Suture Choice and Other Methods of Skin Closure

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Historically, there were few surgical options for wound closure. From catgut, silk, and cotton, there is now an ever-increasing array of sutures, approximately 5,269 different types, including antibiotic-coated and knotless sutures. In addition to the continual advancement in suture material, the variety and refinement of surgical needles and packaging has also increased. New closure methods have recently been developed, such as topical adhesives and absorbable staples, which can either be used alone or in combination with traditional suture repair.

The surgeon evaluating a skin laceration has to choose the best closure method for that particular patient and wound from a multitude of possibilities. Closing a wound in an infant differs greatly from closing a wound in an elderly patient with multiple comorbidities, such as diabetes, heart disease, steroids use, and thin skin. Skin itself varies throughout the body in terms of its thickness, elasticity, speed of healing, and tendency to scar. Suture techniques that avoid suture marks such as “railroad tracks,” especially in skin exposed in normal clothing, are generally more aesthetically pleasing to the patient. In the selection of a suture, a patient’s health status, age, weight and comfort, and the presence or absence of infection are as important as the biomechanical properties of the suture, individual wound characteristics, anatomic location, and a surgeon’s personal preference and experience in handling a suture material. There is often more than one appropriate method of closure. Although suture materials from different companies have similar chemical components, the performance and quality of these products are not always equivalent.

The ultimate responsibility for the choice of the best material lies with the surgeon. The cost of a complication, such as wound dehiscence, a fistula, reoperations, pain, and even death, will never justify the use of a less expensive, lower quality suture. Choosing a method of closure that affords a technically easy and efficient procedure, with a secure closure and minimal pain and scaring, is paramount to any
surgeon. This article addresses the current state of affairs of sutures and methods of wound closure. The nuances, advantages and disadvantages, and strengths and weaknesses of various suture choices in different circumstances are reviewed. Much of this reflection is based on the collective experience of the authors, each of whom has trained at a different institution and brings a unique set of experiences to the discussion.

**PROPERTIES OF SUTURE MATERIALS**

**Tensile Strength**
Tensile strength is the measured force, in pounds, that the suture will withstand before it breaks. Suture material should have, and maintain, adequate tensile strength for its specified purpose.

**Tissue Absorption**
Tissue absorption is a suture characteristic distinct from the rate of tensile strength loss. A suture may display rapid loss of tensile strength yet be absorbed slowly. An absorbable suture is defined as a suture that undergoes degradation and absorption in tissues. A nonabsorbable suture maintains its tensile strength and is resistant to absorption. However, most foreign materials will eventually undergo some degree of degradation over time. The rate of absorption is especially pertinent to late suture complications, such as the development of sinus tracts and granulomas. Absorbable sutures are generally used for buried sutures that approximate deep tissues. Nonabsorbable sutures are most commonly used externally in the skin and will eventually be removed, or for wounds in deeper structures that require prolonged support. Factors that delay wound healing are many and include, but are not limited to, diabetes, corticosteroid therapy, malnutrition, stress, and systemic disease. Such factors significantly influence suture choice, and with an increased risk of delayed healing, a nonabsorbable external closure would likely be chosen over an absorbable suture.

**Cross-Sectional Diameter**
Suture diameter designations are specified in descending sequence (ie, 1-0 is larger than 11-0). When selecting suture size, the finest gauge commensurate with the natural strength of the tissue is recommended. The number and diameter of sutures used to close a wound should be the minimum necessary for coaptation of the edges.

