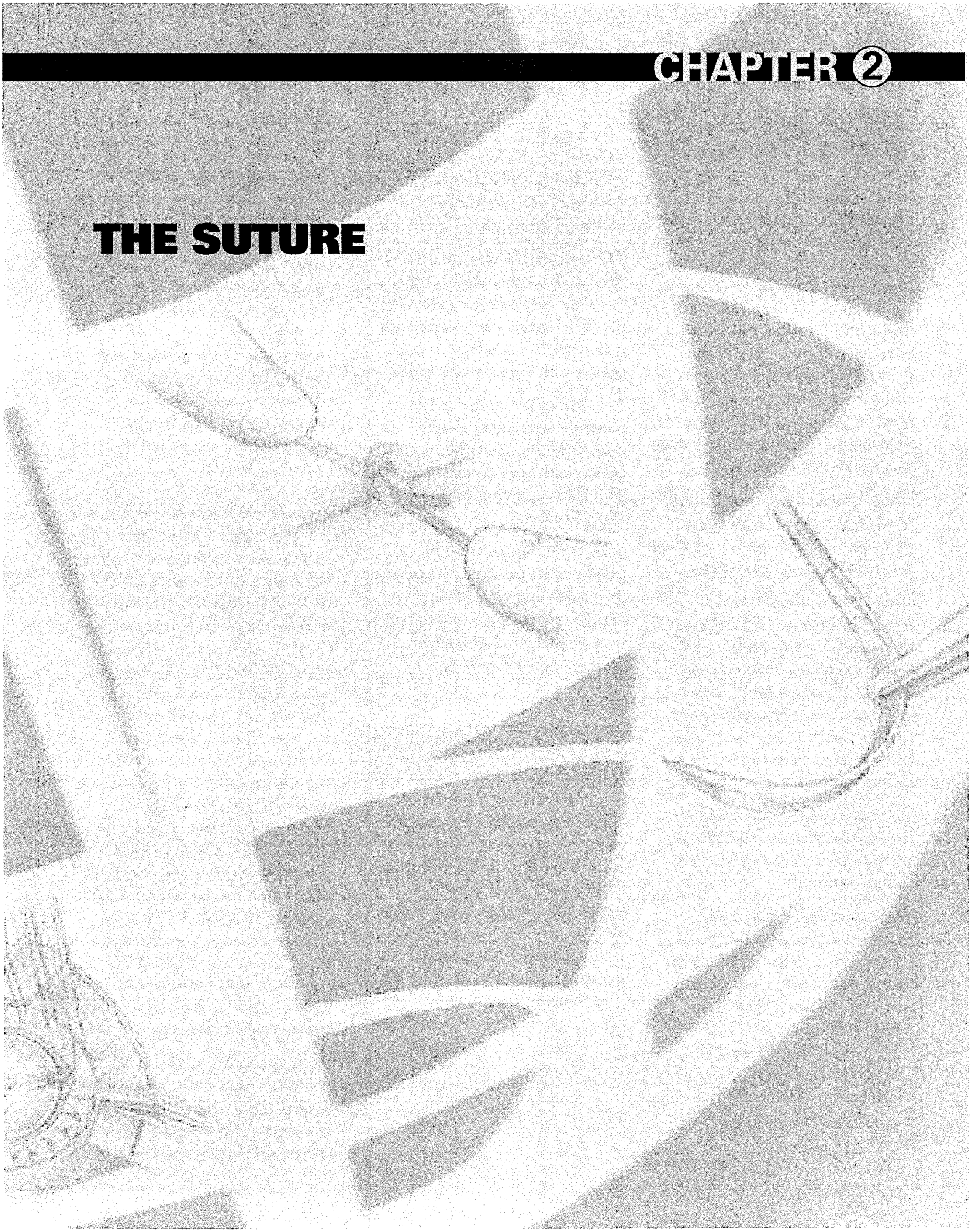
CHAPTER 2

THE SUTURE



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 B.C. 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 orthopaedic surgeons use coated VICRYL suture, coated VICRYL *Plus*, PDS* II (polydioxanone) suture, and ETHIBOND* *EXCEL* polyester suture. Many plastic surgeons prefer ETHILON* nylon suture, VICRYL suture, 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, 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 which 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 U.S.P. SUTURE DIAMETER EQUIVALENTS

TABLE 1

U.S.P. 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

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ABSORBABLE VS. NONABSORBABLE SUTURES

Sutures are classified according to their degradation properties. Sutures that undergo rapid degradation in tissues, losing their tensile strength within 60 days, are considered *absorbable* sutures. Sutures that generally maintain their tensile strength for longer than 60 days 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 considerable overlap, characterized by loss of suture mass. Both stages exhibit leukocytic cellular responses which 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 during handling, prior to being implanted in tissue, 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

TABLE 2

ABSORBABLE SUTURES: BASIC RAW MATERIALS

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 (polyglactin 910) suture, coated VICRYL *Plus* suture, coated VICRYL* *RAPIDE* (polyglactin 910) 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)

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 (i.e., 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, conforming to the United States Pharmacopeia (U.S.P.) limitations for each size. Nonabsorbable sutures have been classified by the U.S.P. 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.

TABLE 3

NON-ABSORBABLE SUTURES: RAW MATERIALS

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

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.

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 U.S.P. specifications, processed ribbons of the submucosa layer of sheep intestine or the serosa layer of beef intestine are electronically 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 (0.0175mm) 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 unexceeded 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

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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 complete within 70 days. The surgeon may choose plain gut for use in tissues which 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 U.S.P. 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 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 which 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 five weeks post implantation. 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 has a 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 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* 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 two weeks post implantation. At three weeks, approximately 50% of the original strength is retained. At four weeks, approximately 25% of the original strength is retained. All of the original tensile strength is lost by five weeks post implantation. 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

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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, orthopaedic, 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 U.S.P. 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 which 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* surgical silk sutures.

Surgical silk loses tensile strength when exposed to moisture and should be used dry. Although silk is classified by the U.S.P. 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 orthopaedic 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	U.S.P.	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 U.S.P. 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 "pliabilized" 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 micro-surgery 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

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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 polybutilate, a biologically inert, nonabsorbable compound which adheres itself to the braided polyester fiber strand. Polybutilate 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.

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.

PROLENE* POLYPROPYLENE SUTURE

Widely used in general, cardiovascular, plastic, and orthopaedic 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.

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 suture 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.

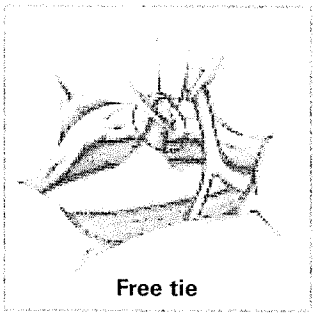
Table 5 gives an overview of the many suturing options that have been discussed in this section. (See attached chart)

COMMON SUTURING TECHNIQUES

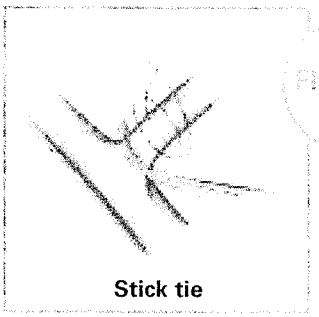
LIGATURES

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 two 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



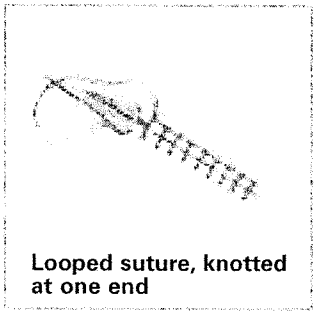
Free tie



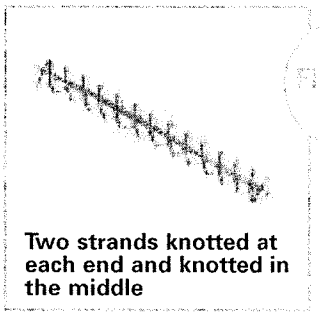
Stick tie

FIGURE 1

LIGATURES



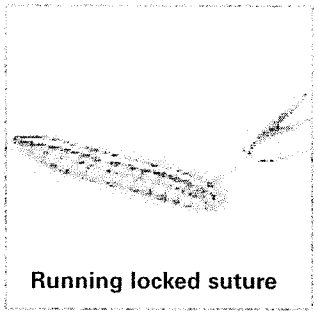
Looped suture, knotted at one end



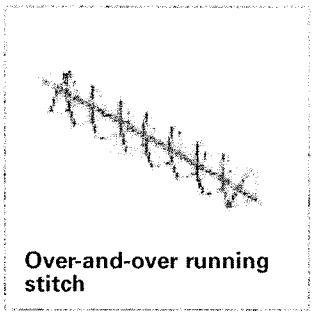
Two strands knotted at each end and knotted in the middle

FIGURE 2

CONTINUOUS SUTURING TECHNIQUES



Running locked suture



Over-and-over running stitch

suture. Additional throws are added 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

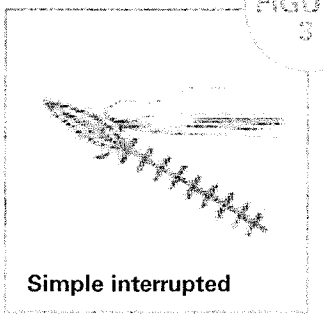
The *primary suture line* is the line of sutures that holds the wound edges in approximation during healing by first intention. It may consist of a continuous strand of material or a series of interrupted suture strands. Other types of primary sutures, such as deep sutures, buried sutures, purse-string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

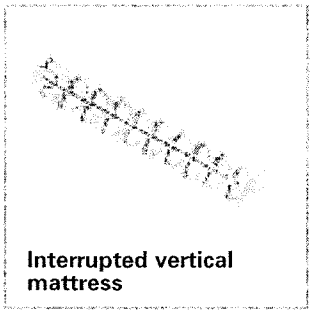
Also referred to as *running stitches*, continuous sutures are a series of stitches taken with one strand of material. The strand may be tied to itself at each end, or looped, with both cut ends of the strand tied together. A continuous suture line can be placed rapidly. It derives its strength from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

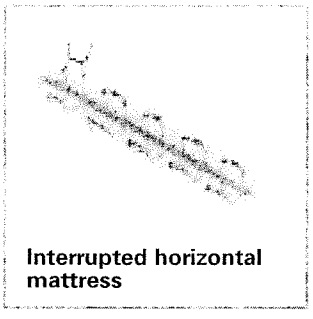
FIGURE 3



Simple interrupted



Interrupted vertical mattress



Interrupted horizontal mattress

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ABSORBABLE SUTURES

SUTURE	TYPES	COLOR OF MATERIAL	RAW MATERIAL	TENSILE STRENGTH RETENTION *in vivo*	ABSORPTION RATE	TISSUE REACTION
Surgical Gut Suture	Plain	Yellowish-tan Blue Dyed	Collagen derived from healthy beef and sheep.	Individual patirent characteristics can affect rate of tensile strength loss.	Absorbed by proleolytic enzymatic digestive process.	Moderate reaction
Surgical Gut Suture	Chromic	Brown Blue Dyed	Collagen derived from healthy beef and sheep.	Individual patirent characteristics can affect rate of tensile strength loss.	Absorbed by proleolytic enzymatic digestive process.	Moderate reaction
Coated VICRYL* *RAPIDE* (polyglactin 910) Suture	Braided	Undyed (Natural)	Copolymer of lactide and glycolide coated with 370 and calcium stearate.	Approximately 50% remains at 5 days. All tensile strength is lost at approximately 14 days.	Essentially complete between 42 days. Absorbed by hydrolysis.	Minimal to moderate acute inflammatory reaction
MONOCRYL* (poliglecaprone 25) Suture	Monofilament	Undyed (Natural) Violet	Copolymer of glycolide and epsilon-caprolactone.	Approximately 50-60% (violet: 60-70%) remains at 1 week. Approximately 20-30% (violet: 30-40%) remains at 2 weeks. Lost within 3 weeks (violet: 4 weeks).	Complete at 91-119 days. Absorbed by hydrolysis.	Minimal acute inflammatory reaction
Coated VICRYL* *Plus* Antibacterial (polyglactin 910) Suture	Braided Monofilament	Undyed (Natural) Violet	Copolymer of lactide and glycolide coated with 370 and calcium stearate.	Approximately 75% remains at two weeks. Approximately 50% remains at three weeks, 25% at four weeks.	Essentially complete between 56-70 days. Absorbed by hydrolysis.	Minimal acute inflammatory reaction
Coated VICRYL* (polyglactin 910) Suture	Braided Monofilament	Violet Undyed (Natural)	Copolymer of lactide and glycolide coated with 370 and calcium stearate.	Approximately 75% remains at two weeks. Approximately 50% remains at three weeks, 25% at four weeks.	Essentially complete between 56-70 days. Absorbed by hydrolysis.	Minimal acute inflammatory reaction
PDS* II (polydioxanone) Suture	Monofilament	Violet Blue Clear	Polyester polymer.	Approximately 70% remains at 2 weeks. Approximately 50% remains at 4 weeks. Approximately 25% remains at 6 weeks.	Minimal until about 90th day. Essentially complete within 6 months. Absorbed by slow hydrolysis.	Slight reaction

