end of the suture during an instrument tie.
5. Excessive tension applied by the surgeon will cause breaking of the suture and may cut tissue. Practice in avoiding excessive tension leads to successful use of finer gauge materials.
6. Sutures used for approximation should not be tied too tightly, because this may contribute to tissue strangulation.
7. After the first loop is tied, it is necessary to maintain traction on one end of the strand to avoid loosening of the throw if being tied under any tension.
8. Final tension on final throw should be as nearly horizontal as possible.
9. The surgeon should not hesitate to change stance or position in relation to the patient in order to place a knot securely and flat.
10. Extra ties do not add to the strength of a properly tied and squared knot. They only contribute to its bulk. With some synthetic materials, knot security requires the standard surgical technique to flat and square ties with additional throws if indicated by surgical circumstance and the experience of the surgeon.

KNOT TYING TECHNIQUES MOST OFTEN USED

An important part of good suturing technique is correct method in knot tying. A seesaw motion, or the sawing of one strand down over another until the knot is formed, may materially weaken sutures to the point that they may break when the second throw is made, or even worse, in the postoperative period when the suture is further weakened by increased tension or motion. If the 2 ends of the suture are pulled in opposite directions with uniform rate and tension, the knot may be tied more securely.

Some procedures involve tying knots with the fingers, using 1 or 2 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.

Following are the most frequently used knot tying techniques with accompanying illustrations of finished knots.

SQUARE KNOT

The 2-hand square knot is the easiest and most reliable for tying most suture materials. It may be used to tie surgical gut, virgin silk, surgical cotton, and surgical stainless steel. Standard technique of flat and square ties with additional throws if indicated by the surgical circumstance and the experience of the operator should be used to tie MONOCRYL Suture, MONOCRYL Plus Suture, VICRYL Suture, Coated VICRYL Suture, Coated VICRYL Plus Suture, Coated VICRYL *RAPIDE*

Suture, PDS II Suture, ETHILON Nylon Suture, ETHIBOND *EXCEL* Suture, PERMA-HAND Suture, PRONOVA poly (hexafluoropropylene-VDF) Suture, and PROLENE Suture.

Wherever possible, the square knot is tied using the 2-hand technique. On some occasions it will be necessary to use 1 hand, either the left or the right, to tie a square knot.

CAUTION: If the strands of a square knot are inadvertently incorrectly crossed, a granny knot will result. Granny knots are not recommended because they have a tendency to slip when subjected to increased stress.

SURGEON'S OR FRICTION KNOT

The surgeon's or friction knot is recommended for tying VICRYL Suture, Coated VICRYL Plus Suture, ETHIBOND *EXCEL* Suture, ETHILON Nylon Suture, MERSILENE Suture, NUROLON Suture, PRONOVA poly (hexafluoropropylene-VDF) Suture, and PROLENE Suture. The surgeon's knot also may be performed using a 1-hand technique.

DEEP TIE

Tying deep in a body cavity can be difficult. The square knot must be firmly snugged down as in all situations. However, the operator must avoid upward tension that may tear or avulse the tissue.

LIGATION USING A HEMOSTATIC CLAMP

Frequently it is necessary to ligate a blood vessel or tissue grasped in a hemostatic clamp to achieve hemostasis in the operative field.

INSTRUMENT TIE

The instrument tie is useful when one or both ends of the suture material are short. For best results, exercise caution when using a needleholder with any monofilament suture, as repeated bending may cause these sutures to break.

ENDOSCOPIC KNOT TYING TECHNIQUES

During an endoscopic procedure, a square knot or surgeon's knot may be tied either outside the abdomen and pushed down into the body through a trocar (extracorporeal) or directly within the abdominal cavity (intracorporeal).

In *extracorporeal knot tying*, the suture appropriately penetrates the tissue, and both needle and suture are removed from the body cavity, bringing both suture ends outside of the trocar. Then a series of half-hitches are tied, each one being pushed down into the cavity and tightened with an endoscopic knot pusher.

Intracorporeal knot tying is performed totally within the abdominal cavity. After the suture has penetrated the tissue, the needle

is cut from the suture and removed. Several loops are made with the suture around the needleholder, and the end of the suture is pulled through the loops. This technique is then repeated to form a surgeon's knot, which is tightened by the knot pusher.

In both extracorporeal and intracorporeal knot tying, the following principles of suture manipulation on tissue should be observed:

1. Handle tissue as gently as possible to avoid tissue trauma.
2. Grasp as little tissue as possible.
3. Use the smallest suture possible for the task.
4. Exercise care in approximating the knot so that the tissue being approximated is not strangulated.
5. Suture must be handled with care to avoid damage.

CUTTING THE SECURED 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 inch (6 mm) from the knot.

SUTURE LOCATION	TIME FOR SUTURE REMOVAL
Skin on the face and neck	2 to 5 days
Other skin sutures	5 to 8 days
Retention sutures	2 to 6 weeks

TABLE
7

SUTURE
REMOVAL

Other materials are cut closer to the knot, approximately $\frac{1}{8}$ inch (3 mm), 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 external wound has healed so that it no longer needs the support of nonabsorbable 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. General rules are as follows.

Sutures should be removed using aseptic and sterile technique. The surgeon uses a sterile suture removal tray prepared for the procedure. The following steps are taken:

- **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, 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.

NOTE: Fast-absorbing synthetic or gut suture material tend to lose all tensile strength in 5 to 7 days and can

be removed easily without cutting. A common practice is to cover the skin sutures with PROXI-STRIP* Skin Closures during the required healing period. After the wound edges have regained sufficient tensile strength, the sutures may be removed by simply removing the PROXI-STRIP Skin Closures.

SUTURE HANDLING TIPS

These guidelines will help the surgical team keep their suture inventory up-to-date and their sutures in the best possible condition.

1. Read labels.
2. Heed expiration dates and rotate stock.
3. Open only those sutures needed for the procedure at hand.
4. Straighten sutures with a gentle pull. Never crush or rub them.
5. Don't pull on needles.
6. Avoid crushing or crimping suture strands with surgical instruments.

7. Don't store surgical gut near heat.
8. Moisten—but never soak—surgical gut.
9. Do not wet rapidly absorbing sutures.
10. Keep silk dry.
11. Wet linen and cotton to increase their strength.
12. Don't bend stainless steel wire.
13. Draw nylon between gloved fingers to remove the packaging "memory."
14. Arm a needleholder properly.

SUTURE SELECTION PROCEDURE

PRINCIPLES OF SUTURE SELECTION

The surgeon has a choice of suture materials from which to select for use in body tissues. Adequate strength of the suture material will prevent suture breakage. Secure knots will prevent knot slippage. But the surgeon must understand the nature of the suture material,

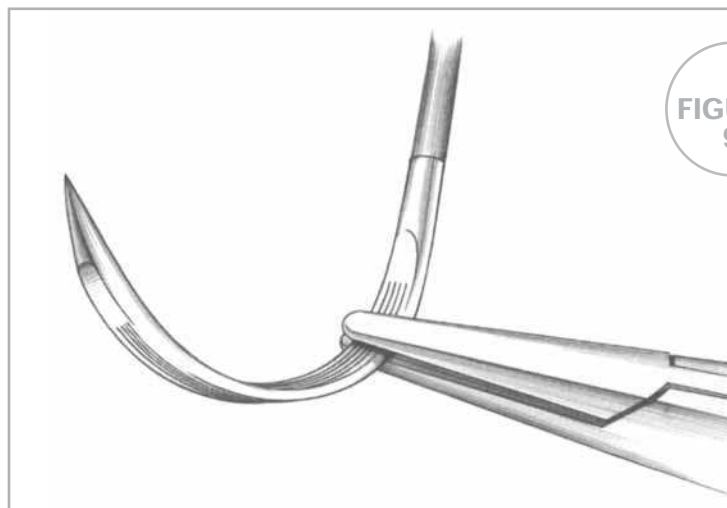


FIGURE
9

**ARMING
A NEEDLE-
HOLDER
PROPERLY**

Grasp the needle one third to one half of the distance from the swaged end to the point.

curved needles of 22 mil wire or heavier are ribbed as well as flattened. Longitudinal ribbing or grooves on the inside or outside curvatures of curved needles provides a crosslocking action in the needleholder for added needle control. This reduces undesirable rocking, twisting, and turning in the needleholder.