**Coefficient of Friction**
The coefficient of friction pertains to how easily a suture passes through tissue.

**Knot Security**
Knot strength is calculated by determining the force necessary to cause a knot to slip. The least reliable part of any suture is the knot. Knot security is the quality of a suture that allows it to be tied securely with a minimum number of throws per knot. Greater knot strength minimizes the risk of wound dehiscence. A knot stays tied because of the friction produced by one part of the knot acting on another, which relates to the coefficient of friction of the suture material. A suture with a high coefficient of friction has good knot security but tends to abrade and drag through tissue. A knot should hold securely without fraying or cutting. For safety, a knot should have at least 3 throws with 3-mm long ends. Smooth surfaces decrease knot security and must be compensated for with extra throws.
Elasticity

Elasticity is the ability of a material to return to its original length after stretching.\(^4\) High elasticity will allow the suture to stretch with wound edema but return to its original length and form once swelling has subsided. A high degree of elasticity provides obvious clinical advantages, because highly elastic suture material is less likely to cut through the skin with swelling and effectively approximates wound edges throughout the healing process.

Plasticity

Plasticity is defined as the capacity of a suture to be permanently molded or altered.\(^4\) Plasticity refers to the ability of a suture to stretch with wound edema without return to its original form once swelling subsides. Thus, sutures that are highly plastic may become too loose when swelling decreases and fail to correctly appose wound edges.

Memory

Memory is the capacity of a suture to assume a stable linear configuration after removal from packaging and after stretching. Memory is the capacity of a suture to remain free of curling and other contortions that may interfere with surgical handling and use. Sutures with significant memory are not pliable, which makes them difficult to work with, and significant memory necessitates additional knots.\(^9\) (Nylon has significant memory, whereas Gore-Tex suture has no memory).

Handling

Several factors impact on how a suture handles including elasticity, plasticity, and memory.\(^3\) The material should handle comfortably and naturally. The hallmark of silk is its exceptional handling characteristics (workability) and ease of knot tying, setting the standard with which all other material is compared.\(^3,6\)

Tissue Reactivity

All suture materials are foreign to human tissue and may elicit a tissue reaction,\(^3\) such as an inflammatory response, that interferes with wound healing and increases the risk of infection. The duration and severity of the tissue response depends on the type and quantity of suture material used along with its configuration.\(^9,10\) An ideal suture stimulates minimal tissue reaction and does not create a situation favorable to bacterial growth. Suture material should be nonelectrolytic, noncapillary, nonallergenic, and noncarcinogenic.

Origin

Suture material may be either natural or synthetic; natural fibers (eg, surgical gut and silk) cause a more intense inflammatory reaction than synthetic material (eg, polypropylene).

Physical Configuration

Suture material may be composed either of a single filament or multiple filaments.

- **Monofilament.** Monofilament sutures have several desirable qualities, including strength, low tissue drag, and low propensity to harbor infection. The incidence of wound infection is significantly lower with monofilament compared with braided sutures.\(^4,11\) However, monofilament sutures do not handle as easily as braided sutures.
• **Multifilament (braided or twisted).** A multifilament configuration handles easily but has been shown to promote tissue infection and reactivity. The increase in tissue infection is a result of capillary penetration by bacteria and other foreign materials. A braided suture may harbor bacteria within its crevices and bacteria may escape phagocytosis.

**Capillarity**

Capillarity of a suture describes the ease of transporting liquids along the suture strand and is an inherent physical property of multifilament sutures due to the available interstitial space. Capillarity is related to the ability of a suture to transport and spread microorganisms and is an important property in terms of wound infection. A braided nylon could take up to three times as many microorganisms as monofilament nylon. Monofilament sutures do not exhibit capillarity. Braided polyester (Mersilene) shows capillarity, whereas braided silk with wax and plain and chromic gut do not have capillarity.

**Fluid Absorption**

Fluid absorption and capillarity properties are presumed to be of significance due to the impact of contaminating bacteria on tissues. The chemical nature and physical structure of sutures determine the level of fluid absorption. However, the chemical nature seems to be more important than the physical structure. Synthetic sutures have much lower fluid absorption capability than natural sutures, because synthetic sutures are more hydrophobic. Multifilament sutures have a higher fluid absorption than monofilament sutures. Plain and chromic gut sutures demonstrate the highest fluid absorption.

**Ease of Removal**

For wounds from which suture removal may be painful or difficult and support is only needed for a short time period, rapidly absorbable sutures are indicated.