NONABSORBABLE SUTURES

PERMA-HAND* Silk Suture	Braided	Violet White	Organic protein called fibrin.	Progressive degradation of fiber may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.	Acute inflammatory reaction
Surgical Stainless Steel Suture	Monofilament Mulifilament	Silver metallic	316L stainless steel.	Indefinate.	Nonabsorbable.	Minimal acute inflammatory reaction
ETHILON* Nylon Suture	Monofilament	Violet Green Undyed (Clear)	Long-chain aliphatic polymers Nylon 6 or Nylon 6,6.	Progressive hydrolysis may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.	Minimal acute inflammatory reaction
NUROLON* Nylon Suture	Braided	Violet Green Undyed (Clear)	Long-chain aliphatic polymers Nylon 6 or Nylon 6,6.	Progressive hydrolysis may result in gradual loss of tensile strength over time.	Gradual encapsulation by fibrous connective tissue.	Minimal acute inflammatory reaction
MERSILENE* Polyester Fiber Suture	Braided Monofilament	Green Undyed (White)	Poly (ethylene terephthalate).	No significant change known to occur *in vivo*.	Gradual encapsulation by fibrous connective tissue.	Minimal acute inflammatory reaction
ETHIBOND* *EXCEL* Polyester Fiber Suture	Braided	Green Undyed (White)	Poly (ethylene terephthalate) coated with polybutilate.	No significant change known to occur *in vivo*.	Gradual encapsulation by fibrous connective tissue.	Minimal acute inflammatory reaction
PROLENE* Polypropylene Suture	Monofilament	Clear Blue	Isotactic crystalline stereoisomer of polypropylene.	No subject to degradation or weakening by action of tissue enzymes.	Nonabsorbable.	Minimal acute inflammatory reaction
PRONOVA* POLY (hexafluoro-propylene-VDF) Suture	Monofilament	Blue	Polymer blend of poly (vinylidene fluoride) and poly (vinylidene fluoride-cohexafluoro-propylene).	No subject to degradation or weakening by action of tissue enzymes.	Nonabsorbable.	Minimal acute inflammatory reaction

TABLE 5

SUTURING OPTIONS: MATERIALS, CHARACTERISTICS, AND APPLICATIONS

CONTRAINDICATIONS	FREQUENT USES	HOW SUPPLIED	COLOR CODE OF PACKETS
Being absorbable, should not be used where extended approximation of tissues under stress is required. Should not be used in patients with known sensitivities or allergies to collagen or chromium.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in cardiovascular and neurological tissues.	7-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 0 thru 1 with CONTROL RELEASE needles	Yellow
Being absorbable, should not be used where extended approximation of tissues under stress is required. Should not be used in patients with known sensitivities or allergies to collagen or chromium.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in cardiovascular and neurological tissues.	7-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 0 thru 1 with CONTROL RELEASE needles	Beige
Should not be used where extended approximation of tissue under stress is required or where wound support beyond 7 days is required.	Superficial soft tissue approximation of skin and mucosa only. Not for use in ligation, ophthalmic, cardiovascular or neurological procedures.	5-0 thru 1 with needles	Red
Being absorbable, should not be used where extended approximation of tissue under stress is required. Undyed not indicated for use in fascia.	General soft tissue approximation and/or ligation. Not for use in cardiovascular and neurological tissues, microsurgery, or ophthalmic surgery.	6-0 thru 2 with and without needles 3-0 thru 1 with CONTROL RELEASE needles	Coral
Being absorbable, should not be used where extended approximation of tissue is required.	General soft tissue approximation and/or ligation. Not for use in cardiovascular and neurological tissues.	5-0 thru 2 with and without needles	Violet
Being absorbable, should not be used where extended approximation of tissue is required.	General soft tissue approximation and/or ligation, including use in ophthalmic procedures. Not for use in cardiovascular and neurological tissues.	8-0 thru 3 with and without needles, and on LIGAPAK dispensing reels 4-0 thru 2 with CONTROL RELEASE needles; 8-0 with attached beads for ophthalmic use	Violet
Being absorbable, should not be used where prolonged approximation of tissues under stress is required. Should not be used with prosthetic devices, such as heart valves or synthetic grafts.	All types of soft tissue approximation, including pediatric cardiovascular and ophthalmic procedures. Not for use in adult cardiovascular tissue, microsurgery, and neural tissue.	9-0 thru 2 with needles 4-0 thru 2 with CONTROL RELEASE needles 9-0 thru 7-0 with needles 7-0 thru 1 with needles	Silver
Should not be used in patients with known sensitivities or allergies to silk.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	9-0 thru 5 with and without needles, and on LIGAPAK dispensing reels 4-0 thru 1 with CONTROL RELEASE needles	Light Blue
Should not be used in patients with known sensitivities or allergies to 316L stainless steel, or constituent metals such as chromium and nickel.	Abdominal wound closure, hernia repair, sternal closure and orthoaedic procedures including cerclage and tendon repair.	10-0 thru 7 with and without needles	Yellow-Ochre
Should not be used where permanent retention of tensile strength is required.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	11-0 thru 2 with and without needles	Mint Green
Should not be used where permanent retention of tensile strength is required.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	6-0 thru 1 with and without needles 4-0 thru 1 with CONTROL RELEASE needles	Mint Green
None known.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	6-0 thru 5 with and without needles 10-0 and 11-0 for ophthalmic (green monofilament); 0 with CONTROL RELEASE needles	Turquoise
None known.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	7-0 thru 5 with and without needles 4-0 thru 1 with CONTROL RELEASE needles; various sizes attached to TFE polymer pledgets	Orange
None known.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	6-0 thru 2 (clear) with and without needles; 10-0 thru 8-0 and 6-0 thru 2 with and without needles; 0 thru 2 with CONTROL RELEASE needles; various sizes attached to TFE polymer pledgets	Deep Blue
None known.	General soft tissue approximation and/or ligation, including cardiovascular, ophthalmic and neurological procedures.	6-0 through 5-0 with TAPERCUT* surgical needle 8-0 through 5-0 with taper point needle	Royal Blue

* Trademark

tissue strangulation. Excessive tension and instrument damage should be avoided to prevent suture breakage which could disrupt the entire line of a continuous suture.

Continuous suturing leaves less foreign body mass in the wound. In the presence of infection, it may be desirable to use a monofilament suture material because it has no interstices which can harbor microorganisms. This is especially critical as a continuous suture line can transmit infection along the entire length of the strand. A continuous one layer mass closure may be used on peritoneum and/or fascial layers of the abdominal wall to provide a temporary seal during the healing process.

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 technique is useful when using large diameter permanent sutures on deeper layers in thin patients who may be able to feel large knots that are not buried.

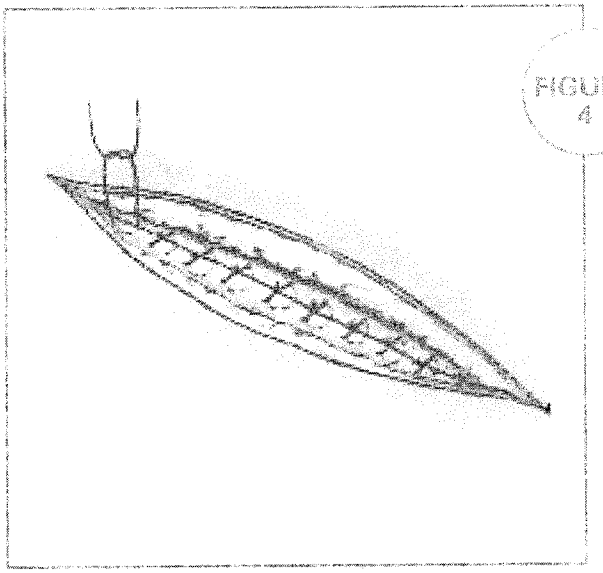

FIGURE 4

DEEP SUTURES

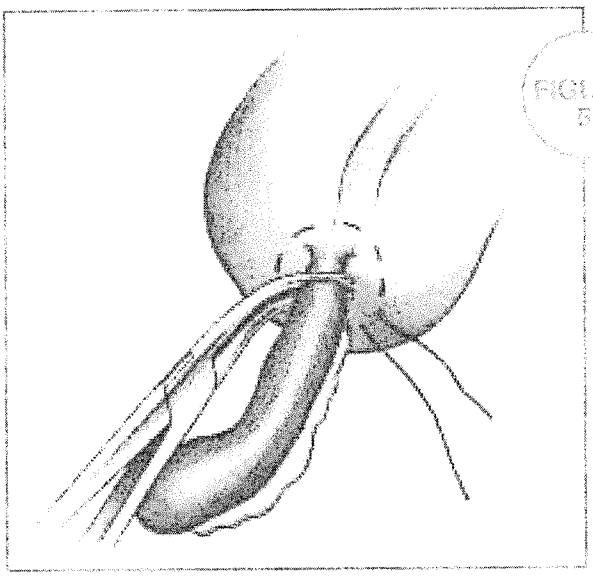

FIGURE 5

PURSE-STRING SUTURES

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

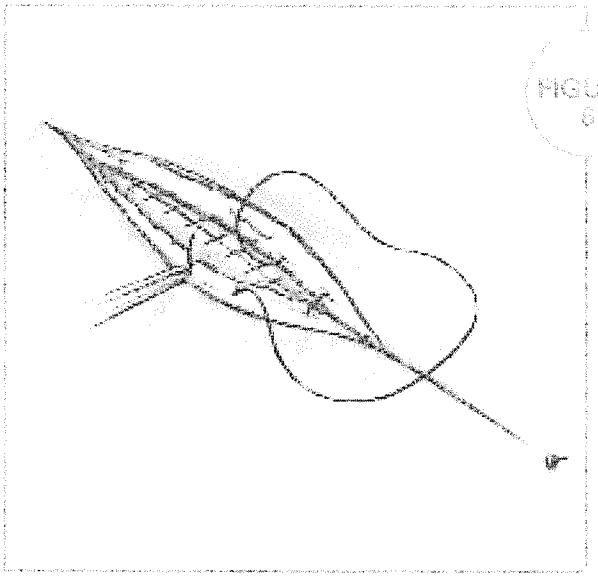

FIGURE 6

SUBCUTANEOUS SUTURES

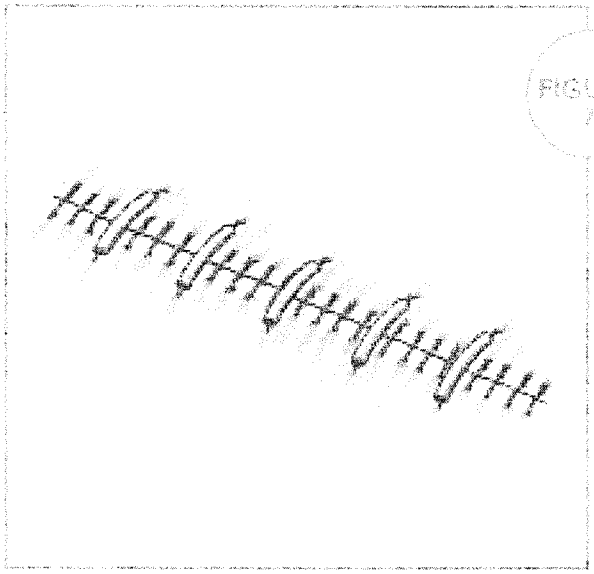

FIGURE 7

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 (i.e., 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-fourths its length. Then the retention sutures in this area may be drawn together and tied. It is important that a finger be placed within the abdominal cavity to prevent strangulation of the viscera in the closure. The remainder of the wound may then be closed. Prior to tightening and tying the final retention sutures, it is important to explore the abdomen again with a finger to prevent strangulation of viscera in the closure. The remainder of the wound may then be closed.

Retention sutures utilize nonabsorbable suture material. They should therefore be removed as soon as the danger of sudden

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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 ENCYLCOPEDIA 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.

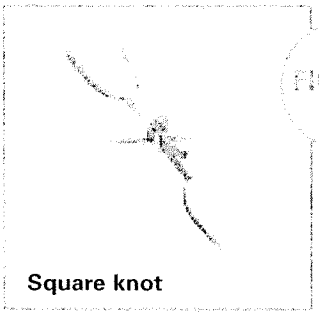
The general principles of knot tying which apply to all suture materials are:

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.

TABLE 6

COMMONLY USED TYPES OF STITCHES

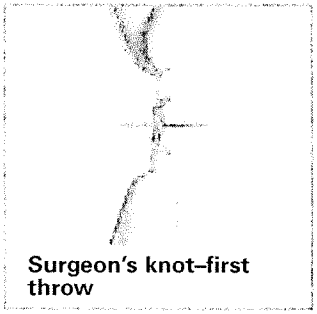
CONTINUOUS SUTURE	INTERRUPTED SUTURES
To appose skin and other tissue	
Over-and-over Subcuticular	Over-and-over Vertical mattress Horizontal mattress
To invert tissue	
Lembert Cushing Connell	Lembert Halsted Purse-string
To evert tissue	
Horizontal mattress	Horizontal mattress



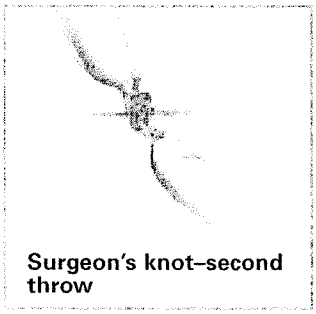
Square knot

FIGURE 9

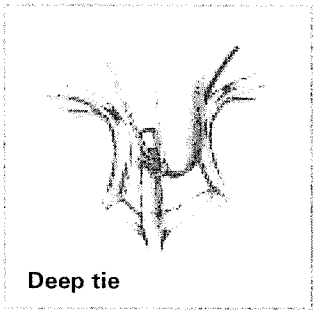
FINISHED SUTURE TIES



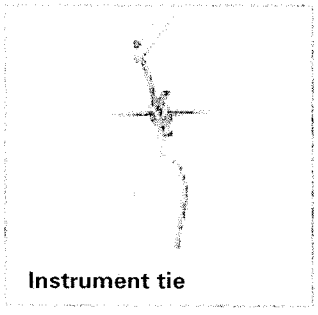
Surgeon's knot–first throw



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 two 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 one or two hands; others involve tying with the help of instruments. Perhaps the most complex method of knot tying is done during endoscopic procedures, when the surgeon must manipulate instruments from well outside the body cavity.