PRINCIPLES OF CHOOSING A SURGICAL NEEDLE

While there are no hard and fast rules governing needle selection, the following principles should be kept in mind. (*Specific types of needles mentioned here will be described in full detail later on in this section.*)

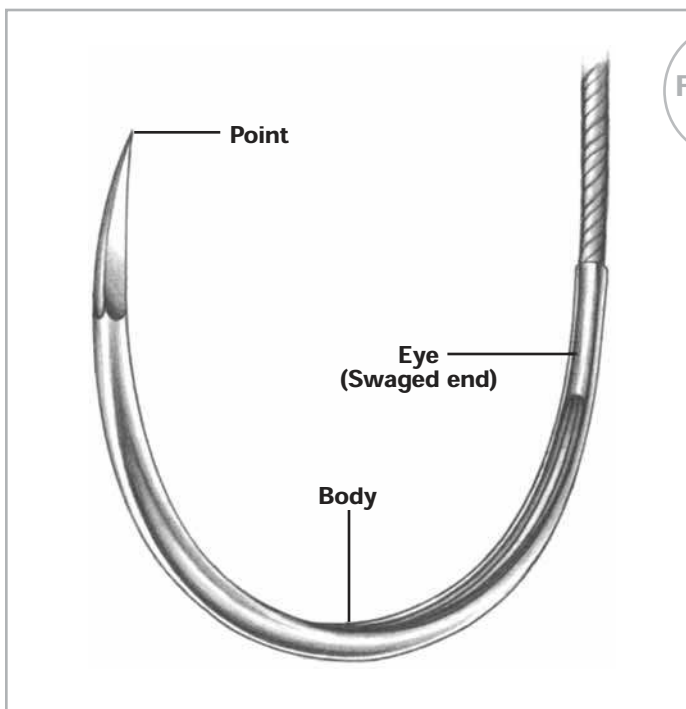


FIGURE 3

NEEDLE COMPONENTS

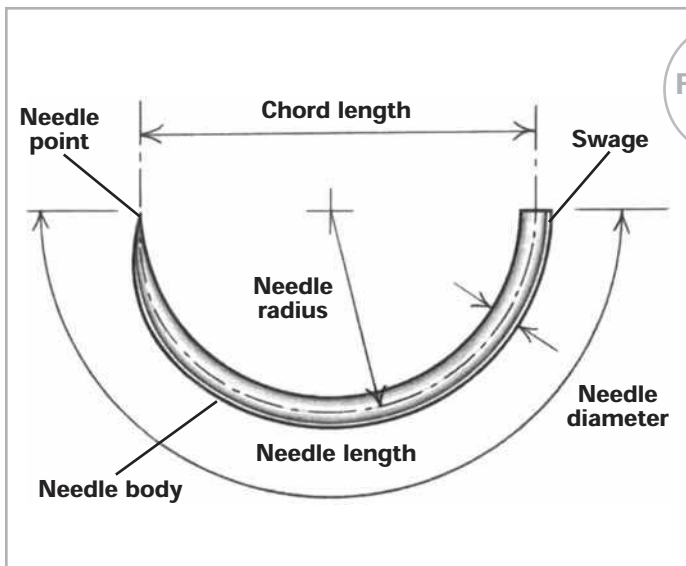


FIGURE 4

ANATOMY OF A NEEDLE

1. 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* Surgical 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.
2. Watch the surgeon's technique closely. 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.
3. Consult frequently with the surgeon. Working with the same surgeon repeatedly leads to familiarity with his or her individual routine. However, even the same surgeon may need to change needle type or size to meet specific requirements, even during a single operative procedure.
4. 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.
5. The best general rule of thumb for the scrub person to follow is pay attention and remain alert to the progress of the operation.

Observation is the best guide to needle selection if the surgeon has no preference.

THE ANATOMY OF A NEEDLE

Regardless of its intended use, every surgical needle has 3 basic components:

- ◆ The eye.
- ◆ The body.
- ◆ 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.

- ◆ **CHORD LENGTH**—The straight line distance from the point of a curved needle to the swage.
- ◆ **NEEDLE LENGTH**—The distance measured along the needle itself from point to end.
- ◆ **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.
- ◆ **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 to penetrate the sternum and to place retention sutures in the abdominal wall. A broad spectrum of sizes are available between the 2 extremes.

THE NEEDLE EYE

The eye falls into 1 of 3 categories: closed eye, French (split or spring) eye, or swaged (eyeless).

The closed eye is similar to a household sewing needle. The shape of the eye may be round, oblong, or square. French eye needles have a slit from inside the eye to the end of the needle with ridges that catch and hold the suture in place.

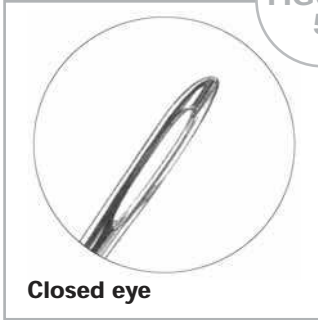
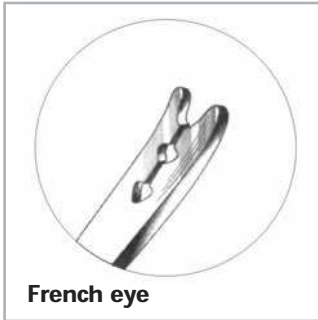
Eyed needles must be threaded, a time-consuming procedure for the scrub person. This presents the disadvantage of having to pull a double strand of suture material through tissue, creating a larger hole with additional tissue disruption. In addition, the suture may still become unthreaded while the surgeon is using it. While tying the suture to the eye may minimize this possibility, it also adds to the bulk of the suture. Another disadvantage of eyed needles is that repeated use of these needles with more than 1 suture strand causes the needle to become dull, thereby making suturing more difficult.

Virtually all needles used today are swaged. This configuration joins the needle and suture together as a continuous unit—one that is convenient to use and minimizes trauma. The method of attaching the suture to the needle varies with the needle diameter. In larger diameter needles, a hole is drilled in the needle end. In smaller diameter needles, a channel is made by forming a "U" at the swage end or a hole is drilled in the wire with a laser. Each hole or channel is specifically engineered for the type and size of suture material it will hold, and crimped or closed around the suture to hold it securely. When the surgeon has finished placing the suture line in the patient's tissue, the suture may

be cut, or easily released from the needle as is the case when using CONTROL RELEASE* Needles (Patent No. 3,980,177).

The diameter of a needle swaged to suture material is no larger than necessary to accommodate the diameter of the suture strand itself. Swaged sutures offer several advantages to the surgeon, nurse, and patient.

1. The scrub person does not have to select a needle when the surgeon requests a specific suture material since it is already attached.
2. Handling and preparation are minimized. The strand with needle attached may be used directly from the packet. This helps maintain the integrity of the suture strand.
3. Tissues are subjected to minimal trauma.
4. Tissue trauma is further reduced because a new, sharp, undamaged needle is provided with each suture strand.
5. Swaged sutures do not unthread prematurely.
6. If a needle is accidentally dropped into a body cavity, the attached suture strand makes it easier to find.
7. Inventory and time spent cleaning, sharpening, handling, and sterilizing reusable eyed needles is eliminated, thereby reducing cost as well as risk of needle punctures.
8. CONTROL RELEASE Needles allow placement of many sutures rapidly. This may reduce

THE NEEDLE EYE**FIGURE 5****Closed eye****French eye****Swaged**

operating time and, ultimately, the length of time the patient is anesthetized.

9. The ATRALOC* Surgical Needle and CONTROL RELEASE Needle ensure consistent quality and performance.
10. Swaged sutures eliminate suture fraying or damage due to sharp corners in the eye of eyed needles.
11. Needles are corrosion-free.

Small diameter ETHICON, INC., taper point needles commonly used in cardiovascular surgery were compared in laboratory tests—some with "split" channels and some with laser-drilled holes. The needles with laser-drilled holes produced less drag force as they passed through a membrane that simulated vascular tissue. This could be associated with less trauma to the vessel walls.