**Color**

Sutures are available in dyed and undyed material. A dyed material provides easy visualization when the sutures are removed. If suture removal is not planned, undyed material can be used to avoid unsightly show through the skin.

**SUTURES**

**Absorbable**

- **Polyglactic 910 (Vicryl)** is a synthetic, absorbable, braided suture made of polyglactin 910 coated with a copolymer of L-lactide and glycolide (Polyglactin 370) and calcium stearate. Polyglactin 910 thus retains 65% of its tensile strength at 2 weeks and 40% at 3 weeks. It is extremely useful as a completely buried suture to approximate wound edges until the wound has gained enough strength to keep the edges from separating. Complete absorption of Vicryl occurs between 60 and 90 days by hydrolysis. There is less of an inflammatory response due to the absorption of polyglactic acid by hydrolysis if compared with the proteolytic absorption of surgical gut. Vicryl is available in a clear undyed or violet-dyed form. In cutaneous closures, the dyed form is often visible beneath the skin surface. Vicryl can be extruded if used in the subcuticular layer.

- **Polyglactic 910 (Vicryl Rapide)** is a synthetic, absorbable, multifilament suture. It is derived from polyglyactin 910 that is partially hydrolyzed in a buffer solution and sterilized with gamma irradiation. This processing speeds absorption, leaving the
mechanical properties of the suture intact.\textsuperscript{14} Fifty percent of tensile strength is retained at 5 days. At 2 weeks, the tensile strength is 0%. Vicryl Rapide sutures fall off in 10 to 14 days and absorption occurs by hydrolysis in 7 to 14 days.

- **Antibacterial suture (coated Vicryl Plus)** is an absorbable suture with an antimicrobial coating that was first developed using triclosan, a well-known antimicrobial material with a long history of safe use as the active agent in consumer health care products.\textsuperscript{4} Pediatric surgeons noted less postoperative pain in patients treated with coated Vicryl Plus. The reduction in postoperative pain was attributed to inhibition of bacterial colonization and, likely, the avoidance of subclinical infection.\textsuperscript{15} Long-term studies are not yet available.

- **Polyglycolic suture (Dexon II)** is a synthetic, coated, braided, absorbable suture made of polyglycolic acid polycaprolactone. The lubricant coating decreases the coefficient of friction. Polyglycolic acid retains 89\% of its tensile strength at 7 days, 63\% at 14 days, and 17\% at 21 days.\textsuperscript{16} Compared with Dexon, Vicryl showed the slowest loss of function and the highest knot-breaking strength. In the same study, Dexon II showed the greatest irreversible elongation.\textsuperscript{17}

- **Poliglecaprone (Monocryl)** is a synthetic, absorbable, monofilament suture made of a copolymer of glycolide and e-caprolactone. In a side-by-side comparison with Vicryl Rapide, poliglecarpone subcuticular closure resulted in significantly smaller, less reactive scars and a lower tendency to hypertrophic scar formation.\textsuperscript{18} This suture has significant initial tensile strength, which allows for the selection of a suture that is 1 to 2 sizes smaller than would customarily be chosen.\textsuperscript{4} Dyed Monocryl retains 30 to 40\% of its tensile strength at 2 weeks, whereas undyed Monocryl retains 25\% at 2 weeks and 0\% at 21 days. Absorption of the sutures occurs by hydrolysis in approximately 90 to 120 days.

- **Polydioxanone (PDS)** is a synthetic, absorbable, monofilament suture made from polyester, poly(p-dioxanone). This suture retains 74\% of its tensile strength after 2 weeks, 50\% after 4 weeks and 25\% after 6 weeks. Polydioxanone is somewhat stiff and difficult to handle. It is a low reactivity suture that maintains its integrity in the presence of bacterial infection.\textsuperscript{6} The absorption rate of this material is minimal until 90 days and it is absorbed slowly by hydrolysis in 180 to 210 days.