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

SQUARE KNOT

The two-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* (poliglecaprone 25) suture, VICRYL* suture, Coated VICRYL* suture, Coated VICRYL* *RAPIDE* (polyglactin 910) suture,

* Trademark

PDS* II (polydioxanone) suture, ETHILON* nylon suture, ETHIBOND* *EXCEL* polyester suture, PERMA-HAND* silk suture, PRONOVA* poly (hexafluoropropylene-VDF) suture, and PROLENE* polypropylene suture.

Wherever possible, the square knot is tied using the two-hand technique. On some occasions it will be necessary to use one 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* suture, ETHIBOND* *EXCEL* polyester suture, ETHILON* nylon suture, MERSILENE* polyester fiber suture, NUROLON* nylon suture, PRONOVA* poly (hexafluoropropylene-VDF) suture, and PROLENE* polypropylene suture. The surgeon's knot also may be performed using a one-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 which 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" (6mm) from the knot.

TABLE 7
SUTURE REMOVAL

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

Other materials are cut closer to the knot, approximately 1/8" (3mm), to decrease tissue reaction and minimize the amount of foreign material left in the wound. To ensure that the actual knot is not cut, twist or angle the blades of the scissors prior to cutting. Make certain to remove the cut ends of the suture from the operative site.

SUTURE REMOVAL

When the 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,

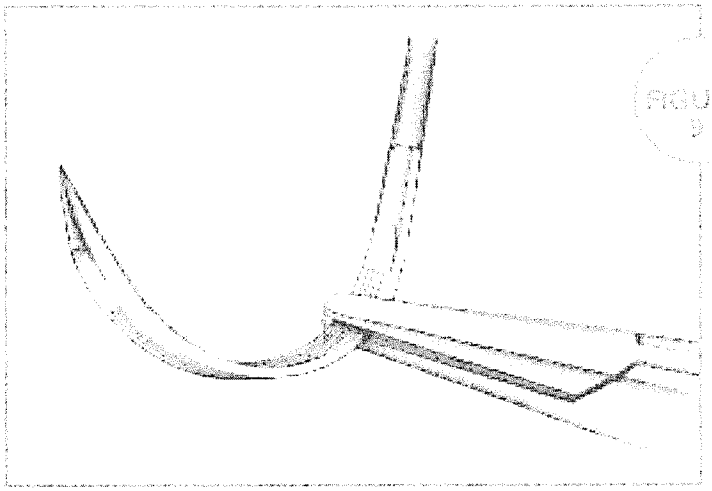


FIGURE 2

ARMING A NEEDLE-HOLDER PROPERLY

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

* Trademark

the biologic forces in the healing wound, and the interaction of the suture and the tissues. The following principles should guide the surgeon in suture selection.

1. When a wound has reached maximal strength, sutures are no longer needed. Therefore:
   a. Tissues that ordinarily heal slowly such as skin, fascia, and tendons should usually be closed with nonabsorbable sutures. An absorbable suture with extended (up to 6 months) wound support may also be used.
   b. Tissues that heal rapidly such as stomach, colon and bladder may be closed with absorbable sutures
2. Foreign bodies in potentially contaminated tissues may convert contamination into infection.
3. Where cosmetic results are important, close and prolonged apposition of wounds and avoidance of irritants will produce the best results. Therefore:
   a. Use the smallest inert monofilament suture materials such as nylon or polypropylene.
   b. Avoid skin sutures and close subcuticularly whenever possible.
   c. Under certain circumstances, to secure close apposition of skin edges, a topical skin adhesive or skin closure tape may be used.
4. Foreign bodies in the presence of fluids containing high concentrations of crystalloids may act as a nidus for precipitation and stone formation. Therefore:
   a. In the urinary and biliary tracts, use rapidly absorbed sutures.
5. Regarding suture size:
   a. Use the finest size suture commensurate with the natural strength of the tissue.
   b. If the postoperative course of the patient may produce sudden strains on the suture line, reinforce it with retention sutures. Remove them as soon as the patient's condition is stabilized.

SURGERY WITHIN THE ABDOMINAL WALL CAVITY

Entering the abdomen, the surgeon will need to seal or tie off subcutaneous blood vessels immediately after the incision is made, using either an electrosurgical unit designed for this purpose or free ties (ligatures). If ligatures are used, an absorbable suture material is generally preferred. When preparing the ties, the scrub person often prepares one strand on a needle for use as a suture ligature should the surgeon wish to transfix a large blood vessel. Once inside, the type of suture selected will depend upon the nature of the operation and the surgeon's technique.

THE GASTROINTESTINAL TRACT

Leakage from an anastomosis or suture site is the principal problem encountered performing a procedure involving the gastrointestinal tract. This problem can lead to localized or generalized peritonitis. Sutures should not be tied too tightly in an anastomotic closure. Wounds of the stomach and intestine are rich in blood supply and may become edematous and hardened. Tight sutures may cut through the tissue and cause leakage. A leak-proof anastomosis can be achieved with either a single or double-layer closure.

For a single-layer closure, interrupted sutures should be placed approximately 1/4" (6mm) apart. Suture is placed through the submucosa, into the muscularis and through the serosa. Because the submucosa provides strength in the gastrointestinal tract, effective closure involves suturing the submucosal layers in apposition without penetrating the mucosa. A continuous suture line provides a tighter seal than interrupted sutures. However, if a continuous suture breaks, the entire line may separate.

Many surgeons prefer to use a double-layer closure, placing a second layer of interrupted sutures through the serosa for insurance. Absorbable VICRYL* sutures, or chromic gut sutures may be used in either a single or double-layer closure. Surgical silk may also be used for the second layer of a double-layer closure.
Inverted, everted, or end-to-end closure techniques have all been used successfully in this area, but they all have drawbacks. The surgeon must take meticulous care in placing the sutures in the submucosa. Even with the best technique, some leakage may occur. Fortunately, the omentum usually confines the area, and natural body defenses handle the problem.

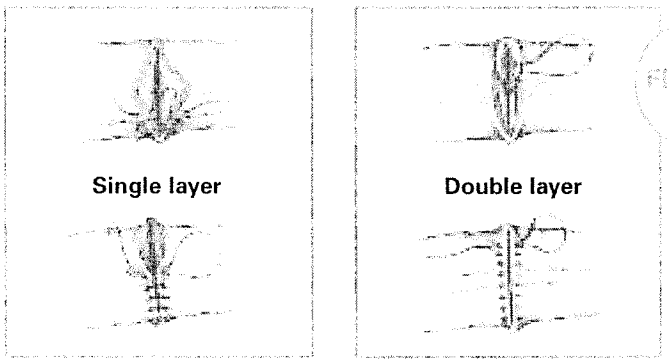


FIGURE 10

ANASTOMOTIC CLOSURE TECHNIQUE

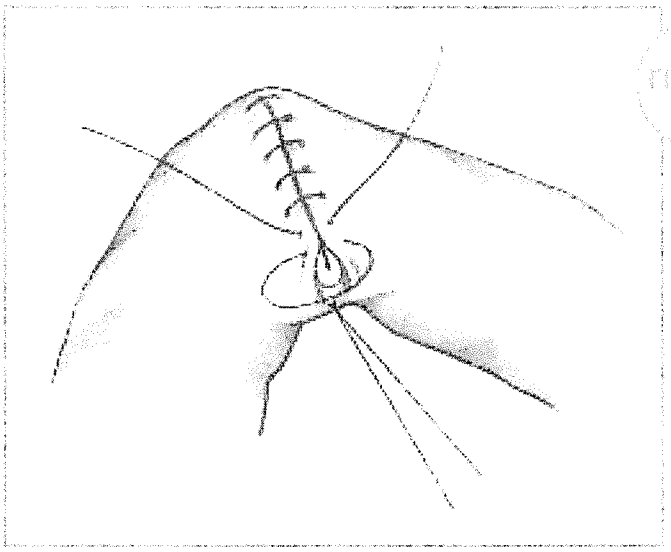


FIGURE 11

INVERTED CLOSURE TECHNIQUE

THE STOMACH

For an organ that contains free hydrochloric acid and potent proteolytic enzymes, the stomach heals surprisingly quickly. Stomach wounds attain maximum strength within 14 to 21 days

postoperatively, and have a peak rate of collagen synthesis at 5 days.

Absorbable sutures are usually acceptable in the stomach, although they may produce a moderate reaction in both the wound and normal tissue. Coated VICRYL* sutures are most commonly used. PROLENE* sutures may also be used for stomach closure.

THE SMALL INTESTINE

Closure of the small intestine presents the same considerations as the stomach. Proximal intestinal contents, primarily bile or pancreatic juices, may cause a severe chemical (rather than bacterial) peritonitis.

If using an inverted closure technique, care must be taken to minimize the cuff of tissue which protrudes into the small sized intestinal lumen in order to avoid partial or complete obstruction. *Absorbable sutures* are usually preferred, particularly because they will not permanently limit the lumen diameter. A *nonabsorbable suture* may be used in the serosal layer for added assurance.

The small intestine heals very rapidly, reaching maximal strength in approximately 14 days.

THE COLON

The high microbial content of the colon once made contamination a major concern. But absorbable sutures, once absorbed, leave no channel for microbial migration. Still, leakage of large bowel contents is of great concern as it is potentially more serious than leakage in other areas of the gastrointestinal tract.

The colon is a strong organ—approximately twice as strong in the sigmoid region as in the cecum. Yet, wounds of the colon gain strength at the same rate regardless of their location. This permits the same suture size to be used at either end of the colon. The colon heals at a rate similar to that of the stomach and small intestine. A high rate of collagen synthesis is maintained for a prolonged period (over 120 days). The entire gastrointestinal tract exhibits a loss of collagen and increased collagenous activity immediately following colon anastomosis. Both *absorbable* and *nonabsorbable sutures* may be used for closure of the colon. Placement of sutures in the submucosa, avoiding penetration of the mucosa, will help prevent complications.

THE RECTUM

The rectum heals very slowly. Because the lower portion is below the pelvic peritoneum, it has no serosa. A large bite of muscle should be included in an anastomosis, and the sutures should be tied carefully to avoid cutting through the tissues.

* Trademark

Monofilament sutures reduce the risk of bacterial proliferation in the rectum.

THE BILIARY TRACT
THE GALLBLADDER

Within the gallbladder, the cystic and common bile ducts heal rapidly. Their contents present special considerations for suture selection. The presence of a foreign body such as a suture in an organ that is prone to crystal formation may precipitate the formation of "stones." Multifilament sutures should probably not be used because it is not always possible to prevent exposure of a suture in the ducts. The surgeon should choose an *absorbable suture* in the finest size possible that leaves the least surface area exposed.

PARENCHYMATOUS ORGANS
THE SPLEEN, LIVER AND KIDNEY

On occasion, a surgeon may be called upon to repair a laceration of one of these vital organs. If large vessels, particularly arteries, within these organs have been severed, they must be located and ligated before attempting to close the defect. Otherwise, hematomas or secondary hemorrhage may occur.

Because these organs are composed chiefly of cells with little connective tissue for support, attempts must be made to coapt the outer fibrous capsule of the torn tissue. In the absence of hemorrhage, little tension is placed on the suture line and only small size sutures need to be used. If the tissue cannot be approximated, tacking a piece of omentum over the defect will usually suffice to provide closure. Sutures do not need to be placed close together or deeply into the organ.

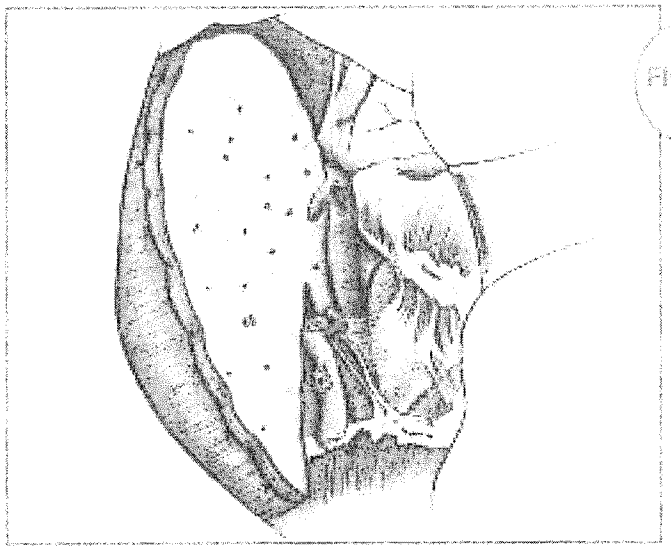


FIGURE 12

LIVER RESECTION

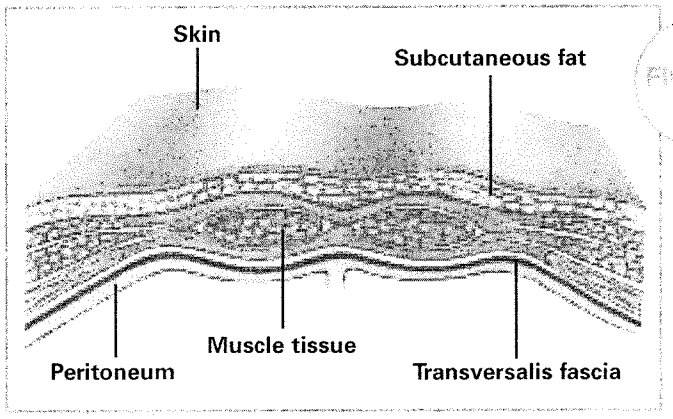


FIGURE 13

THE ABDOMINAL WALL

Lacerations in this area tend to heal rapidly. New fibrous tissue will usually form over the wound with 7 to 10 days.

In a liver resection, suturing of the wedges in a horizontal through-and-through fashion should hold the tissue securely. Large vessels should be tied using VICRYL* sutures or silk. Raw surfaces can be closed or repaired using VICRYL (polyglactin 910) mesh.