The swaged ATRALOC Needles made by ETHICON, INC., are supplied in a variety of sizes, shapes, and strengths. Some of them incorporate the CONTROL RELEASE Needle Suture principle that facilitates fast separation of the needle from the suture when desired by the surgeon. This feature allows rapid placement of many sutures, as in interrupted suturing techniques. Even though the suture is securely fastened to the needle, a slight, straight tug will release it.

This needle/suture configuration was created originally for abdominal closure and hysterectomies, but is now used in a wide variety of procedures.

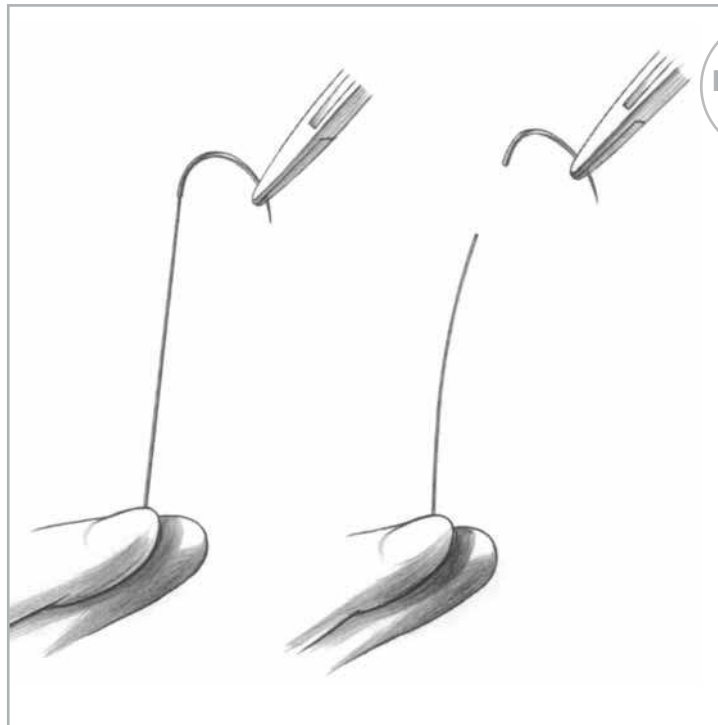
THE NEEDLE BODY

The body of the needle is the portion that is grasped by the needleholder during the surgical procedure. The body of the needle should be as close as possible to the diameter of the suture material to minimize bleeding and leakage. This is especially true for cardiovascular, gastrointestinal, and bladder procedures.

The curvature of the needle body may come in a variety of different shapes. Each shape gives the needle different characteristics.

STRAIGHT NEEDLE

This shape may be preferred when suturing easily accessible tissue. Most of these needles are designed

**FIGURE 6****CONTROL RELEASE NEEDLE SUTURE**

Holding the needle securely in the needleholder, the suture should be grasped securely and pulled straight and taut. The needle will be released with a straight tug of the needleholder.

to be used in places where direct finger-held manipulation can easily be performed.

The Keith needle is a straight cutting needle. It is used primarily for skin closure of abdominal wounds. Varying lengths are also used for arthroscopic suturing of the meniscus in the knee.

Bunnell (BN) needles are used for tendon repair. Taper point needle variations may also be used for suturing the gastrointestinal tract.

Some microsurgeons prefer straight needles for nerve and vessel repair. In ophthalmology, the straight trans-chamber needle protects endothelial cells and facilitates placement of intraocular lenses.

HALF-CURVED NEEDLE

The half-curved or "ski" needle may be used for skin closure or in laparoscopy. Its low profile allows easy passage down laparoscopic trocars. Its use in skin closure is limited because, while the curved

portion passes through tissue easily, the remaining straight portion of the body is unable to follow the curved path of the needle without bending or enlarging its path in the tissue.

CURVED NEEDLE

Curved needles allow predictable needle turnout from tissue, and are therefore used most often. This needle shape requires less space for maneuvering than a straight needle, but the curve necessitates manipulation with a needleholder. The curvature may be 1/4, 3/8, 1/2, or 5/8 circle.

The most common use for the 3/8 circle is skin closure. 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. A 5/8 circle needle may be more useful in this situation, especially in some anal, urogenital, intraoral, and cardiovascular procedures.

COMPOUND CURVED NEEDLE

The compound curved needle (Patent No. 4,524,771) was originally developed for anterior segment ophthalmic surgery. It allows the surgeon to take precise, uniform bites of tissue. The tight



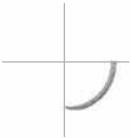

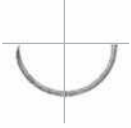

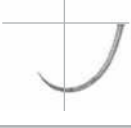
SHAPE	APPLICATION
Straight 	gastrointestinal tract, nasal cavity, nerve, oral cavity, pharynx, skin, tendon, vessels
Half-curved 	skin (rarely used) laparoscopy
1/4 Circle 	eye (primary application) microsurgery
3/8 Circle 	aponeurosis, biliary tract, cardiovascular system, dura, eye, gastrointestinal 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, tendon, subcutaneous fat, urogenital tract
5/8 Circle 	anal (hemorrhoidectomy), nasal cavity, pelvis, urogenital tract (primary application)
Compound Curved 	eye (anterior segment) laparoscopy

FIGURE 7

NEEDLE SHAPES AND TYPICAL APPLICATIONS

80° curvature of the tip follows into a 45° curvature throughout the remainder of the body. The initial curve allows reproducible, short, deep bites into the tissue. The curvature of the remaining portion of the body forces the needle out of the tissue, everting the wound edges and permitting a view into the wound. This ensures equidistance of the suture material on both sides of the incision. Equalized pressure on both sides of the corneal-scleral junction minimizes the possibility of astigmatism following anterior segment surgery.

THE NEEDLE POINT

The point extends from the extreme tip of the needle to the maximum cross-section of the body. Each needle point is designed and produced to the required degree of sharpness to smoothly penetrate specific types of tissue.

TYPES OF NEEDLES

CUTTING NEEDLES

Cutting needles have at least 2 opposing cutting edges. They are sharpened to cut through tough, difficult-to-penetrate tissue.

Cutting needles are ideal for skin sutures that must pass through dense, irregular, and relatively thick connective dermal tissue.

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.

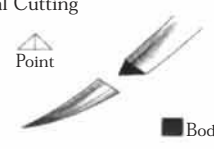







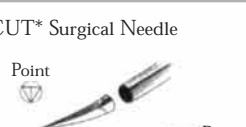

SHAPE	APPLICATION
Conventional Cutting 	skin, sternum
Reverse Cutting 	fascia, ligament, nasal cavity, oral mucosa, pharynx, skin, tendon sheath
Precision Point Cutting 	skin (plastic or cosmetic)
PC PRIME* Needle 	skin (plastic or cosmetic)
MICRO-POINT* Reverse Cutting Needle 	eye
Side-Cutting Spatula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

FIGURE 8

NEEDLE POINTS AND BODY SHAPES AND TYPICAL APPLICATIONS

CONVENTIONAL CUTTING NEEDLES

In addition to the 2 cutting edges, conventional cutting needles have a third cutting edge on the inside concave curvature of the needle. The shape changes from a triangular cutting blade to that of a flattened body on both straight and curved needles. This needle type may be prone to cutout of tissue because the inside cutting edge cuts toward the edges of the incision or wound.

The PC PRIME* Needle (Precision Cosmetic, Patent No. 5,030,228) is designed specifically for aesthetic plastic surgery, and has conventional cutting edges. Where cosmetic results are important, the PC PRIME needle is superior to any other for more delicate surgery, especially facial surgery. The narrow point, fine wire diameter, and fine taper ratio allow superior penetration of soft tissue. The inside and outside curvatures of the body are flattened in the needle grasping area for greater stability in the needleholder. Fattened sides reduce bending that might occur due to the fine wire diameter.