- **Polyglycolide-trimethylene carbonate (Maxon)** is a synthetic, absorbable, monofilament suture. It is a copolymer of glycolide and trimethylene carbonate. Compared with PDS, Maxon was somewhat unwieldy.\textsuperscript{19} Maxon can be used for the deep and superficial portions of a closure. Tensile strength was measurable for 42 to 92 days for Maxon, and 64 to 80 days for PDS. Absorption of Maxon is complete in 6 to 7 months.\textsuperscript{4}

- **Barbed suture (Quill SRS)** is a knotless, synthetic suture made of dyed polydioxanone and is now available as undyed poliglecaprone (Monoderm). Barbed suture is effective due to bidirectional fixation within the wound. Closure with barbed sutures begins at the midpoint of the wound with suturing that extends in two directions from the midpoint. Barbs within the suture distribute tension across the wound and eliminate the need for knots.\textsuperscript{20} This material facilitates the use of a continuous suturing technique in place of interrupted sutures in a deep, layered closure. Because the Quill suture cannot slip backward, it does not gap in areas of tension, allowing an esthetic subcuticular closure with fewer preliminary buried sutures, which affords significant time savings (as much as one half to two thirds). Thus, the greatest benefit of using
Quill suture is its speed in closing deep layers. However, a disadvantage is that this suture has significant memory, and the needle size is not always appropriate for certain procedures. The product is in its infancy and will surely be refined.

- **Plain, chromic and fast-absorbing plain gut** are biologic, absorbable, monofilament sutures. These materials are made by twisting together strands of mostly purified collagen prepared from the submucosal layers of the small intestine of sheep or the serosal layer of the small intestine of cattle. The plain gut is untreated, the strength retention is 7 days, and absorption occurs in 10 to 14 days. The chromic gut is tanned with chromic salts to increase the holding time to approximately 14 days with absorption in 21 days. Fast-absorbing plain gut is heat-treated to create more rapid absorption. These sutures have less tensile strength than plain gut of comparable size. Fast-absorbing plain gut is used primarily for epidermal suturing where sutures are required for only 5 to 7 days. Fast-absorbing plain gut is helpful for suturing wounds in children or wounds in locations from which it is difficult to remove sutures. Chromic gut is absorbed by proteolysis and macrophages, and plain gut attracts small lymphocytes that facilitate absorption.

**Nonabsorbable**

- **Nylon (Ethilon)**, a synthetic, nonabsorbable, monofilament suture made of a chemically inert polyamide polymer fiber, has low tissue reactivity. Nylon sutures are the most commonly used sutures in cutaneous operations. The tensile strength of this material at 2 weeks is high, with a potential loss of 50% by 1 to 2 years due to progressive hydrolysis over time.

- **Polypropylene (Prolene)**, a synthetic, nonabsorbable, monofilament suture made by catalytic polymerization of propylene, has low tissue reactivity and high tensile strength, similar to nylon. Polypropylene has an extremely smooth surface, which decreases knot security and must be compensated for with extra throws. A significant advantage of Prolene is its high plasticity, and ability to accommodate wound edema. Polypropylene is easy to remove and is therefore an ideal suture for a running, subcuticular stitch. This suture is also not subject to degradation.

- **Silk** is a natural, nonabsorbable, braided suture that is white, extruded by silk worm larvae, and made of protein filaments. Surgical silk is braided for easy handling and dyed for greater visibility. Silk has good knot security but evokes a significant inflammatory response. Owing to its braided configuration, silk is also prone to infection and can be infiltrated by tissue ingrowth. Silk suffers progressive degradation that may result in gradual loss of tensile strength.

- **Braided polyester (Mersilene)** is a synthetic, nonabsorbable, uncoated, braided or monofilament suture material. The tensile strength at 2 weeks is high, and the material has a high coefficient of friction. The monofilament form has poor knot security, whereas the braided form gives a more secure knot. The braided form cannot be used in the presence of infection or contamination. This suture has low tissue reactivity and undergoes no significant changes in vivo.