CLOSING THE ABDOMEN

When closing the abdomen, the closure technique may be more important than the type of suture material used.

THE PERITONEUM

The peritoneum, the thin membranous lining of the abdominal cavity, lies beneath the posterior fascia. It heals quickly. Some believe that the peritoneum does not require suturing, while others disagree. If the posterior fascia is securely closed, suturing the peritoneum may not contribute to the prevention of an incisional hernia. Among surgeons who choose to close the peritoneum, a continuous suture line

with *absorbable suture material* is usually preferred. Interrupted sutures can also be used for this procedure.

FASCIA

This layer of firm, strong connective tissue covering the muscles is the main supportive structure of the body. In closing an abdominal incision, the fascial sutures must hold the wound closed and also help to resist changes in intra-abdominal pressure. Occasionally, synthetic graft material may be used when fascia is absent or weak. PROLENE* polypropylene mesh may be used to replace abdominal wall or repair hernias when a great deal of stress will be placed on the suture line during healing. *Nonabsorbable sutures* such as PROLENE suture may be used to suture the graft to the tissue.

Fascia regains approximately 40% of its original strength in 2 months. It may take up to a year or longer to regain maximum strength. Full original strength is never regained.

The anatomic location and type of abdominal incision will influence how may layers of fascia will be sutured. The posterior fascial layer is always closed. The anterior layer may be cut and may also require suturing. Mass closure techniques are becoming the most popular.

Most suture materials have some inherent degree of elasticity. If not tied too tightly, the suture will "give" to accommodate postoperative swelling that occurs. Stainless steel sutures, if tied too tightly, will cut like a knife as the tissue swells or as tension is placed upon the suture line. Because of the slow healing time and because the fascial suture must bear the maximum stress of the wound, a moderate size *nonabsorbable suture* may be used. An *absorbable suture* with longer lasting tensile strength, such as PDS* II sutures, may also provide adequate support. PDS II sutures are especially well-suited for use in younger, healthy patients.

Many surgeons prefer the use of interrupted simple or figure-of eight sutures to close fascia, while others employ running suture or a combination of these techniques. In the absence of infection or gross contamination, the surgeon may choose either *monofilament* or *multifilament* sutures. In the presence of infection, a *monofilament absorbable material* like PDS II sutures or inert *nonabsorbable sutures* like stainless steel or PROLENE* sutures may be used.

MUSCLE

Muscle does not tolerate suturing well. However, there are several options in this area.

Abdominal muscles may be either cut, split *(separated)*, or retracted, depending upon the location and type of the incision chosen. Where possible, the surgeon prefers to avoid interfering with the blood supply and nerve function by making a muscle-splitting incision or retracting the entire muscle toward its nerve supply. During closure, muscles handled in this manner do not need to be sutured. The fascia is sutured rather than the muscle.

The Smead-Jones far-and-near-technique for abdominal wound closure is strong and rapid, provides good support during early healing with a low incidence of wound disruption, and has a low incidence of late incisional problems. This is a single-layer closure through both layers of the abdominal wall fascia, abdominal muscles, peritoneum,

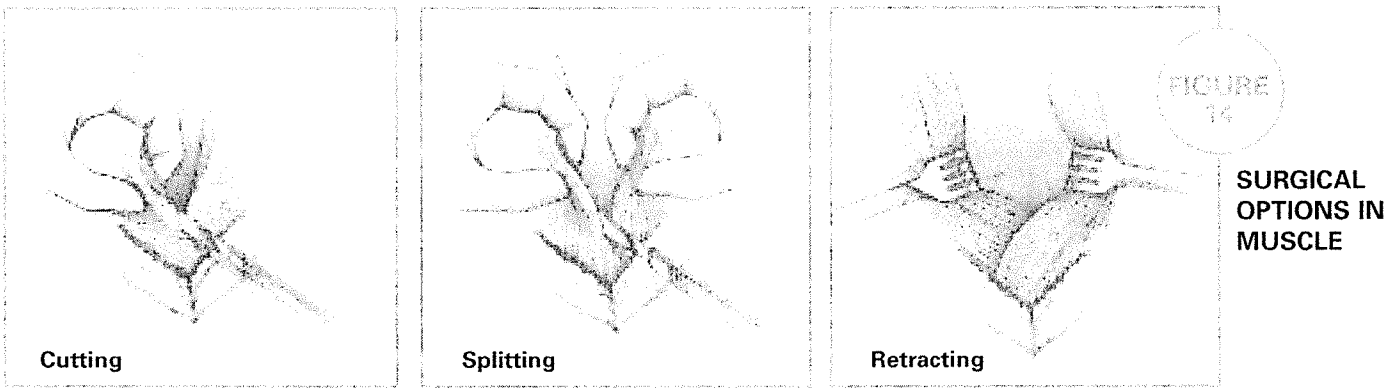


FIGURE 14

SURGICAL OPTIONS IN MUSCLE

* Trademark

and the anterior fascial layer. The interrupted sutures resemble a "figure of eight" when placed. *Absorbable* PDS II sutures or VICRYL* sutures are usually used.

Stainless steel sutures may also be used. *Monofilament* PROLENE sutures also provide all the advantages of steel sutures: strength, minimal tissue reactivity, and resistance to bacterial contamination. They are better tolerated than steel sutures by patients in the late postoperative months and are easier for the surgeon to handle and tie. However, both stainless steel and PROLENE sutures may be detectable under the skin of thin patients. To avoid this problem, knots should be buried in fascia instead of in the subcutaneous space.

SUBCUTANEOUS FAT

Neither fat nor muscle tolerate suturing well. Some surgeons question the advisability of placing sutures in fatty tissue because it has little tensile strength due to its composition, which is mostly water. However, others believe it is necessary to place at least a few sutures in a thick layer of subcutaneous fat to prevent dead space, especially in obese patients. Dead spaces are most likely to occur in this type of tissue, so the edges of the wound must be carefully approximated. Tissue fluids can accumulate in these pocket-like spaces, delaying healing and predisposing infection. *Absorbable sutures* are usually selected for the subcutaneous layer. VICRYL* suture is especially suited for use in fatty, avascular tissue since it is absorbed by hydrolysis. The surgeon may use the same type and size of material used earlier to ligate blood vessels in this layer.

SUBCUTICULAR TISSUE

To minimize scarring, suturing the subcuticular layer of tough connective tissue will hold the skin edges in close approximation. In a single-layer subcuticular closure, less evidence of scar gaping or expansion may be seen after a period of 6 to 9 months than is evident with simple skin closure. The surgeon takes continuous short lateral stitches beneath the epithelial layer of skin. Either *absorbable* or *nonabsorbable sutures* may be used. If nonabsorbable material is chosen, one end of the suture strand will protrude from each end of the incision, and the surgeon may tie them together to form a "loop" or knot the ends outside of the incision.

To produce only a hair-line scar (on the face, for example), the skin can be held in very close approximation with skin closure tapes in addition to subcuticular sutures. Tapes may be left on the wound for an extended period of time depending upon their location on the body.

When great tension is not placed upon the wound, as in facial or neck surgery, very fine sizes of subcuticular sutures may be used. Abdominal wounds that must withstand more stress call for larger suture sizes.

Some surgeons choose to close both the subcuticular and epidermal layers to achieve minimal scarring. *Chromic surgical gut* and *polymeric materials*, such as MONOCRYL* suture, are acceptable for placement within the dermis. They are capable of maintaining sufficient tensile strength through the collagen synthesis stage of healing which lasts approximately 6 weeks. The sutures must not be placed too close to the epidermal surface to reduce extrusion. If the skin is nonpigmented and thin, *a clear or white monofilament suture* such as MONOCRYL suture will be invisible to the eye. MONOCRYL suture is particularly well-suited for this closure because, as a monofilament, it does not harbor infection and, as a synthetic absorbable suture, tissue reaction is minimized. After this layer is closed, the skin edges may then be approximated.

SKIN

Skin is composed of the epithelium and the underlying dermis. It is so tough that a very sharp needle is essential for every stitch to minimize tissue trauma. *(See Chapter 3: The Surgical Needle.)*

Skin wounds regain tensile strength slowly. If a nonabsorbable suture material is used, it is typically removed between 3 and 10 days postoperatively, when the wound has only regained approximately 5% to 10% of its strength. This is possible because most of the stress placed upon the healing wound is absorbed by the fascia, which the surgeon relies upon to hold the wound closed. The skin or subcuticular sutures need only be strong enough to withstand natural skin tension and hold the wound edges in apposition.

The use of coated VICRYL* *RAPIDE* suture, a rapidly absorbed synthetic suture, eliminates the need for suture removal. Coated

VICRYL *RAPIDE* suture, which is indicated for superficial closure of skin and mucosa, provides short-term wound support consistent with the rapid healing characteristics of skin. The sutures begin to fall off in 7 to 10 days, with absorption essentially complete at 42 days.

Suturing technique for skin closure may be either continuous or interrupted. Skin edges should be everted. Preferably, each suture strand is passed through the skin only once, reducing the chance of cross-contamination across the entire suture line. Interrupted technique is usually preferred.

If surgeon preference indicates the use of a nonabsorbable suture material, several issues must be considered. Skin sutures are exposed to the external environment, making them a serious threat to wound contamination and stitch abscess. The interstices of multifilament sutures may provide a haven for microorganisms. Therefore, *monofilament nonabsorbable sutures* may be preferred for skin closure. Monofilament sutures also induce significantly less tissue reaction than multifilament sutures. For cosmetic reasons, *nylon* or *polypropylene monofilament sutures* may be preferred. Many skin wounds are successfully closed with silk and polyester multifilaments as well. Tissue reaction to nonabsorbable sutures subsides and remains relatively acellular as fibrous tissue matures and forms a dense capsule around the suture. (Note, surgical gut has been known to produce tissue reaction. Coated VICRYL* *RAPIDE* suture elicits a lower tissue reaction than chromic gut suture due to its accelerated absorption profile.) The key to success is early suture removal before epithelialization of the suture tract occurs and before contamination is converted into infection.

A WORD ABOUT SCARRING (EPITHELIALIZATION)

When a wound is sustained in the skin—whether accidentally or during a surgical procedure—the epithelial cells in the basal layer at the margins of the wound flatten and move into the wound area. They move down the wound edge until they find living, undamaged tissue at the base of the wound. Then they move across the wound bed to make contact with similar cells migrating from the opposite side of the wound. They move down the suture tract after if has been embedded in the skin. When the suture is removed, the tract of the epithelial cells remains. Eventually, it may disappear, but some may remain and form keratin. A punctate scar is usually seen on the skin surface and a "railroad track" or "crosshatch" appearance on the wound may result. This is relatively rare if the skin sutures are not placed with excessive tension and are removed by the seventh postoperative day.

The forces that create the distance between the edges of the wound will remain long after the sutures have been removed. Significant collagen synthesis will occur from 5 to 42 days postoperatively. After this time, any additional gain in tensile will be due to remodeling, or crosslinking, of collagen fibers rather than to collagen synthesis. Increases in tensile strength will continue for as long as 2 years, but the tissue will never quite regain its original strength.

CLOSURE WITH RETENTION SUTURES

We have already discussed the techniques involved with placing retention sutures, and using them in a secondary suture line. *(See the section on Suturing Techniques.) Heavy sizes (0 to 5) of nonabsorbable materials* are usually used for retention sutures, not for strength, but because larger sizes are less likely to cut through tissue when a sudden rise in intra-abdominal pressure occurs from vomiting, coughing,

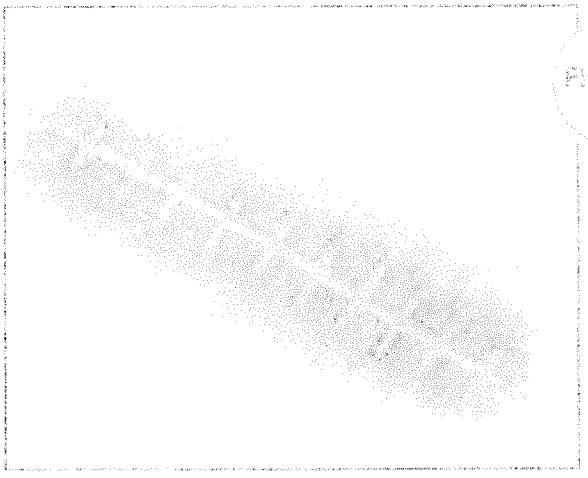


FIGURE 15

THE RAILROAD TRACK SCAR CONFIGURATION

* Trademark

straining, or distention. To prevent the heavy suture material from cutting into the skin under stress, one end of the retention suture may be threaded through a short length of plastic or rubber tubing called a *bolster* or *bumper* before it is tied. A plastic bridge with adjustable features may also be used to protect the skin and primary suture line and permit postoperative wound management for patient comfort.

Properly placed retention sutures provide strong reinforcement for abdominal wounds, but also cause the patient more postoperative pain than does a layered closure. The best technique is to use a material with needles swaged on each end *(double-armed)*. They should be placed from the inside of the wound toward the outside skin to avoid pulling potentially contaminated epithelial cells through the entire abdominal wall.

The ETHICON retention suture line includes ETHILON* sutures, MERSILENE* sutures, ETHIBOND* *EXCEL* sutures, and PERMA-HAND* sutures. Surgical steel sutures may also be used.

Retention sutures may be left in place for 14 to 24 days postoperatively. Three weeks is an average length of time. Assessment of the patient's condition is the controlling factor in deciding when to remove retention sutures.