The tip configuration of the conventional cutting sternotomy needle is slightly altered to resist bending as it penetrates the sternum. The alloy used for this needle provides the increased strength and ductility needed for its function. The cutting edges of the point extend approximately $\frac{1}{4}$ inch (6 mm) from the round body and terminate in a triangular-shaped tip. This particular sternotomy needle maximizes cutting efficiency and control in the needleholder. TAPERCUT Needles may also be used for this procedure.

REVERSE CUTTING NEEDLES

These needles were created specifically for tough, difficult-to-penetrate tissue such as skin, tendon sheath, or oral mucosa. Reverse cutting needles are used in ophthalmic and cosmetic surgery where minimal trauma, early regeneration of tissue, and little scar formation are primary concerns. The reverse cutting needle is as sharp as the conventional cutting needle, but its design is distinctively different. The third cutting edge is located on the *outer* convex curvature of the needle. This offers several advantages:

- ◆ Reverse cutting needles have more strength than similar-sized conventional cutting needles.
- ◆ The danger of tissue cutout is greatly reduced.
- ◆ The hole left by the needle leaves a wide wall of tissue against which the suture is to be tied.

The MICRO-POINT* Surgical Needle for ophthalmic procedures has a smooth surface and is honed to extreme sharpness. This allows the surgeon to suture the extremely tough tissues of the eye with optimum precision and ease.

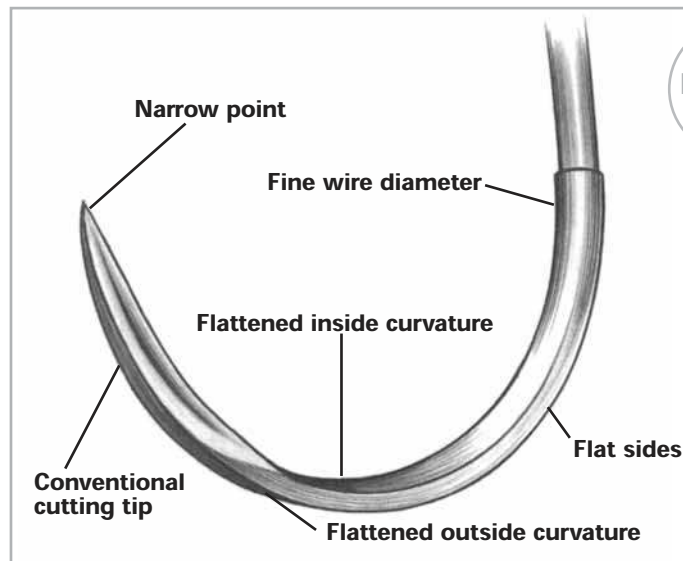


FIGURE 9

THE PC PRIME NEEDLE

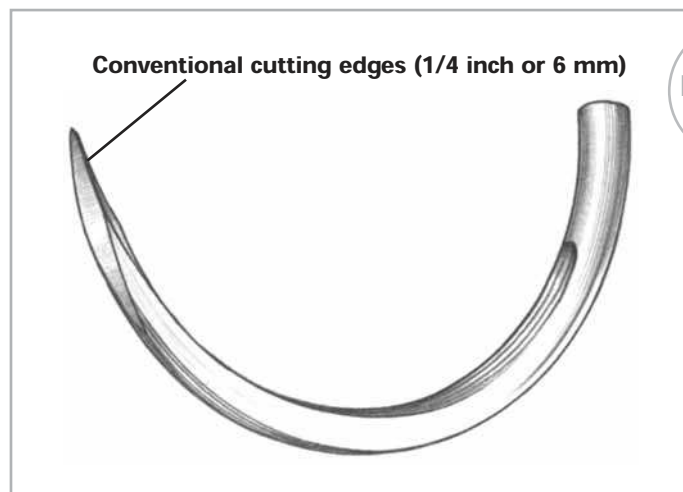


FIGURE 10

STERNOTOMY NEEDLE

A needle manufactured by the exclusive ETHICON Precision Point Process may be used for plastic or cosmetic surgery, and passes smoothly through tissue creating a minute needle path.

This results in superior apposition. The bottom third cutting edge on the Precision Point needle flattens out as it transitions to the needle body for greater security in the needleholder.

The OS (Orthopedic Surgery) needles are curved, heavy bodied, reverse-cutting needles. The orthopedic surgeon may use the OS needle for extremely tough tissue, such as cartilage, where force is required for penetration.

SIDE CUTTING NEEDLES

Also referred to as spatula needles, they feature a unique design that is flat on both the top and bottom, eliminating the undesirable tissue cutout of other cutting needles. The side-cutting edges are designed for ophthalmic procedures. They permit the needle to separate or split through the thin layers of scleral or corneal tissue and travel within the plane between them. The optimal width, shape, and precision sharpness of this needle ensure maximum ease of penetration, and gives the surgeon greater control of the needle as it passes between or through tissue layers. The position of the point varies with the design of each specific type of spatulated needle.

The SABRELOC* Spatula Needle has 2 cutting edges and a trapezoidal-shaped body.

The SABRELOC Needle with

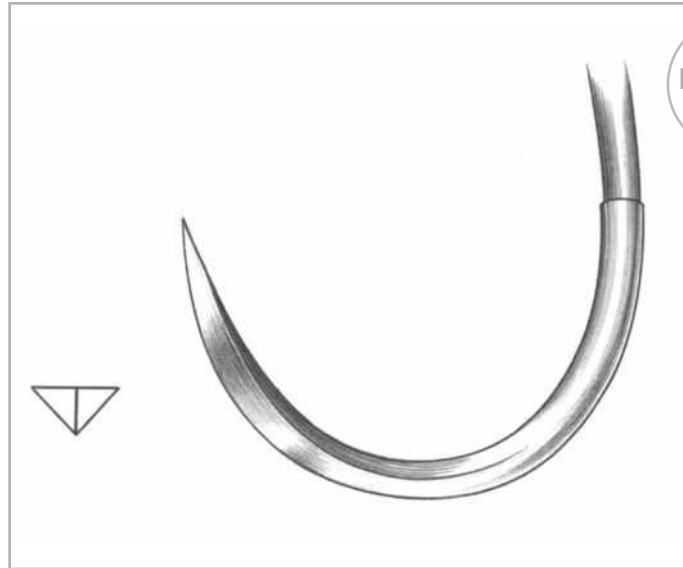


FIGURE 11

REVERSE CUTTING NEEDLE

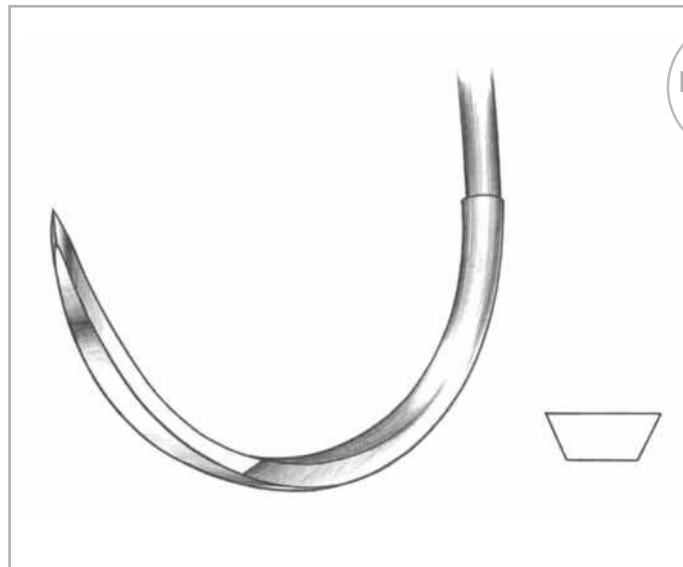


FIGURE 12

SPATULA NEEDLE CROSS-SECTION

the cobra-shaped tip has 4 equidistant defined edges.

The CS ULTIMA* Ophthalmic Needle (Corneal-Scleral, Patent No. 5,002,564) is the sharpest needle in its category and is used for corneal scleral closure. The smaller angles and increased cutting-edge length result in superior sharpness facilitating easy tissue penetration.

The TG PLUS* Needle (Transverse Ground) has a long, ultra-sharp, slim tip. This needle undergoes a unique honing process that results

in a sharper needle. The surgeon encounters low penetration resistance with the TG PLUS Needle, and gets excellent tactile feedback.