- **ePTFE (Gore-Tex CV4)** is a synthetic, nonabsorbable, monofilament suture made of polytetrafluoroethylene that has been expanded to produce a porous microstructure that is 50% air by volume. This suture is white in color and provokes minimal tissue response with cellular ingrowth. The tensile strength does not change in vivo. Gore-Tex is soft and supple, affording excellent handling.
Gore-Tex does not degrade in the presence of infection and is not subject to the action of tissue enzymes.

**SURGICAL NEEDLES**

Needles are manufactured from stainless steel wire, which has excellent resistance to corrosion. Needles are chosen based on strength, temper, rigidity, malleability, ductility, and surface finish. Needles must be matched to the patient and surgery. The factors to be considered include the thickness and accessibility of the tissue to be sutured, the importance of attaining a good cosmetic result, and the size of the suture material. Surgical needle performance is determined by the following parameters: sharpness, resistance to bending, resistance to breaking (ductility), and by the force that must be exerted to grasp a curved needle with the jaws of the needle holder. Surgical needles have distinctive anatomy and characteristics, such as shape, size, point, and method of suture attachment.

**Needle Anatomy**

- **Eye**: the eye is the site of attachment of the needle to the suture. The close eye is similar to a household sewing needle. The French eye has a slit from inside the eye to the end of the needle that holds the suture. The swaged needle is configured so that the suture and the needle form a continuous unit.
- **Body**: the body of the needle is the portion grasped by the needle holder.
- **Point**: the point of the needle extends from the tip to the maximum cross-sectional area of the body.

**Needle Shape**

- **1/4 circle**: used in microsurgery.
- **3/8 circle**: used to approximate the divided edges of thin planar structures that are readily accessible (ie, skin).
- **1/2 circle**: used in deep body cavities and other confined locations.
- **5/8 circle**: used in the nasal cavity.
- **1/2 curved or ski**: used in endoscopic procedures.
- **Straight**: used when suturing easily accessible tissue, where direct finger-held manipulation can be easily performed.

**Needle Size**

The choice of the length and curvature of a needle is determined by the size and depth of the wound. The diameter of the needle should match the suture size to minimize damage as the needle passes through tissue.

**Needle Points**

Each type of needle point is designed to penetrate a specific type of tissue. Needle points are either cut, tapered, or a combination of both.

- **Conventional cutting**: The needle body is triangular and has two opposing cutting edges and a third edge on the inside of the curve. This configuration creates a track that faces the wound edge, producing the potential to accidentally cut tissue. (This point is used in tough tissues like skin and mucosa.)
- **Reverse cutting**: This needle point has the third cutting edge on the outside of the curve to avoid the possibility of accidentally cutting tissue. (This point is used in tough tissues like skin, mucosa, and in the nasal cavity.)
• **Precision cosmetic.** This form offers the most honed point for maintaining sharpness. (This is used in delicate plastic or cosmetic surgery and on the skin.)

• **Trocar point or taperscut.** The needle body is round, tapered and ends in a small triangular cutting point. The cutting edges of the trocar point needle extend only a short distance from the needle tip and blend into a round, tapered body. (This point is used for closures in the oral mucosa and nasal cavity.)

• **Spatula point.** This point is flat on the top and bottom with a cutting edge along the front to one side. (This point is used with corneal or scleral tissue.)

• **Blunt point.** This is simply a blunted, dull point. (This point is used for friable tissues such as fascia.)

• **Taper.** The needle body is round and tapers smoothly to a point that spreads the tissue without cutting it. (This point is used in soft tissue that does not resist needle penetration, such as fascia, subcutaneous fat, and muscle.)

• **Keith needle.** This is a straight, cutting needle. (This point is used primarily for skin closure of abdominal wounds.)

• **Specialty needles.** There are needle points especially designed for cleft palate and microsurgery.

**SUTURE ATTACHMENT**

• **Swaged needle** (atraumatic needle) provides a less traumatic, smaller diameter needle that does not require preparation or handling. The needle may be permanently swaged to the suture or may be designed to come off with a sharp, straight tug. These "pop-offs" are commonly used for interrupted sutures, whereby each suture is only passed once and then tied. Nearly all modern sutures feature the swaged, atraumatic needle.