SUTURE FOR DRAINS

If a drainage tube is placed in a hollow organ or a bladder drain is inserted, it may be secured to the wall of the organ being drained with *absorbable sutures*. The surgeon may also choose to minimize the distance between the organ and the abdominal wall by using sutures to tack the organ being drained to the peritoneum and fascia.
Sutures may be placed around the circumference of the drain, either two sutures at 12 and 6 o'clock positions, or four sutures at 12, 3, 6, and 9 o'clock positions, and secured to the skin with temporary loops. When the drain is no longer needed, the skin sutures may be easily removed to remove the drain. The opening can be left open to permit additional drainage until it closes naturally.

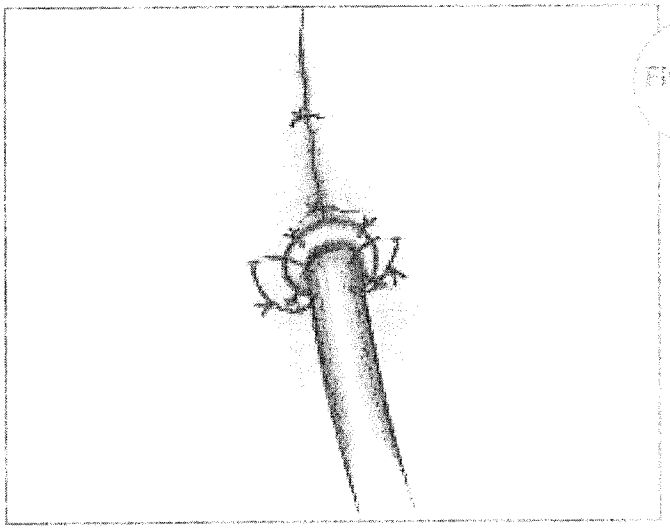


FIGURE 15

PLACEMENT OF SUTURES AROUND A DRAIN

A drainage tube inserted into the peritoneal cavity through a stab wound in the abdominal wall usually is anchored to the skin with one or two nonabsorbable sutures. This prevents the drain from slipping into or out of the wound.

SUTURE NEEDS IN OTHER BODY TISSUES NEUROSURGERY

Surgeons have traditionally used an interrupted technique to close the galea and dura mater.

The tissue of the galea, similar to the fascia of the abdominal cavity, is very vascular and hemostatic. Therefore, scalp hematoma is a potential problem, and the surgeon must be certain to close well.
The dura mater is the outermost of the three meninges that protects the brain and spinal cord. It tears with ease and cannot withstand too much tension. The surgeon may drain some of the cerebrospinal fluid to decrease volume, easing the tension on the dura before closing. If it is too damaged to close, a patch must be inserted and sutured in place.

Surgical silk is appropriate in this area for its pliability and easy knot tying properties. Unfortunately, it elicits a significant foreign body tissue reaction. Most surgeons have switched to NUROLON* sutures or coated VICRYL* sutures because they tie easily, offer greater strength than surgical silk, and cause less tissue reaction. PROLENE* sutures have also been accepted by surgeons who prefer a continuous closure technique, who must repair potentially infected wounds, or who must repair dural tears.

In peripheral nerve repair, precise suturing often requires the aid of an operating microscope. Suture gauge and needle fineness must be consistent with nerve size. After the motor and sensory fibers are properly realigned, the epineurium (the outer sheath of the nerve) is sutured. The strength of sutures in this area is less of a consideration than the degree of inflammatory and fibroplastic tissue reaction. Fine sizes of *nylon*, *polyester*, and *poly-propylene* are preferred.

MICROSURGERY

The introduction of fine sizes of sutures and needles has increased the use of the operating microscope. ETHICON introduced the first microsurgery sutures—ETHILON* sutures—in sizes 8-0 through 11-0. Since then, the microsurgery line has expanded to include PROLENE* sutures and coated VICRYL* sutures. Literally all surgical specialties perform some procedures under the operating microscope, especially vascular and nerve anastomosis.

OPHTHALMIC SURGERY

The eye presents special healing challenges. The ocular muscles, the conjunctiva, and the sclera have good blood supplies; but the cornea is an avascular structure. While epithelialization of the cornea occurs rapidly in the absence of infection, full thickness cornea wounds heal slowly. Therefore, in closing wounds such as cataract incisions, sutures should remain in place for approximately 21 days. Muscle recession, which involves suturing muscle to sclera, only requires sutures for approximately 7 days.

Nylon was the preferred suture material for ophthalmic surgery. While nylon is not absorbed, progressive hydrolysis of nylon *in vivo* may result in gradual loss of tensile strength over time. Fine sizes of *absorbable sutures* are currently used for many ocular procedures. Occasionally, the sutures are absorbed too slowly in muscle recessions and produce granulomas to the sclera. Too rapid absorption has, at times, been a problem in cataract surgery. Because they induce less cellular reaction than surgical gut and behave dependably, VICRYL sutures have proven useful in muscle and cataract surgery.

While some ophthalmic surgeons promote the use of a "no-stitch" surgical technique, 10-0 coated VICRYL (polyglactin 910) violet monofilament sutures offer distinct advantages. They provide the security of suturing immediately following surgery but eliminate the risks of suture removal and related endophthalmitis.

The ophthalmologist has many fine size suture materials to choose from for keratoplasty, cataract, and vitreous retinal microsurgical procedures. In addition to VICRYL* sutures, *other monofilament suture materials* including ETHILON sutures, PROLENE sutures, and PDS* II sutures may be used. *Braided material* such as virgin silk, black braided silk, MERSILENE* sutures, and coated VICRYL sutures are also available for ophthalmic procedures.

UPPER ALIMENTARY TRACT PROCEDURES

The surgeon must consider the upper alimentary tract from the mouth down to the lower esophageal sphincter to be a potentially contaminated area. The gut is a musculomembranous canal lined with mucus membranes. Final healing of mucosal wounds appears to be less dependent upon suture material than on the wound closure technique.

The oral cavity and pharynx generally heal quickly if not infected. Fine size sutures are adequate in this area as the wound is under little tension. *Absorbable sutures* may be

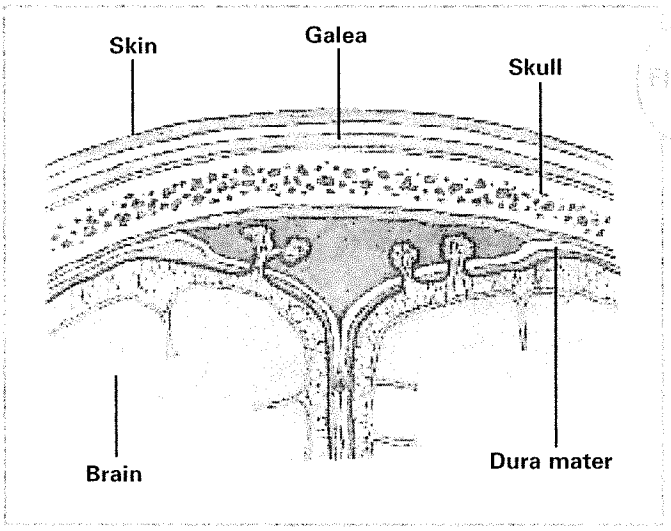


FIGURE 17

LAYERS OF SUTURES SURROUNDING A DRAIN

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preferred. Patients, especially children, usually find them more comfortable. However, the surgeon may prefer a *monofilament nonabsorbable suture* under certain circumstances. This option causes less severe tissue reaction than multifilament materials in buccal mucosa, but also requires suture removal following healing.

In cases involving severe periodontitis, VICRYL periodontal mesh may be used to promote tissue regeneration, a technique that enhances the regeneration and attachment of tissue lost due to periodontitis. VICRYL periodontal mesh, available in several shapes and sizes with a preattached VICRYL ligature, is woven from the same copolymer used to produce absorbable VICRYL* suture. As a synthetic absorbable, VICRYL* periodontal mesh eliminates the trauma associated with a second surgical procedure and reduces the risk of infection or inflammation associated with this procedure.

The esophagus is a difficult organ to suture. It lacks a serosal layer. The mucosa heals slowly. The thick muscular layer does not hold sutures well. If multifilament sutures are used, penetration through the mucosa into the lumen should be avoided to prevent infection.

RESPIRATORY TRACT SURGERY

Relatively few studies have been done on healing in the respiratory tract. Bronchial stump closure following lobectomy or pneumonectomy presents a particular challenge. Infection, long stumps, poor approximation of the transected