TAPER POINT NEEDLES

Also referred to as *round needles*, taper point needles pierce and spread tissue without cutting it. The needle point tapers to a sharp tip. The needle body then flattens to an oval or rectangular shape. This increases the width of the body to help prevent twisting or turning in the needleholder.

Taper point needles are usually used in easily penetrated tissue such as the peritoneum, abdominal viscera, myocardium, dura, and subcutaneous layers. They are preferred when the smallest possible hole in the tissue and minimum tissue cutting are desired. They are also used in internal anastomoses to prevent leakage that can subsequently lead to contamination of the abdominal cavity. In the fascia, taper point needles minimize the potential for tearing the thin connective tissue lying between parallel and interlacing bands of denser, connective tissue.

The Mayo (MO) needle has a taper point, but a heavier and more flattened body than conventional taper needles. This needle was designed for use in dense tissue;

particularly for gynecological procedures, general closure, and hernia repair.

TAPERCUT SURGICAL NEEDLES

ETHICON, INC., manufactures TAPERCUT Needles, which combine the features of the reverse cutting-edge tip and taper point needles. Three cutting edges extend approximately 1/32" back from the point. These blend into a round taper body. All three edges are sharpened to provide uniform cutting action. The point, sometimes referred to as a trocar point, readily penetrates dense, tough tissue. The objective should be for the point itself not to exceed the diameter of the suture material. The taper body portion provides smooth passage through tissue and

eliminates the danger of cutting into the surrounding issue.

Although initially designed for use in cardiovascular surgery on sclerotic or calcified tissue, the TAPERCUT Needle is 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.

ETHICON developed a modified TAPERCUT CC Needle (Calcified Coronary) for anastomosis of small fibrotic and calcified blood vessels. The calcified portion of an artery requires a cutting tip only for initial penetration to avoid tearing the vessel. This needle configuration has a slimmer geometry than other TAPERCUT Needles from the body through the point which facilitates

CODE	MEANING
BB	Blue Baby
BIF	Intraocular Fixation
BN	Bunnell
BP	Blunt Point
BV	Blood Vessel
BVH	Blood Vessel Half
C	Cardiovascular
CC	Calcified Coronary
CCS	Conventional Cutting Sternotomy
CE	Cutting Edge
CFS	Conventional for Skin
CIF	Cutting Intraocular Fixation
CP	Cutting Point
CPS	Conventional Plastic Surgery
CPX	Cutting Point Extra Large
CS	Corneal-Scleral
CSB	Corneal-Scleral Bi-Curve
CSC	Corneal-Scleral Compound Curve
CT	Circle Taper
CTB	Circle Taper Blunt
CTX	Circle Taper Extra Large
CTXB	Circle Taper Extra Large Blunt
CV	Cardiovascular
DC	Dura Closure
DP	Double Point
EN	Endoscopic Needle
EST	Eyed Straight Taper
FN	For Tonsil
FS	For Skin
FSL	For Skin Large

CODE	MEANING
FSLX	For Skin Extra Large
G	Greishaber
GS	Greishaber Spatula
J	Conjunctive
KS	Keith Straight
LH	Large Half
LR	Larger Retention
LS	Large Sternotomy
M	Muscle
MF	Modified Ferguson
MH	Medium Half (circle)
MO	Mayo
MOB	Mayo Blunt
OPS	Ocular Plastic Surgery
OS	Orthopedic Surgery
P	Plastic
PC	Precision Cosmetic
PS	Plastic Surgery
RB	Renal (artery) Bypass
RD	Retinal Detachment
RH	Round Half (circle)
RV	Retinal-Vitreous
S	Spatula
SC	Straight Cutting
SFS	Spatulated for Skin
SH	Small Half (circle)
SIF	Ski Intraocular Fixation
SKS	Sternotomy Keith Straight
SM	Spatulated Module
ST	Straight Taper

CODE	MEANING
STB	Straight Blunt
STC	Straight Cutting
STP	Straight Taper Point
TE	Three-Eighths
TF	Tetralogy of Fallot
TG	Transverse Ground
TGW	Transverse Ground Wide
TN	Trocar Needle
TP	Taper Pericostal/Point
TPB	Taper Pericostal/Point Blunt
TS	Tendon Straight
TQ	Twisty Q
UCL	5/8 Circle Colateral Ligament
UR	Urology
URB	Urology Blunt
V	TAPERCUT Surgical Needle
VAS	Vas Deferens
X or P	Exodontal (dental)
XLH	Extra Large Half (circle)
XXLH	Extra Extra Large Half (circle)

TABLE 1

ETHICON NEEDLE CODES & OTHER MEANINGS

penetration. It also minimizes the risk of leakage from friable vessels or vascular graft material.

BLUNT POINT NEEDLES

Blunt point (BP) 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 gynecological procedures when working in deep cavities that are prone to space and visibility limitations. In addition, blunt point needles for general closure are especially helpful when performing procedures on at-risk patients.

The ETHIGUARD* Blunt Point Needle combines the safety of the blunt point with the security of a ribbed and flattened design, and the convenience of a swaged needle.

NEEDLEHOLDERS

The surgeon uses the needleholder to pass a curved needle through tissue. It must be made of noncorrosive, high strength, good quality steel alloy with jaws designed for holding the surgical needle securely.

Needleholder jaws may be short or flat, concave or convex, smooth or serrated. Smooth jaws may allow the needle to wobble or twist. Jaws with teeth hold most securely but may damage the suture or needle if too much pressure is applied. Most, but not all, needleholders have a ratchet lock near to thumb and finger rings.

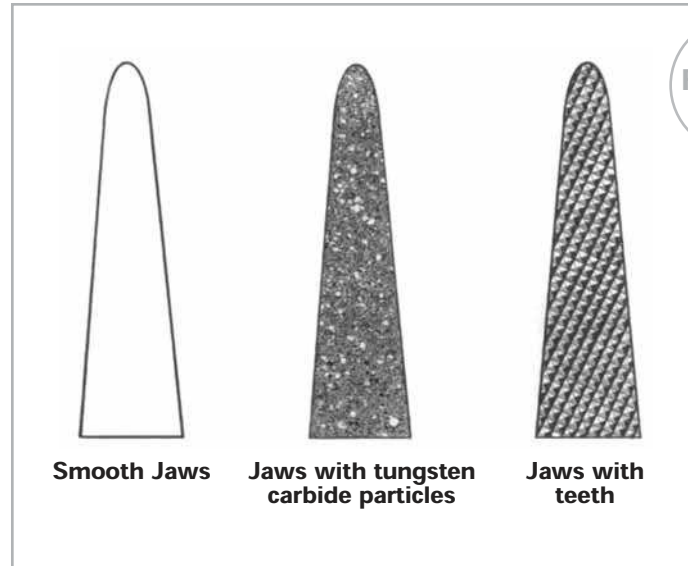


FIGURE 13

Surgical needles are designed for optimum needleholder stability. Because this tool actually drives the needle, its performance will have an impact upon the entire suturing procedure. The surgeon has maximum control only when the needle sits well in the holder without wobbling as it is passed through tissue. Needleholders, like pliers, weaken with repeated use. Therefore, the scrub person should check before each procedure to make sure that the needleholder jaws align properly and grasp securely.

When selecting a needleholder, the following should be taken into consideration:

- ◆ It must be the appropriate size for the needle selected. A very small needle should be held with small, fine jaws. The larger and heavier the needle, the wider and heavier the jaws of the needleholder should be.
- ◆ It should be an appropriate size for the procedure. If the surgeon is working deep inside the body cavity, a longer needleholder is in order.