• **Threaded needle** (traumatic needle) is a needle whereby the suture is threaded through the eye of the needle. Threaded needles are more difficult to handle and cause more tissue trauma than swaged needles. Threaded needles are rarely used today. However, a threaded needle may salvage a suture line if a continuous suture has broken.

**SUTURING TECHNIQUES**

• **Simple interrupted sutures.** These are the most commonly used sutures and are useful in linear or irregular wounds. The needle is introduced at a 90° angle into the skin to include a larger portion of the deeper dermis. This method allows the width of the suture at its base in the dermis to be wider than the epidermal entrance and exit points. An advantage of interrupted sutures is that more selective adjustments of wound edges can be made.

• **Vertical mattress sutures.** These sutures are appropriate for either thick or thin skin. Vertical mattress sutures are used if eversion is not achieved with simple interrupted sutures. This suture provides a secure grasp of tissue and a good approximation of the skin margins. Vertical mattress sutures need to be soft and pliable but should not stretch tissue. These sutures help distribute tension. Unfortunately, permanent hatch mark scars result if the sutures are left in place for more than 5 to 7 days.

• **Half buried horizontal mattress or 3-corner sutures.** This type of suture is used for flap edges, because the suture minimizes tissue ischemia. The 3-corner suture is especially useful for closing a V-shaped wound or for approximating skin edges that differ in texture or thickness.
• Horizontal mattress. This suture is useful in situations where compression of wound edges is necessary for hemostasis. The horizontal mattress suture may also be used to close wounds under moderate tension and to increase wound tensile strength during the period of wound healing. In addition, the horizontal mattress suture can be used to evert wound edges. However, this suture can lead to tissue ischemia and therefore must be applied loosely, which may make the wound appear untidy after the repair.

• Horizontal continuous mattress. These sutures are useful in evert ing wound edges in areas prone to inversion, such as the retroauricular skin.

• Subcuticular continuous suture. This suture provides an excellent way to achieve accurate skin edge apposition without external sutures or cross-hatching. The suture can be an absorbable suture, such as polyglactin 910 (Vicryl) or poliglecaprone (Monocryl), or a nonabsorbable suture, such as polypropylene (Prolene), with external knots that are easy to remove.6

• Running continuous sutures. The running continuous suture provides a rapid, secure closure with an even distribution of tension along the length of the wound preventing tightness in any one area. It is used for linear wounds. This technique also provides additional wound eversion. The only real disadvantage of the running continuous suture is demonstrated if the suture breaks or the surgeon wants to remove only a few sutures at a time.2 Gaps can occur in any continuous suture method if the tension is not controlled with a deep closure.

• Continuous locking suture. These sutures are useful for suturing dermal matrix (AlloDerm). However, the continuous locking suture leaves permanent hatch marks in the skin.

• Purse-string sutures. This is a continuous suture placed around a circle, such as the areola. This suture has the disadvantage of inverting tissues.

• Buried sutures. These sutures are placed so that the knot protrudes to the inside, under the layer to be closed.

• Quilting sutures. This suture refers to the attachment of a skin flap to the underlying aponeurosis with multiple sutures and is an efficient technique for prevention of seroma formation.24

• Frost sutures. These are suspension sutures used in eyelid surgery to prevent ectropium.

• Figure-of-eight or far-near-far pulley suture. These suture are a modification of the vertical mattress suture. The suture provides a pulley effect that allows wound closure under tension, such as the closure of the latissimus dorsi myocutaneous flap donor site. Figure-of-eight sutures have to be removed early to avoid cross-hatching.

• Ligatures. This is a suture tied around a vessel for hemostatic purposes.