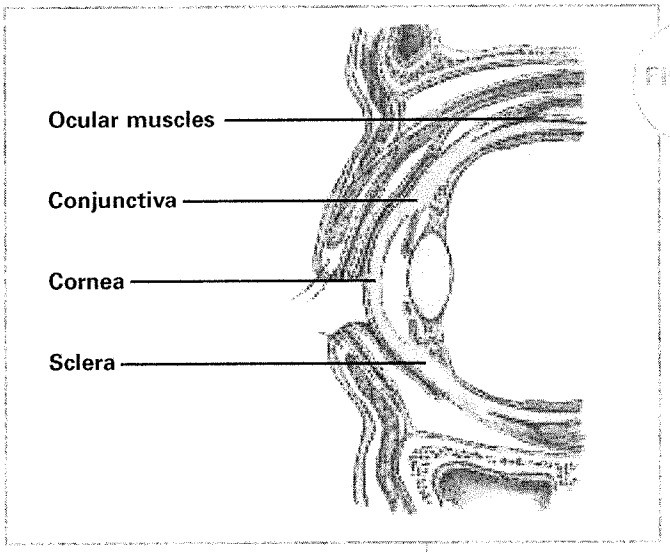

FIGURE 18

THE EYE

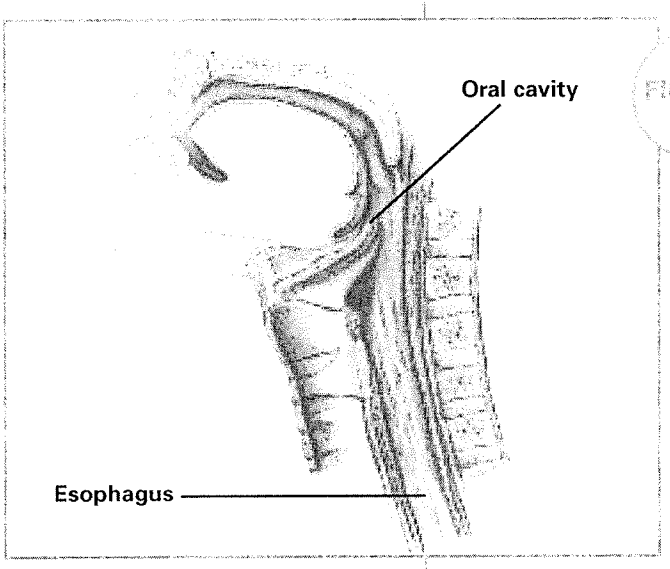

FIGURE 19

THE UPPER ALIMENTARY CANAL

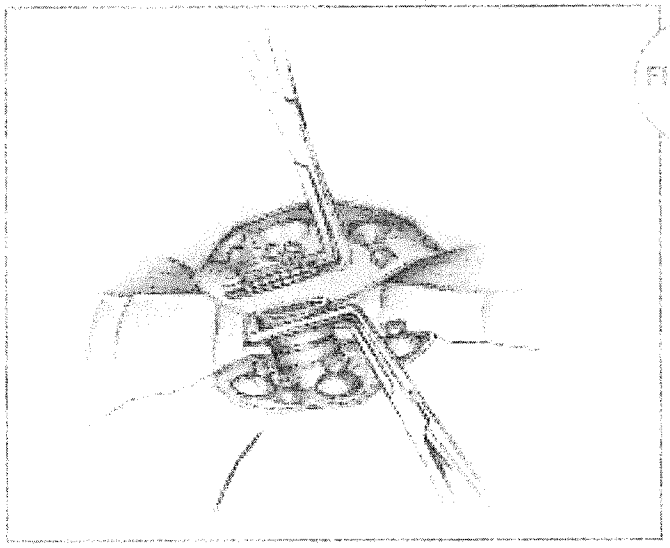

FIGURE 20

BRONCHIAL STUMP CLOSURE

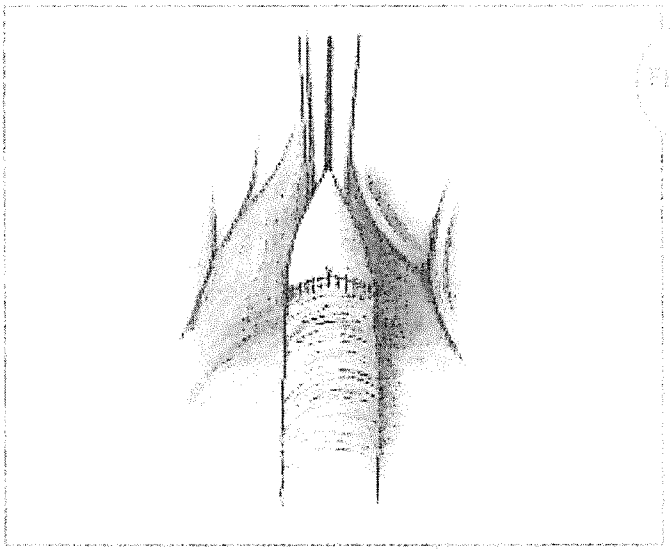

FIGURE 21

CONTINUOUS STRAND SUTURING IN VASCULAR SURGERY

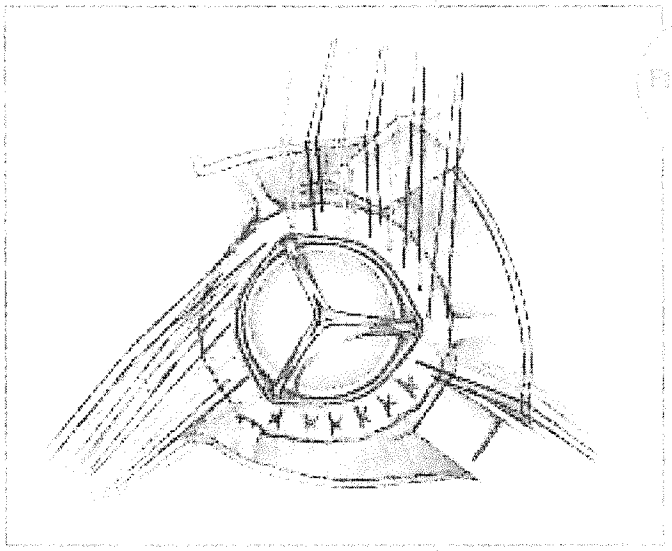

FIGURE 22

SEATING A HEART VALVE WITH ETHIBOND *EXCEL* SUTURE

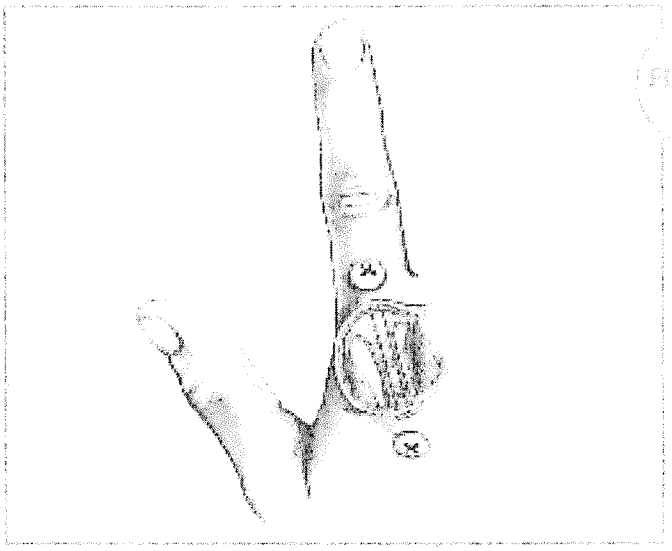

FIGURE 23

THE BUNNELL TECHNIQUE

bronchus, and incomplete closure (i.e., air leaks) may lead to bronchopleural fistula. Avoidance of tissue trauma and maintenance of the blood supply to the area of closure are critical to healing. The bronchial stump heals slowly, and sometimes not at all. Unless it is closed tightly with strong, closely spaced sutures, air may leak into the thoracic cavity.

Closure is usually achieved with *mechanical devices*, particularly staples. When sutures are used, *polypropylene monofilament nonabsorbable* sutures are less likely to cause tissue reaction or harbor infection. Silk suture is also commonly used. Surgeons usually avoid absorbable sutures because they may permit secondary leakage as they lose strength.

Monofilament nylon suture should also be avoided because of its potential for knot loosening.

CARDIOVASCULAR SURGERY

Although definitive studies are few, blood vessels appear to heal rapidly. Most cardiovascular surgeons prefer to use synthetic nonabsorbable sutures for cardiac and peripheral vascular procedures. Lasting strength and leakproof anastomoses are essential. Wire sutures are used on the sternum unless it is fragile, in which case absorbable sutures can be used.

VESSELS

Excessive tissue reaction to suture material may lead to decreased luminal diameter or to thrombus formation in a vessel. Therefore, the more inert synthetics including *nylon* and *polypropylene* are the materials of choice for vessel

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anastomoses. *Multifilament polyester sutures* allow clotting to occur within the interstices which helps to prevent leakage at the suture line. The advantages of a material such as ETHIBOND* *EXCEL* sutures are its strength, durability, and slippery surface which causes less friction when drawn through a vessel. Many surgeons find that PROLENE* sutures, PRONOVA* sutures, or silk are ideal for coronary artery procedures because they do not "saw" through vessels.

Continuous sutures provide a more leakproof closure than interrupted sutures in large vessel anastomoses because the tension along the suture strand is distributed evenly around the vessel's circumference. Interrupted *monofilament sutures* such as ETHILON* sutures, PROLENE* sutures, or PRONOVA* sutures are used for microvascular anastomoses. When anastomosing major vessels in young children, special care must be taken to anticipate the future growth of the patient. Here, the surgeon may use silk to its best advantage, because it loses much of its tensile strength after approximately 1 year, and is usually completely absorbed after 2 or more years. Continuous *polypropylene sutures* have been used in children without adverse effects. The continuous suture, when placed, is a coil which stretches as the child grows to accommodate the changing dimensions of the blood vessel. However, reports of stricture following vessel growth have stimulated interest in use of a suture line which is one-half continuous, one-half interrupted. Clinical studies suggest that a *prolonged absorbable suture*, such as PDS* II suture, may be ideal, giving adequate short-term support while permitting future growth.

Following vascular trauma, mycotic aneurysms from infection are extremely serious complications. A suture may act as a nidus for an infection. In the presence of infection, the chemical properties of suture material can cause extensive tissue damage which may reduce the tissue's natural ability to combat infection. Localized sepsis can also spread to adjacent vascular structures, causing necrosis of the arterial wall. Therefore, the surgeon may choose a *monofilament suture material* that causes only a mild tissue reaction and resists bacterial growth.

VASCULAR PROSTHESES

The fixation of vascular prostheses and artificial heart valves presents an entirely different suturing challenge than vessel anastomosis. The sutures must retain their original physical properties and strength throughout the life of the patient. A prosthesis never becomes completely incorporated into the tissue and constant movement of the suture line occurs. *Coated polyester sutures* are the choice for fixation of vascular prostheses and heart valves because they retain their strength and integrity indefinitely.

Either a continuous or interrupted technique may be used for vessel to graft anastomoses.

To assist in proper strand identification, many surgeons alternate green and white strands of ETHIBOND* *EXCEL* suture around the cuff of the valve before tying the knots.

Some surgeons routinely use pledgets to buttress sutures in valve surgery. They are used most commonly in valve replacement procedures to prevent the annulus from tearing when the prosthetic valve is seated and the sutures are tied. They may also be used in heart wall closure of penetrating injuries, excising aneurysms, vascular graft surgery, and to add support when the surgeon encounters extreme deformity, distortion, or tissue destruction at the annulus.

URINARY TRACT SURGERY

Closure of tissues in the urinary tract must be leakproof to prevent escape of urine into surrounding tissues. The same considerations that affect the choice of sutures for the biliary tract affect the choice of sutures for this area. Nonabsorbable sutures incite the formation of calculi, and therefore cannot be used. Surgeons use *absorbable sutures* as a rule, especially MONOCRYL* sutures, PDS II sutures, VICRYL* sutures, Coated VICRYL* sutures, and chromic gut sutures.

The urinary tract heals rapidly. The transitional cell epithelium migrates over the denuded surfaces quickly. Unlike other epithelium, the migrating cells in the urinary tract undergo mitosis and cell division. Epithelial migration may be found along suture tracts in the body of the bladder. The bladder wall regains 100% of its original tensile strength within 14 days. The rate of collagen synthesis peaks at 5 days and declines rapidly thereafter.

Thus, sutures are needed for only 7 to 10 days.

THE FEMALE GENITAL TRACT

Surgery within this area presents certain challenges. First, it is usually regarded as a potentially contaminated area. Second, the surgeon must frequently work within a very restricted field. Endoscopic technique is frequently used in this area. Coated VICYL* suture is an excellent choice to prevent bacterial colonization.

Most gynecological surgeons prefer to use *absorbable sutures* for repair of incisions and defects. Some prefer using heavy, size 1 surgical gut sutures, MONOCRYL sutures, or VICRYL sutures. However, the stresses on the reproductive organs and the rate of healing indicate that these larger-sized sutures may only be required for abdominal closure.

Handling properties, especially pliability of the sutures used for internal use, are extremely important. *Synthetic absorbable sutures* such as VICRYL* sutures in size 0 may be used for the tough, muscular, highly vascular tissues in the pelvis and vagina. These tissues demand strength during approximation and healing. Coated VICRYL* *RAPIDE* suture, for example, is an excellent choice for episiotomy repair.

TENDON SURGERY

Tendon surgery presents several challenges. Most tendon injuries are due to trauma, and the wound may be dirty. Tendons heal slowly. The striated nature of the tissue makes suturing difficult.

Tendon repair fibroblasts are derived from the peritendonous tissue and migrate into the wound. The junction heals first with scar tissue, then by replacement with new tendon fibers. Close apposition of the cut ends of the tendon (especially extensor tendons) must be maintained to achieve good functional results. Both the suture material and the closure technique are critical for successful tendon repair.

The suture material the surgeon chooses must be inert and strong. Because tendon ends can separate due to muscle pull, sutures with a great degree of elasticity should be avoided. *Surgical steel* is widely used because of its durability and lack of elasticity. *Synthetic nonabsorbable materials* including polyester fibers, polypropylene, and nylon may be used. In the presence of potential infection, the most inert monofilament suture materials are preferred. The suture should be placed to cause the least possible interference with the surface of the tendon, as this is the gliding mechanism. It should also not interfere with the blood supply reaching the wound. Maintenance of closed apposition of the cut ends of the tendons, particularly extensor tendons, is critical for good functional results. The parallel arrangement of tendon fibers in a longitudinal direction makes permanent and secure placement of sutures difficult. Various figure-of-eight and other types of suturing have been used successfully to prevent suture slippage and the formation of gaps between the cut ends of the tendon.

Many surgeons use the Bunnell Technique. The suture is placed to be withdrawn when its function as a holding structure is no longer necessary. Referred to as a *pull-out suture*, it is brought out through the skin and fastened over a polypropylene button. The Bunnell Technique suture can also be left in place.

NUROLON* sutures, PROLENE* sutures, PRONOVA* sutures and ETHIBOND* *EXCEL* sutures may be used for connecting tendon to bone. Permanent wire sutures also yield good results because healing is slow. In periosteum, which heals fairly rapidly, surgical gut or coated VICRYL sutures may be used. In fact, virtually any suture may be used satisfactorily in the periosteum.

SUTURES FOR BONE

In repairing facial fractures, *monofilament surgical steel* has proven ideal for its lack of elasticity. Facial bones do not heal by callus formation, but more commonly by fibrous union. The suture material must remain in place for a long period of time—perhaps months—until the fibrous tissue is laid down and remodeled. Steel sutures immobilize the fracture line and keep the tissues in good apposition.

Following median stemotomy, surgeons prefer interrupted steel sutures to close. Sternum closure may be difficult. Appropriate tension must be maintained, and the surgeon must guard against weakening the wire. Asymmetrical twisting of the wire may cause it to buckle, fatiguing the metal, and ultimately causing the wire to break. Motion between the sides of the sternum will result, causing postoperative pain and possibly dehiscence. Painful nonunion is another possible complication. (In osteoporotic patients, very heavy

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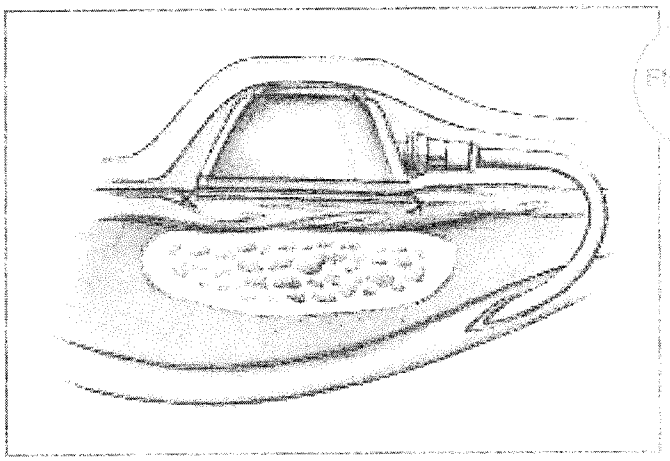

FIGURE 24

TACKING A PROSTHETIC DEVICE IN POSITION TO PREVENT MIGRATION

VICRYL sutures may be used to close the sternum securely.)

The surgeon may use a bone anchor to hold one end of a suture in place when needed (e.g., shoulder repair surgery). This involves drilling a hole in the bone and inserting the anchor, which expands once completely inside the bone to keep it from being pulled out.

OTHER PROSTHETIC DEVICES

Often, it is necessary for the surgeon to implant a prosthetic device such as an automatic defibrillator or drug delivery system into a patient. To prevent such a device from migrating out of position, it may be tacked to the fascia or chest wall with nonabsorbable sutures.

CLOSING CONTAMINATED OR INFECTED WOUNDS

Contamination exists when microorganisms are present, but in insufficient numbers to overcome the body's natural defenses. Infection exists when the level of contamination exceeds the tissue's ability to defend against the invading microorganisms. Generally, contamination becomes infection when it reaches approximately 10^6 bacteria per gram of tissue in an immunologically normal host. Inflammation without discharge and/or the presence of culture-positive serous fluid indicate possible infection. Presence of purulent discharge indicates positive infection.

Contaminated wounds can become infected when hematomas, necrotic tissue, devascularized tissue, or large amounts of devitalized tissue (especially in fascia, muscle, and bone) are present. Microorganisms multiply rapidly under these conditions, where they are safe from cells that provide local tissue defenses.

In general, contaminated wounds should not be closed but should be left open to heal by secondary intention because of the risk of infection. Foreign bodies, including sutures, perpetuate localized infection. Therefore, the surgeon's technique and choice of suture is critical. *Nonabsorbable monofilament nylon sutures* are commonly used in anticipation of delayed closure of dirty and infected wounds. The sutures are laid in but not tied. Instead, the loose suture ends are held in place with PROXI-STRIP* skin closures (sterile tape). The wound should be packed to maintain a moist environment. When the infection has subsided, the surgeon can easily reopen the wound, remove the packing and any tissue debris, and then close using the previously inserted monofilament nylon suture.

IN THE NEXT SECTION

The surgeon depends as much upon the quality and configuration of the needle used as on the suturing material itself to achieve a successful closure. The relationship between needles and sutures will be explored on the pages that follow.