NEEDLEHOLDER USE

The following guidelines are offered to the scrub person for needleholder use:

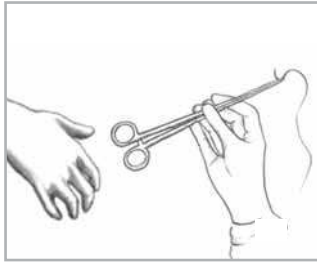
1. Grasp the needle with the tip of the needleholder jaws in an area approximately one third to one half of the distance from the swaged end to the point. Avoid placing the holder on or near the swaged area which is the weakest part of the needle.
2. Do not grasp the needle too tightly as the jaws of the needleholder may deform, damage, or bend it irreversibly.
3. Always check alignment of the needleholder jaw to make certain the needle does not rock, twist, or turn.
4. Handle the needle and needleholder as a unit.
5. Pass the needleholder to the surgeon so that he or she will not have to readjust it before placing the suture in tissue. Make sure the needle is pointing in the direction in which it will be used and that the suture strand is not entangled.

6. Always provide a needleholder—never a hemostat—to pull the needle out through tissue. A hemostat or other clamp can damage the needle.
7. Immediately after use, every needle should be returned to the scrub person while clamped in a needleholder. Needles are less likely to be lost if they are passed one-for-one (one returned for each one received).

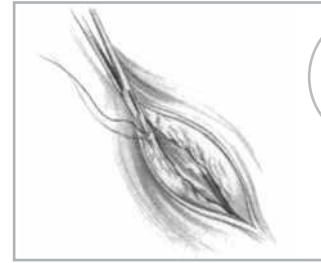
PLACING THE NEEDLE IN TISSUE

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

1. Apply force in the tissue to be sutured in the same direction as the curve of the needle.
2. Do not take excessively large bites of tissue with a small needle.
3. Do not force a dull needle through tissue. Take a new needle.
4. 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.
5. Avoid using the needle to bridge or approximate tissues for suturing.
6. Do not damage taper points or cutting edges when using the needleholder to pull the needle through tissue. Grasp as far back on the body as possible.
7. Depending upon the patient, the tissue may be tougher or more fibrous than anticipated and



1. The surgeon receives the needleholder with the needle point toward the thumb to prevent unnecessary wrist motion. The scrub person controls the free end of the suture to prevent dragging it across the sterile field, and to keep the suture from entering the surgeon's hand along with the needleholder.



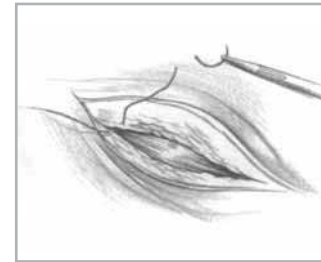
2. The surgeon begins closure with the swaged suture.

FIGURE 14

PLACEMENT OF THE NEEDLE IN TISSUE



3. The needle is passed into the tissue. The surgeon releases the needle from the holder and re-clamps the holder onto the body of the needle near the point end to pull the needle and strand through tissue. The needle is released or cut from the suture strand. The surgeon leaves the needle clamped in the same position and returns it to the scrub person. The scrub person immediately passes another prepared suture to the surgeon, one-for-one.



require the use of a heavier gauge needle. Conversely, a smaller needle may be required when tissue is more friable than usual.

8. 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 and a second needleholder should be used to locate a needle in a confined body cavity.
9. 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. Appropriate serological testing of the patient

should be undertaken for transmissible agents such as hepatitis B and C and HIV.

NEEDLE HANDLING TIPS

Needles should be protected from bacterial contamination and damage during handling by adhering to the following guidelines:

1. Open needle packets and prepare sutures carefully, protecting needle sharpness.
2. Make sure the needle is free of corrosion.
3. If using eyed needles, make sure they do not have rough or sharp edges inside the eye to fray or break suture strands. Also check

- the eyes for burrs or bluntness to ensure easy penetration and passage through tissue.
4. If a needle is defective, discard it.
 5. Pass needles on an exchange basis; one is passed to the surgeon for one returned.
 6. Employ the nontransfer technique to avoid inadvertent needlesticks: the surgeon places the needle and needleholder down in a neutral area of the sterile field; the scrub person then picks up the needleholder.
 7. Secure each needle as soon as it is used. Do not allow needles to lie loose on the sterile field or Mayo stand. Keep them away from sponges and tapes so they will not inadvertently be dragged into the wound.
 8. If a needle breaks, all pieces must be accounted for.
 9. Count all needles before and after use according to hospital procedure. Retain the packets containing descriptive information on quantity and needle type for swaged needles to help determine if all are accounted for.
3. Return eyed needles to the needle rack. If eyed needles are to be reused, they must be cleaned and reprocessed at the end of the operation.
 4. Do not collect used needles in a medicine cup or other container since they must then be handled individually to count them. This can potentially contaminate gloves and increase the risk of an accidental puncture.
 5. Discard used needles in a "sharps" container.

Follow these steps for safe needle handling:

1. Use sterile adhesive pads with or without magnets or disposable magnetic pads to facilitate counting and safe disposal.
2. Swaged needles can be inserted through or into their original packet after use. An empty packet indicates a missing needle. If using an E-PACK procedure kit, compare the count of needles used to the number preprinted on the kit label.

IN THE NEXT SECTION

In the section that follows, the dual role that suture and needle packaging plays will be covered. Packaging does much more than keep the needle and suture sterile. Package design can help or seriously hinder the efficiency of the surgical procedure.

Low tension wounds (those where the skin edges lie close together without significant tension) can be closed by gluing the skin edges together with a skin adhesive. Butylcyanoacrylate adhesives have been available in Europe, Israel, and Canada for decades.¹ They have been used successfully for the closure of traumatic lacerations and surgical incisions. Application of butylcyanoacrylate was found to be more rapid and cost effective than suturing, but only recently has it been evaluated in well-designed clinical trials for wound closure.¹ The most significant advance in the field of topical skin adhesives has been the development of 2-octyl cyanoacrylate, marketed as DERMABOND* Topical Skin Adhesive by ETHICON Products. This topical skin adhesive forms a transparent and flexible bond, unlike the opaque and brittle bond formed by butylcyanoacrylate adhesives. The flexibility of octyl cyanoacrylate allows it to be applied over nonuniform surfaces. This flexibility also combats the topical shear forces exerted on the adhesive, reducing the risk of premature sloughing and wound dehiscence. Additionally, octyl cyanoacrylate adhesive has been found to have twice the breaking strength of butylcyanoacrylate, and it can be used on longer incisions and lacerations.¹

DERMABOND*
TOPICAL SKIN ADHESIVE
(2-OCTYL CYANOACRYLATE)

is a sterile, liquid topical adhesive designed to hold closed, easily approximated skin edges of lacerations and surgical incisions.

It utilizes the moisture on the skin's surface to form a strong, flexible bond and can be used in many instances where sutures, staples or skin strips have been traditionally used. DERMABOND Adhesive is ideally suited for wounds on the face, torso and limbs. It can be used in conjunction with, but not in place of, deep dermal sutures.

Approved by the FDA in 1998, DERMABOND Adhesive has been used extensively by health professionals in the fields of trauma and other surgeries, emergency medicine, and pediatrics. Since its approval, DERMABOND Adhesive has been proven effective in closing a variety of surgical incisions and wounds. Unlike sutures, the adhesive does not produce suture or "track" marks along the healed incision and a patient can shower right away without fear of compromising the incision.

HIGH VISCOSITY
DERMABOND*
TOPICAL SKIN ADHESIVE
(2-OCTYL CYANOACRYLATE)

High Viscosity DERMABOND Adhesive is 6 times thicker² for better control, especially where runoff is most likely to occur, such as around the eyes and nose.

High Viscosity Dome, ProPen, and DERMABOND ProPen XL Adhesive applicators allow for fine-line delivery of adhesive²—ideal for delicate skin closures on the face and near the eyes.

DERMABOND ProPen Adhesive and DERMABOND ProPen XL Adhesive deliver the high viscosity formulation with greater ease of use. DERMABOND ProPen XL Adhesive delivers twice as much

adhesive for use on longer incisions and lacerations.