• Retention sutures. Retention sutures have been used in an attempt to reduce the risk of acute fascial dehiscence and to repair postoperative fascial dehiscence. However, these sutures do not seem to reduce the risk of wound complications. In addition, in one study, 50% of patients with retention sutures had them removed prematurely due to pain.12,25

SUTURE KNOTS

Knots must be tight enough to coapt the wound edges and should be no tighter. Regarding knot strength, sliding knots with extra throws are as secure as square knots, and surgeon’s knots are no more secure than square knots for smaller diameter
sutures. For safety, a knot should have at least three throws with 3-mm long ends. Smooth surfaces, as seen with monofilament sutures, decrease knot security and must be compensated for with extra throws.

**PRINCIPLES OF SUTURING SKIN WOUNDS**

1. The primary function of the suture is to maintain tissue approximation during healing.
2. Sutures placed in the dermal layer provide tensile strength, and control tension for the outer layer.
3. Sutures placed in the epidermis should coapt the edges and correct any intervening gaps in the suture line or discrepancies in height between the two sides.
4. Debridment of the skin edges should be done if necessary.
5. Avoidance of direct tissue trauma helps ensure optimal outcomes.
6. Clean passage of the needle, following the arc, is imperative, as is avoidance of multiple punctures.
7. Skin sutures that blanch the underlying skin are too tight.
8. Skin edges are always kept everted and without tension. The everted skin edges will gradually flatten.
9. Skin edges must just touch each other.

**SUTURES ACCORDING TO ANATOMIC LOCATION**

The final decision concerning the method and material used in closure is highly dependent on the length and anatomic location of the wound (Table 1).

**STAPLES**

- **Nonabsorbable (Proximate).** These staples are made of stainless steel and combine the highest tensile strength of any suture material in use today with a low tissue reactivity. Metal staples come in two sizes, regular and wide, and are dispensed from lightweight easy to grip cartridges. Metal staples provide a faster closure than sutures. Metal staples also provide excellent wound edge eversion without strangulation of tissue and result in minimal cross-hatch scarring. Staples yield a satisfactory result for cutaneous wound closure in a wide variety of circumstances and are extremely useful in fixation of skin grafts. Metal staples may offer a slightly superior cosmetic outcome when used to close scalp wounds. It is common to use staples to close scalp wounds that are under a great deal of tension. Contaminated wounds closed with staples have a lower incidence of infection than those closed with sutures. Staple closure also eliminates the risk that a health care provider will experience a needle stick, which is a particularly important consideration in caring for trauma patients with unknown medical histories. There are specially designed extractors for staple removal, although removal can also be accomplished with a hemostat.

- **Absorbable (Insorb).** A novel form of skin closure that uses absorbable subcuticular staples is now available. The staple is composed of an absorbable copolymer of predominantly polylactide and a lesser component of polyglycolide. The closure of contaminated wounds with Insorb staples was found to be superior to closure with Vicryl sutures, because the Insorb staples had a significantly lower incidence of infection. Insorb staples will not interfere with MRI examinations. In some studies, the performance of Insorb staples was similar to that of percutaneous metal staples with respect to the development of wound infection.
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<td>5-0 Nylon simple interrupted sutures</td>
</tr>
<tr>
<td>Areola</td>
<td>Dermal</td>
<td>4-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-0 Gore-Tex CV4 pull-string sutures or 5-0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td>Epidermal</td>
<td>6-0 Monocryl continuous running suture</td>
</tr>
<tr>
<td>Presternal</td>
<td>Dermal</td>
<td>3-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-0 Monocryl continuous running suture</td>
</tr>
<tr>
<td></td>
<td>Epidermal</td>
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<tr>
<td></td>
<td></td>
<td>Metal staples</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Dermal</td>
<td>3-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-0 Monocryl or 5-0 Prolene continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>subcuticular suture</td>
</tr>
<tr>
<td></td>
<td>Epidermal</td>
<td>4-0 Monocryl continuous running suture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal staples</td>
</tr>
<tr>
<td>Back</td>
<td>Dermal</td>
<td>3-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-0 Nylon simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td>Epidermal</td>
<td>4-0 Monocryl continuous running suture</td>
</tr>
<tr>
<td>Arm and forearm</td>
<td>Dermal</td>
<td>4-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-0 Nylon simple interrupted sutures</td>
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<tr>
<td></td>
<td>Epidermal</td>
<td>5-0 Monocryl continuous running suture</td>
</tr>
<tr>
<td>Hand</td>
<td>Epidermal</td>
<td>5-0 Nylon simple interrupted sutures</td>
</tr>
<tr>
<td>Palm</td>
<td>Epidermal</td>
<td>5-0 Nylon simple interrupted sutures,</td>
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<tr>
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<td>alternate with vertical mattress sutures</td>
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<tr>
<td>Leg and thigh</td>
<td>Dermal</td>
<td>3-0 Vicryl simple interrupted sutures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-0 Nylon simple interrupted sutures or metal</td>
</tr>
<tr>
<td></td>
<td>Epidermal</td>
<td>Staples</td>
</tr>
<tr>
<td>Foot</td>
<td>Epidermal</td>
<td>5-0 Nylon simple interrupted sutures</td>
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Other studies have suggested that the Insorb staples may be superior to metal staples with respect to inflammation, pain, and cosmetic outcome.31,32