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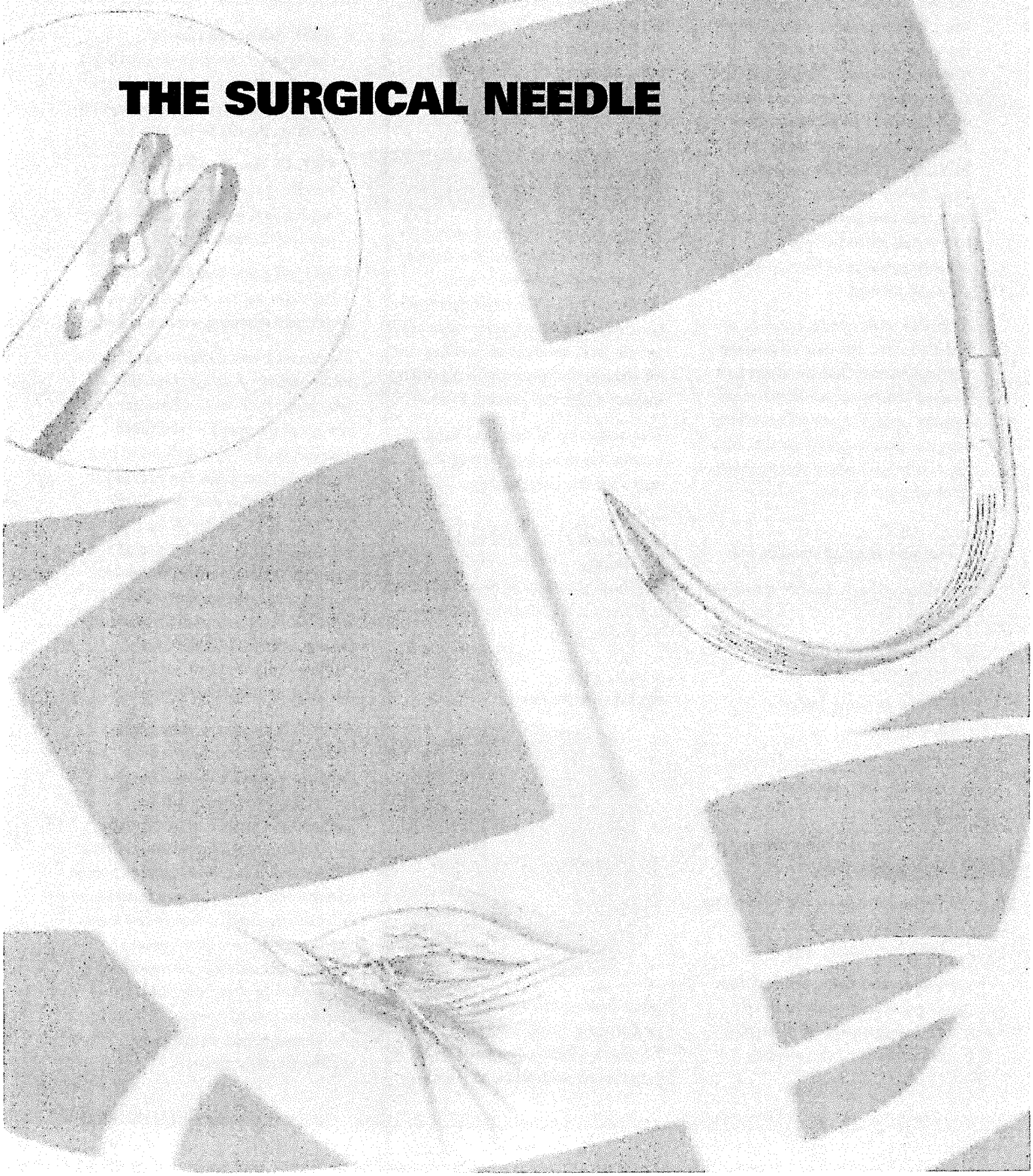
CHAPTER 3

THE SURGICAL NEEDLE



Necessary for the placement of sutures in tissue, surgical needles must be designed to carry suture material through tissue with minimal trauma. They must be sharp enough to penetrate tissue with minimal resistance. They should be rigid enough to resist bending, yet flexible enough to bend before breaking. They must be sterile and corrosion-resistant to prevent introduction of microorganisms or foreign bodies into the wound.

Comfort with needle security in the needleholder, the ease of passage through tissue, and the degree of trauma that it causes all have an impact upon the overall results of surgical needle performance. This is especially true when precise cosmetic results are desired.

The best surgical needles are:

- Made of high quality stainless steel.
- As slim as possible without compromising strength.
- Stable in the grasp of a needleholder.
- Able to carry suture material through tissue with minimal trauma.
- Sharp enough to penetrate tissue with minimal resistance.
- Rigid enough to resist bending, yet ductile enough to resist breaking during surgery.
- Sterile and corrosion-resistant to prevent introduction of microorganisms or foreign materials into the wound.

Variations in needle geometries are just as important as variations in suture sizes. Needle dimensions must be compatible with suture sizes, allowing the two to work in tandem.

ELEMENTS OF NEEDLE DESIGN

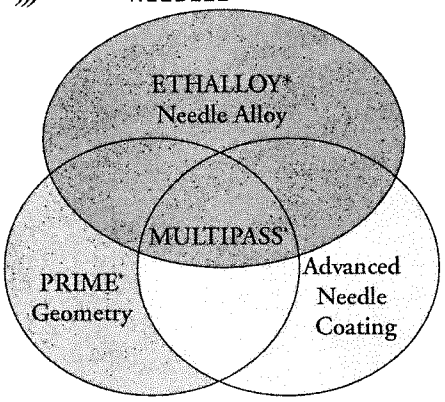
Needle design involves analyzing a surgical procedure and the density of the tissue involved in great detail. ETHICON engineers work continuously to improve upon their needle line, sometimes making subtle alterations resulting in a positive impact upon the procedure itself.

The anatomy of the ideal surgical needle has three key factors that make up the ideal needle.

– Alloy
– Geometry – tip and body
– Coating

The combination of these attributes is ETHICON MultiPass Needle Technology.

ETHICON MultiPass* NEEDLES



MultiPass needles are the highest performing needles that ETHICON Products offers; comprised of three proprietary technologies which ensure superior strength, tissue penetration and control; pass after pass.

- ***NEW* Advanced Needle Coating**—new silicone coating helps to maintain needle sharpness pass after pass and consistency from needle to needle
- **PRIME Needle Geometry**—needles have less mass and require less penetration force to minimize tissue trauma
- **ETHALLOY Needle Alloy**—provides superior strength and ductility (bending without breaking)

The various metal alloys used in the manufacture of surgical needles determine their basic characteristics to a great degree. ETHICON* stainless steel alloy needles are heat-treated to give them the maximum possible strength and ductility. ETHALLOY* needle alloy (Patent No. 5,000,912) was developed for unsurpassed strength in precision needles used in cardiovascular, ophthalmic, plastic, and microsurgical procedures. It is produced economically without sacrificing ductility or corrosion resistance.

A needle's *strength* is determined by how it resists deformation during repeated passes through tissue. Tissue trauma can be induced if a needle bends during penetration and compromises tissue apposition. Therefore, greater needle strength equals less tissue trauma. A weak needle that bends too easily can compromise the surgeon's control and damage surrounding tissue during the procedure. In addition, loss of control in needle placement could result in an inadvertent needlestick.

Manufacturers measure needle strength in the laboratory by bending them 90° to determine the needle's maximum strength. This is referred to as the needle's "ultimate moment," and is more important to the needle manufacturer than to the surgeon. The most critical aspect of needle strength to the surgeon is the "surgical yield" point. Surgical yield indicates the amount of angular deformation the needle can withstand before becoming permanently deformed. This point is usually 10° to 30° depending upon the material and the manufacturing process. Any angle beyond that point renders the needle useless. Reshaping a bent needle may cause it to lose strength and be less resistant to bending and breaking.

At ETHICON, the combination of alloy selection and the needle manufacturing process are carefully selected to achieve the highest possible surgical yield, which also optimizes needle strength.

Ductility refers to the needle's resistance to breaking under a given amount of bending. If too great a force is applied to a needle it may break, but a ductile needle will bend before breaking. Needle breakage during surgery can prevent apposition of the wound edges as the broken portion passes through tissue. In addition, searching for part of a broken needle can cause added tissue trauma and add to the time the patient is anesthetized. A piece that cannot be retrieved will remain as a constant reminder to both the patient and surgeon. Needle bending and breakage can be minimized by carefully passing needles through tissue in the direction of the needle body. Needles are not designed to be used as retractors to lift tissue.

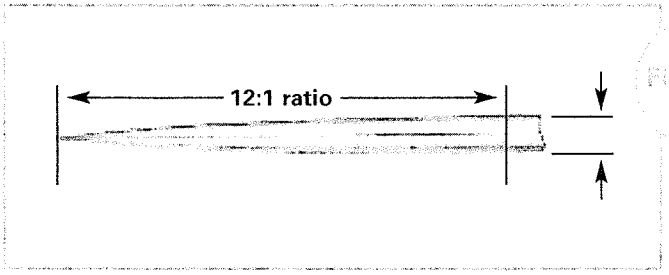


FIGURE 1

TAPER RATIO

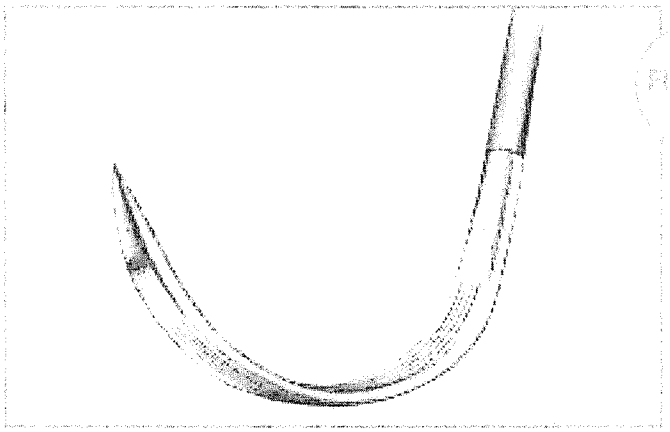


FIGURE 2

ETHICON RIBBED NEEDLE

Needle *sharpness* is especially important in delicate or cosmetic surgery. The sharper the needle, the less scarring that will result. However, the right balance must be found. If a needle is too sharp, a surgeon may not feel he or she has adequate control of needle passage through tissue.

Sharpness is related to the angle of the point as well as the taper ratio of the needle. The ETHICON sharpness tester incorporates a thin, laminated, synthetic membrane that simulates the density of human tissue, allowing engineers to gauge exactly how much force is required for penetration.

MultiPass needles have a micro-thin coating comprised of a patented silicone formulation that improves penetration performance over multiple passes. According to laboratory tests, this coating serves several important functions:

- It reduces the force needed to make initial penetration through tissue; thus it is 58% sharper (than other surgical needles) on multiple passes in human tissue
- Significantly improves the consistency of the needle penetration (pass to pass, needle to needle)
- Maintains sharpness for better penetration and control over multiple passes while delivering ongoing strength, sharpness and control

Needle performance is also influenced by the stability of the needle in the grasp of a needleholder. Most curved needles are flattened in the grasping area to enhance control. All ETHICON

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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.)*

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* 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.

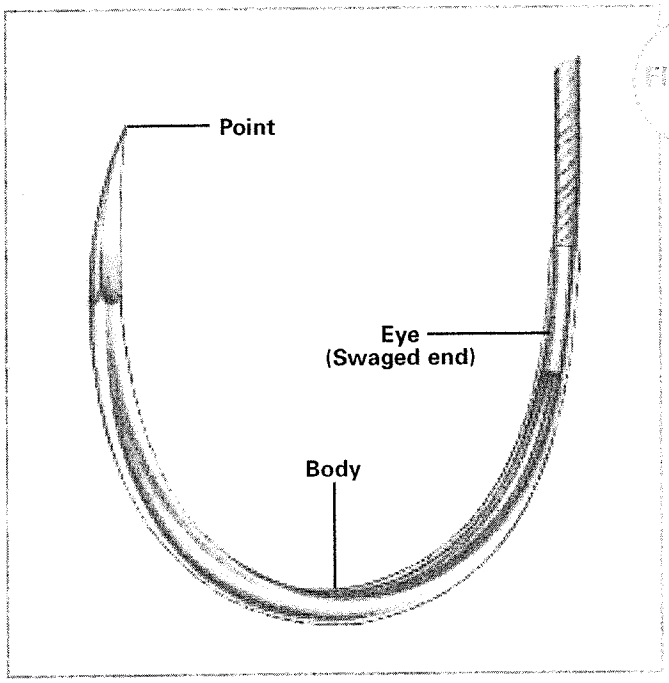


FIGURE 3
NEEDLE COMPONENTS

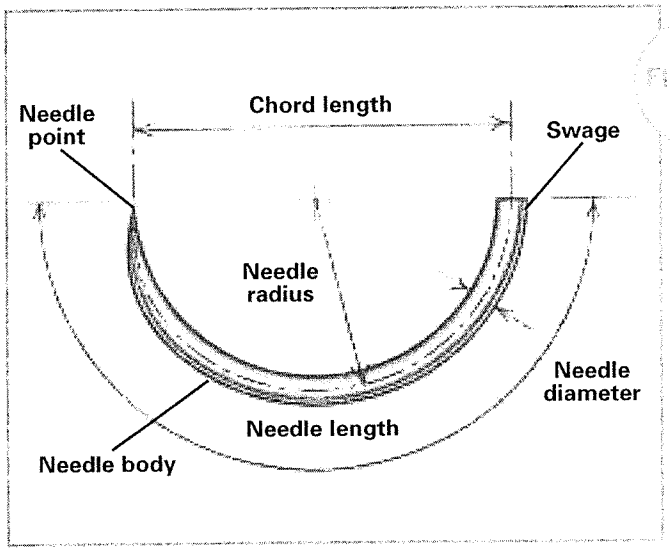


FIGURE 4
ANATOMY OF A NEEDLE

THE ANATOMY OF A NEEDLE

Regardless of its intended use, every surgical needle has three 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 two extremes.