STRENGTH AND SECURITY

In less than three minutes, DERMABOND Adhesive provides the strength of healed tissue at 7 days.² A strong, flexible 3-dimensional bond makes it suitable for use in closing easily approximated wounds of many types (example—deep, short, long).³

SEALS OUT BACTERIA

DERMABOND Adhesive *is approved to protect wounds and incisions from common microbes that can lead to infection.* For trauma and postsurgical patients, infections are often the most common, and in some cases, the most serious complications. DERMABOND Adhesive helps protect against the penetration of bacteria commonly associated with surgical site infections.² *In vitro* studies demonstrated that DERMABOND acts as a barrier against *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Enterococcus faecium* as long as the adhesive film remains intact.²

PROMOTES A MOIST, WOUND HEALING ENVIRONMENT

DERMABOND Adhesive creates a protective seal and provides the benefits of an occlusive dressing that helps the wound stay moist.² Maintaining a moist wound healing environment around the wound has been shown to speed the rate of epithelialization.⁴ As the wound heals, DERMABOND Adhesive will gradually slough off (generally between 5 to 10 days).²

PROVIDES EXCELLENT COSMETIC RESULTS

In a prospective, randomized, controlled, unmasked study of 818 patients, DERMABOND* Topical Skin Adhesive provided cosmesis equivalent to that of sutures. At 3 months, it produced optimal cosmesis in 80% of patients, using the Modified Hollander Cosmesis Scale.²

ADDITIONAL PHYSICIAN AND PATIENT BENEFITS

In most cases, DERMABOND Adhesive allows for significantly faster closure than sutures.^{3,5,6} DERMABOND Adhesive application requires fewer surgical supplies, reduced equipment needs, and eliminates the need for suture removal.^{6,7}

DERMABOND Adhesive is also more convenient and comfortable for the patient because it often does not require anesthetic, is gentler to the skin than sutures or staples, and does not require suture removal. DERMABOND Adhesive also reduces the risk of needlestick injury.

INDICATIONS AND CONTRAINDICATIONS

DERMABOND Adhesive is intended for topical application only to hold closed easily approximated skin edges of wounds from surgical incisions, including punctures from minimally invasive surgery, and simple, thoroughly cleansed, trauma-induced lacerations. DERMABOND Adhesive may be used in conjunction with, but not in place of, deep dermal sutures. Topical skin adhesives are not appropriate for closing wounds that are subject to significant static or

dynamic tensions unless deep sutures, immobilization, or both are also used.

DERMABOND Adhesive is contraindicated for use on any wounds with evidence of active infection or gangrene. It should also not be used on mucosal surfaces or across mucocutaneous junctions (eg, lips, oral cavity), or on skin that is regularly exposed to body fluids or with dense hair (eg, scalp). DERMABOND Adhesive should not be used on patients with a known hypersensitivity to cyanoacrylate or formaldehyde.

APPLICATION

Mastery of tissue adhesive use is generally quite rapid. Proper wound selection, evaluation and preparation before closure is important. Wounds must be thoroughly cleansed and debrided in accordance with standard practice before using adhesives. The wound edges must be tightly apposed so that the adhesive is not placed into the wound. Patient positioning is also important to reduce runoff of tissue adhesive. The patient should be positioned so that the wound surface is parallel to the floor, taking special care that any runoff does not flow in the direction of vital structures such as the eye.

TECHNIQUE

1. Follow standard surgical practice for wound preparation and achieve hemostasis.
2. Approximate skin edges and use deep sutures to relieve tension if necessary.
3. Crack the DERMABOND Adhesive vial in the upright

position, invert, and apply pressure to saturate the tip. Release pressure, then reapply pressure to express adhesive. When using the DERMABOND ProPen Adhesive applicator, simply twist the collar to crack the vial and lightly press the button to saturate the tip and express the adhesive.

DIRECTIONS FOR USE

1. The application of high viscosity DERMABOND Adhesive requires thorough wound cleansing. Follow standard surgical practice for wound preparation before application of high viscosity DERMABOND Adhesive (ie, anesthetize, irrigate, debride, obtain hemostasis, and close deep layers).
2. Pat the wound dry with dry, sterile gauze to assure direct tissue contact for adherence of the high viscosity DERMABOND Adhesive to the skin. Moisture accelerates polymerization of high viscosity DERMABOND Adhesive and may affect wound closure results.
3. To prevent inadvertent flow of liquid high viscosity DERMABOND Adhesive to unintended areas of the body, the wound should be held in a horizontal position and the high viscosity DERMABOND Adhesive should be applied from above the wound.
4. High viscosity DERMABOND Adhesive should be used immediately after crushing the glass ampule, since the liquid high viscosity DERMABOND Adhesive will flow freely from the tip for only a few minutes. Remove the applicator from the blister pouch. Hold the applicator with the thumb and finger and away from the patient to prevent any unintentional placement of the liquid high viscosity DERMABOND Adhesive into the wound or on the patient. While holding the applicator, and with the applicator tip pointed upward, apply pressure at the midpoint of the ampule to crush the inner glass ampule. Invert and gently squeeze the applicator just sufficiently to express the liquid high viscosity DERMABOND Adhesive to moisten the applicator.

PATIENT CARE FOR A WOUND AFTER IT'S TREATED WITH DERMABOND TOPICAL SKIN ADHESIVE

TABLE
1

DERMABOND Adhesive (2-octyl cyanoacrylate) is a sterile, liquid skin adhesive that holds wound edges together. The film will usually remain in place for 5 to 10 days, then naturally falls off the patient's skin.

The following will answer some questions and provide instructions for proper care for your patient's wounds while they are healing.

CHECK WOUND APPEARANCE

- Some swelling, redness, and pain are common with all wounds and normally will go away as the wound heals. If swelling, redness, or pain increases or if the wound feels warm to the touch, instruct patients to contact a doctor. They should also contact a doctor if the wound edges reopen or separate.

REPLACE BANDAGES

- If the wound is bandaged, keep the bandage dry.
- Replace dressing daily until the adhesive film has fallen off or if the bandage should become wet, unless otherwise instructed by the physician.
- When changing the dressing, do not place tape directly over the DERMABOND Adhesive film, because removing the tape later may also remove the film.

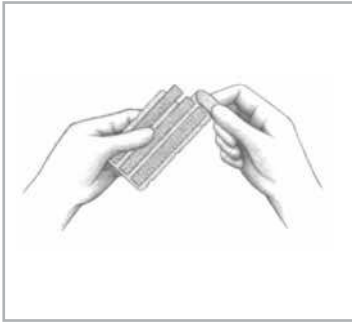
AVOID TOPICAL MEDICATIONS

- Do not apply liquid or ointment medications or any other product to the wound while the DERMABOND Adhesive film is in place. These may loosen the film before the wound is healed.

KEEP WOUND DRY AND PROTECTED

- Apply a clean, dry bandage over the wound if necessary to protect it.
- Patients may occasionally and briefly wet the wound in the shower or bath. Do not soak or scrub the wound, do not swim, and avoid periods of heavy perspiration until the DERMABOND Adhesive has naturally fallen off. After showering or bathing, gently blot the wound dry with a soft towel. If a protective dressing is being used, a fresh, dry bandage should be applied, keeping tape off the DERMABOND Adhesive film.





1. Using sterile technique, remove card from sleeve and tear off tab.



2. Peel off tapes as needed in diagonal direction.



3. Apply tapes at $1/8$ -inch intervals as needed to complete wound apposition. Make sure the skin surface is dry before applying each tape.



4. When healing is judged to be adequate, remove each tape by peeling off each half from the outside toward the wound margin. Then, gently lift the tape away from the wound surface.

FIGURE 1

SKIN CLOSURE TAPES

SKIN CLOSURE TAPES

PROXI-STRIP* Skin Closures are long, narrow, sterile strips of tape with an adhesive backing. They are used for approximating the edges of lacerations and for closing skin following many operative procedures.

PROXI-STRIP Skin Closures have a high degree of porosity to allow the wound to breathe, but have sufficient adhesive strength to negate the use of adjunct applications, such as tincture of benzoin. Their antistatic properties minimize the tendency of the tape strips to curl up.

POLYESTER FIBER STRIP

MERSILENE* Polyester Fiber Strip is comprised of a double thickness of **MERSILENE*** Polyester Fiber Mesh that is 5 mm wide. The strips

are available with and without needles and may be used instead of large-sized suture for ligation, repair, and/or support in selected operative procedures.