**TOPICAL TISSUE ADHESIVES**

- **2-Octylcyanoacrylate (Dermabond).** Tissue adhesive provides an excellent, strong, and flexible method of approximating wound edges. Compared with sutures, staples, and tapes, adhesives provide faster closure12 and are essentially equivalent to the other methods of closure in terms of cosmetic outcome,33 infection rate,34 and dehiscence rate. Adhesives can be used on most parts of the body and have been employed to close wounds ranging from 0.5 to 50 cm in length. Advantages of tissue adhesives include reduced cost, ease of application, absence of needles and suture removal, and higher rate of patient satisfaction;35 the major disadvantage is lack of strength. Tissue adhesives should not be applied to tissues within wounds; they should be applied to intact skin at wound edge to hold the injured surfaces together. In addition, these products should not be used for wounds in mucous membranes,2 contaminated wounds, deep wounds, or wounds under tension.26,36 Adhesives are particularly useful in superficial wounds or wounds in which the deep dermis has been closed with sutures. The avoidance of postoperative suture removal is beneficial, particularly in the pediatric population.37 Dermabond used over sutures at the time of surgery7 provides extra support,6,38 creates an impermeable suture line, decreases the need for postoperative care, and may reduce redness on the suture line.

**TAPES**

- **Steri-Strips.** Modern cutaneous tapes have an important role in wound closure and have certain advantages over sutures and staples. Closure with microporous tape produces far more resistance to infection than other closure techniques.6 Tapes maintain the integrity of the epidermis, resulting in less tension to the wound.2 Linear wounds in areas with little tension are easily approximated with tape alone, whereas wounds in areas where the skin is more taut generally require that tape skin closure be supplemented with dermal sutures. In addition, tape will not adhere to mobile areas under tension or moist areas. Retention of sutures in skin wounds beyond a few days may result in slower development of tensile strength than if sutures are removed earlier. Thus, some surgeons prefer to replace cutaneous sutures with tape at 3 to 6 days,6 and some surgeons prefer to use tape in conjunction with liquid adhesive (Mastisol).2 If used over sutures at the time of surgery, wound closure tape can relieve tension at the wound edges, provide a partially closed environment, improve the aesthetics of the wound, and reduce the often tedious wound management for which the patient is responsible.2 Wound edge approximation is less precise with tape alone than with sutures. Wound edema can lead to blistering at the tape margins and to eversion of taped wound edges.

**SUMMARY**

Numerous options for skin closure have become available in the last 30 years. It is paramount to choose a method tailored to each patient and wound. With excellent technical execution, several methods of closure can achieve similar, high quality results. A full understanding of the biomechanical properties of suture material allows wound closure decisions to be made based on sound scientific knowledge.
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REFERENCES