THE NEEDLE EYE

The eye falls into one of three 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 one 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).

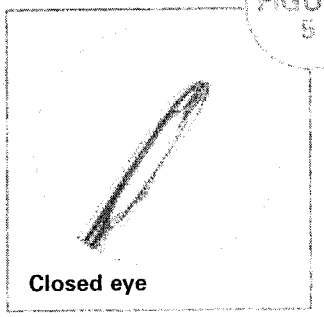
The diameter of a needle swaged to suture material is no larger than necessary to accommodate the diameter of the suture strand itself. Swaged sutures offer several advantages to the surgeon, nurse, and patient.

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

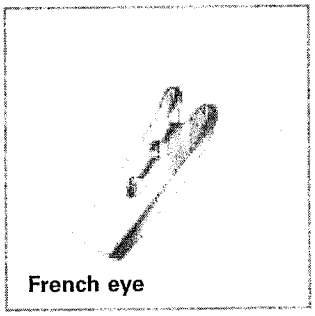
* Trademark

THE NEEDLE EYE

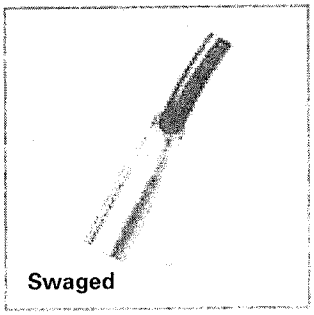
FIGURE 5



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 comers in the eye of eyed needles.
11. Needles are corrosion-free.

Small diameter ETHICON 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 surgical needles made by ETHICON are supplied in a variety of sizes, shapes, and strengths. Some of them incorporate the CONTROL RELEASE needle suture principle which 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

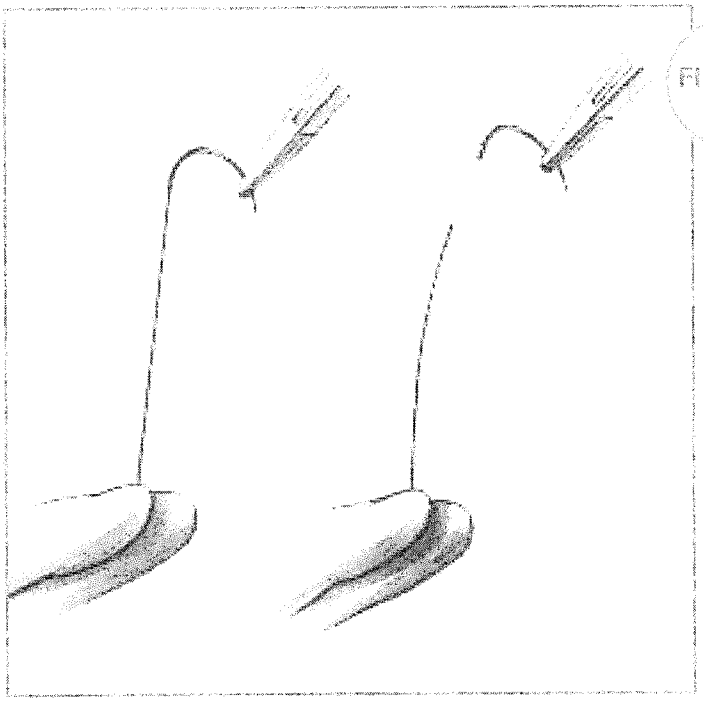
The body of the needle is the portion which is grasped by the needleholder during the surgical procedure. The body of the needle should be as close as possible to the diameter of the suture material to minimize bleeding and leakage. This is especially true for cardiovascular, gastrointestinal, and bladder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

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.

suturing easily accessible tissue. Most of these needles are designed 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 transchamber 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,

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, resporatory 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

* Trademark

uniform bites of tissue. The tight 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.

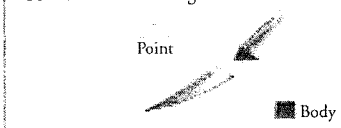
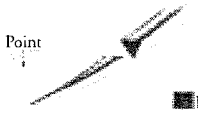
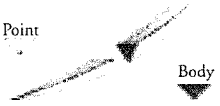
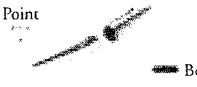
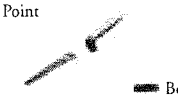
TYPES OF NEEDLES

CUTTING NEEDLES

Cutting needles have at least two 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.

FIGURE 8

NEEDLE POINTS AND BODY SHAPES AND TYPICAL APPLICATIONS

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

CONVENTIONAL CUTTING NEEDLES

In addition to the two 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 1/4" (6mm) from the round body and terminate in a triangular-shaped tip. This particular sternotomy needle maximizes cutting efficiency and control in the needleholder. TAPERCUT surgical 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.

A needle manufactured by the

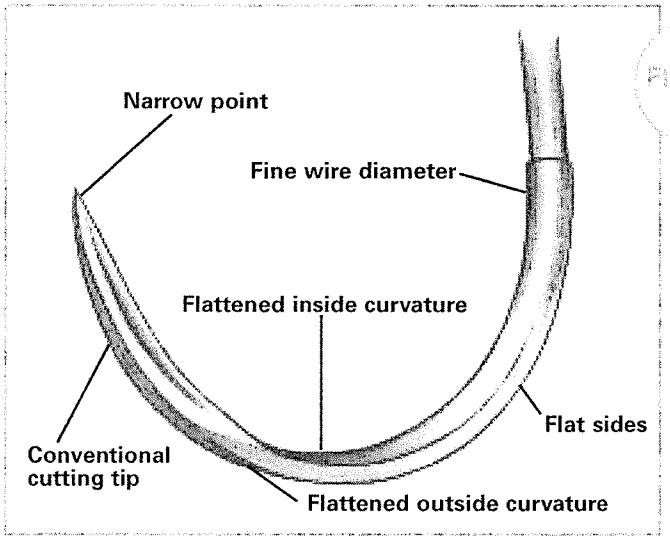


FIGURE 9

THE PC PRIME NEEDLE

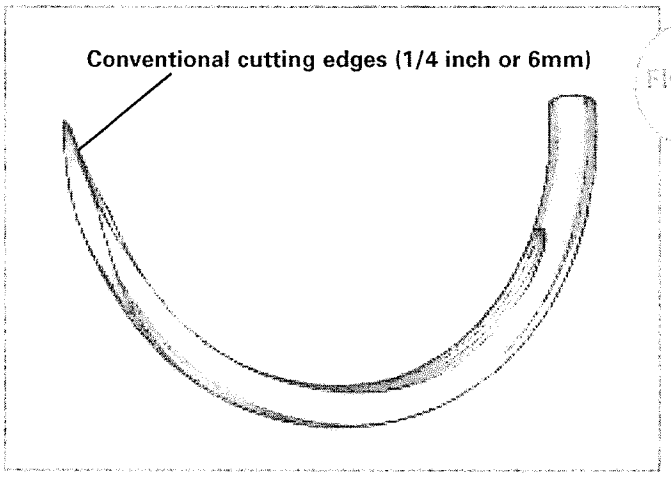


FIGURE 10

STERNOTOMY NEEDLE

* Trademark

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

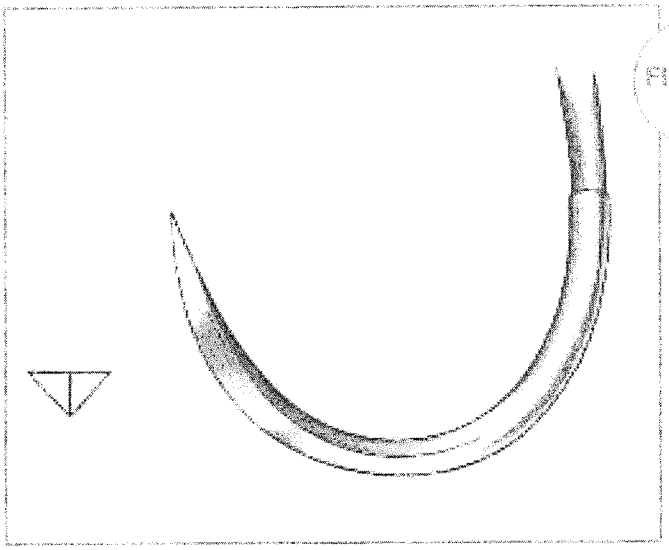


FIGURE 11

REVERSE CUTTING NEEDLE

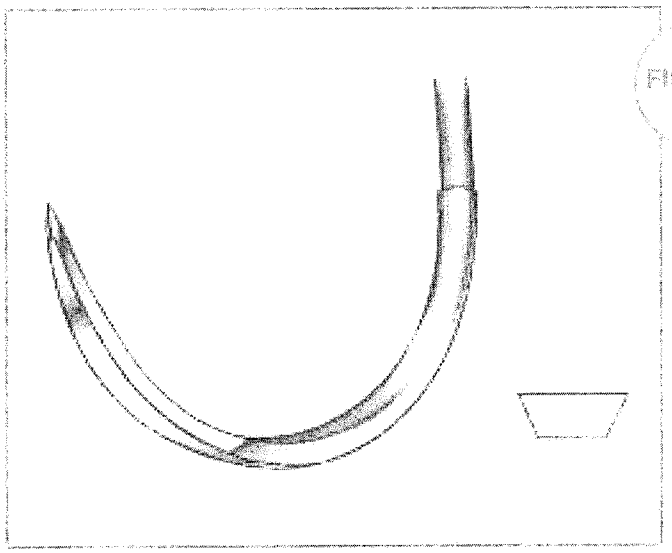


FIGURE 12

SPATULA NEEDLE CROSS-SECTION

SIDE CUTTING NEEDLES

Also referred to as spatula needles, they feature a unique design which 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 comeal 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 two cutting edges and a trapezoidal-shaped body.

The SABRELOC* needle with the cobra-shaped tip has four 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 which 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 which 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* 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 tissue.

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

TABLE 1

ETHICON NEEDLE CODES & OTHER MEANING

CODE	MEANING
BB	Blue Baby
BIF	Intraocular Fixation
BN	Bunnell
BP	Blunt Point
BV	Blood Vessel
BVH	Blood Vessel Half
C	Cardiovascular
CC	Calcified Cornary
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
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 Fergusan
MH	Medium Half (circle)
MO	Mayo
MOB	Mayo Blunt
OPS	Ocular Plastic Surgery
OS	Orthopaedic 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
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)

* Trademark

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 which 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.

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.

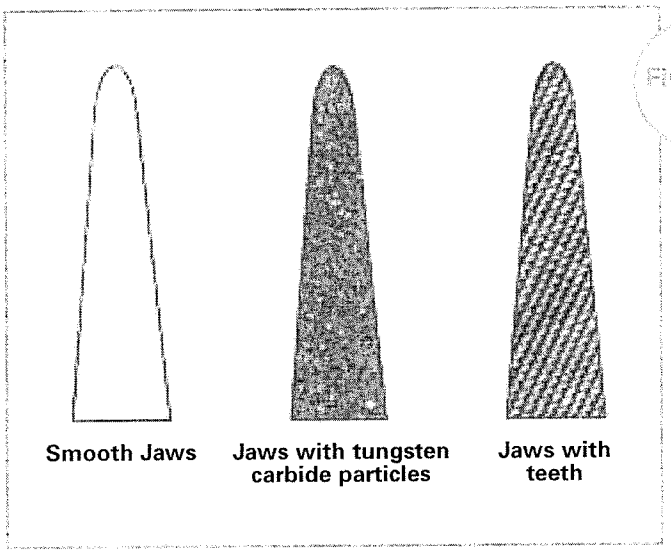


FIGURE 11

REVERSE CUTTING NEEDLE

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

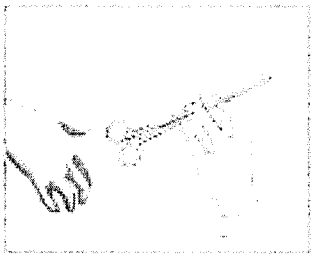
not entangled.

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).

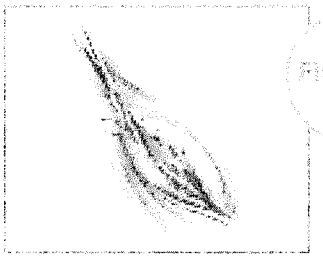
PLACING THE NEEDLE IN TISSUE

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 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 transmissable agents such as hepatitis B and C and HIV.



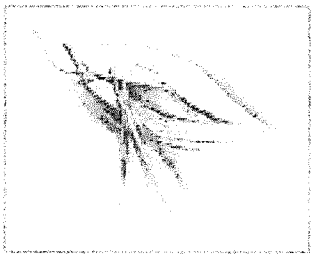
1. The surgeon receives the needleholder with the needle point toward the thumb to prevent unnecessary wrist motion. The scrub person controls the free end of the suture to prevent dragging it across the sterile field, and to keep the suture from entering the surgeon's hand along with the needleholder.

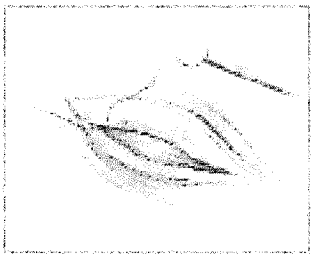


2. The surgeon begins closure with theswaged suture.

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 reclamps 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.

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

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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.

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.
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.

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.