Incompetence of the cervix is a condition characterized by the habitual premature, spontaneous abortion of the fetus. A ligature is placed around the cervix in a collar-like fashion, drawn tight, and either sutured together or tied closed. A **MERSILENE** Strip is then woven carefully with a swage blunt needle in and out of the mucosa. When placed properly, the flatness of the ligature will not cut or damage the wall of the cervix.

MERSILENE Strip attached to a heavy reverse cutting needle provides a wide band of strong

material for orthopedic procedures such as rotator cuff repair and support. The blunt needles used for the incompetent cervix ligation may also be used for this purpose.

UMBILICAL TAPE

Umbilical tape is a white woven cotton ligature, $1/8$ or $1/4$ inch (0.32 or 0.64 cm) wide that is strong enough to tie off the umbilical cord of the newborn infant. While this was its original use, umbilical tape is also used in pediatric and cardiovascular procedures to suspend small structures and vessels during the operation, but is not left in place.

Umbilical tape easily absorbs blood when used in an area of gross bleeding. The $1/8$ -inch (0.32 cm) tape is available with a radiopaque thread woven into the length of the fabric to facilitate x-ray identification.

SURGICAL STAPLES

The staple closure is mainly used for large wounds that are not on the face. Stapling is especially useful for closing scalp wounds. Staples are also used for linear lacerations of the torso and extremities, especially if they are relatively long.

Many surgeons routinely use skin staples for closure of standard abdominal, thorax and extremity incisions. Advantages of stapling include ease of use, rapidity, cost effectiveness, and minimal damage to host defenses.¹

A variety of stapling devices is available for wound closure. With all devices, the staple creates an incomplete rectangle: the legs of the staple extend into the skin, and the cross-limb lies on the skin surface across the wound. Each device may differ in its handling characteristics, visual access, the angle at which the staples enter tissues, the ease of position and the pre-cocking mechanism. Optimal visibility as the staple is placed in the skin is important, as is the angle at which the staple enters the skin because insertion of the staple perpendicular to the surface of the skin results in deep penetration that increases the likelihood of tissue strangulation and permanent cross-hatching of the wound. The ability of the staple end to swivel allows the head to be adjusted for use in deep recesses. Finally, the presence of a pre-cocking mechanism allows the practitioner to maintain constant control while stapling the skin.¹

Before inserting staples, it is important to line up the wound edges with the centerline indicator on the head of the stapler to make sure that the legs of the staple will enter the skin at equal distances on either side of the wound edge. Each edge is typically picked up with a forceps, everted and precisely lined up. The surgeon then places the staples to close the wound while the first assistant advances the forceps, everting the edges of the wound. This technique is continued until the entire wound is everted and closed with staples.²

INDICATIONS AND USAGE

Wound closure with staples is indicated for scalp lacerations that do not require extensive hemostasis and do not involve tears in the underlying frontooccipital aponeurosis (galea). They are also indicated for linear nonfacial lacerations caused by shear forces (eg, sharp objects).

AFTERCARE AND REMOVAL

Skin staples should be removed at the same time that sutures would be removed, based on wound location and tension. For scalp wounds, staples should be removed on day 7 after insertion. For trunk and extremity wounds, staples should be removed between days 7 and 14. Wounds closed with staples may be covered with a topical antibiotic cream or ointment. Patients may bathe or shower the next day, but should avoid prolonged exposure to moisture. When used on the scalp, patients should be very careful about combing or brushing their hair. A specially designed, single-handed, disposable staple remover should be used to remove the staples by a healthcare professional.

PROXIMATE* Skin Staplers

PROXIMATE Skin Staplers place single staples to close surgical incisions. Staples are made of lubricant-coated stainless steel;

PROXIMATE* SKIN STAPLERS

TABLE 2

PROXIMATE* RH Skin Staplers (Rotating Head Skin Staplers)		PROXIMATE* PX Skin Staplers		PROXIMATE* PLUS MD Skin Staplers (Multi-Directional Skin Staplers)	
Features	Benefits	Features	Benefits	Features	Benefits
Rectangular staples	Minimizes staple rotation	Ergonomic pistol grip	Intuitive and comfortable to use	Improved kick-off spring design	Multi-direction release
Head rotates 360°; cartridge is clear	Improves visibility and access	Positive ratchet mechanism	Easy staple placement	Ergonomic design	Comfortable for smaller hands
Staples are coated with lubricant	Easy staple extraction	Staples are coated with lubricant	Easy staple extraction	Alignment indicator	Improves visibility
Pistol-grip handle	Comfortable to use			Staples are coated with lubricant	Easy staple extraction

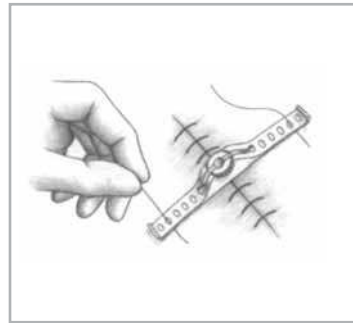
the staplers are not reloadable. ETHICON Endo-Surgery makes 3 different skins staplers to meet surgeons' needs.

PROXIMATE* PX skin stapler provides many of the same features as the PROXIMATE RH skin stapler but in a fixed-head format.

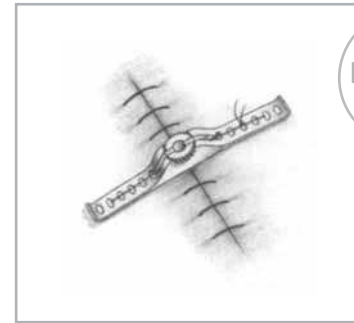
PROXIMATE* PLUS MD is a high-value, low-cost skin stapler that permits multi-directional release in an ergonomic design.

LOOPED SUTURE

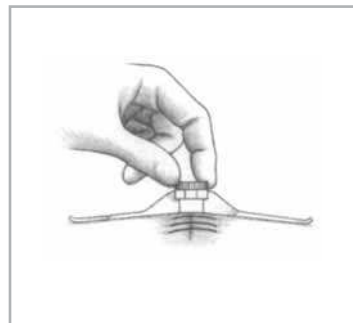
ETHICON looped sutures range in length up to a 60-inch strand with both ends swaged to a single taper point needle. Available in various materials and suture sizes, they provide a simple, reliable technique for continuous closure of the fascia of the abdominal wall. The needle of the looped suture is passed through the fascia from inside out at one end of the incision, then through the opposite wound edge from outside in, and then passed through the loop. The locking stitch lies beneath the wound edge. The double strand is run over and over to the other end of the incision. The final stitch is completed by passing the needle from the outside in, cutting one strand, and passing the needle through the opposite wound edge from the outside in. The needle is then cut off and the loose suture ends tied together, leaving the knot inverted under the fascia.



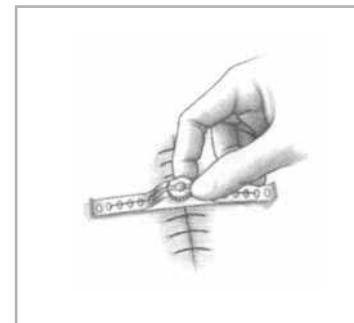
1. Pass the retention suture through appropriate holes in the bridge.



2. Place the suture with tension over the slit in the capstan, and tie.



3. To adjust tension, lift capstan.



4. Rotate capstan until desired tension is attained.



5. To lock, press capstan down into bridge.

FIGURE 1

ADJUSTMENT OF RETENTION SUTURE BRIDGE

RETENTION SUTURE DEVICES

Retention sutures, if not placed carefully without excessive tension, can cut the skin. Devices such as bolsters and bridges are used to prevent such complications and eliminate pressure. However, care should also be taken in the use of these devices.

Retention suture bolsters are sterile 2 1/2-inch (6 cm) lengths of 3/16-inch

(0.48 cm) diameter surgical latex tubing with a 1/32-inch (0.08 cm) wall. The suture is threaded through the bolster and tied. Sutures sheathed in this manner can cause an inflammatory response with reaction both at the site of the suture exit from the skin and along the entire length of the suture itself. Also, the skin may become necrotic beneath the bolsters if the sutures are too tight. This invariably occurs if the sutures are tightly tied at the time of the operation, as subsequent tissue edema ensues.