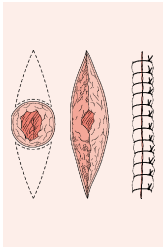

CHAPTER 10

Basic Laceration Repair: Principles and Techniques

Key Practice Points

- Applying the principles of wound closure is key to acceptable wound and scar appearance.
- Matching the layers of the wound surfaces with sutures is critical to scar appearance.
- Because scar tissue contracts over time, wound edge eversion prevents "pitting" of the scar and eliminates a poor result.
- Excessive wound tension, caused by sutures placed too tightly, can cause ischemia of the edges and an increased amount of scar tissue.
- Deep sutures become foreign material when buried in a wound. Placing as few deep sutures as possible is recommended to reduce the risk of infection and the risk of an increase in the amount of scar tissue.
- "Dead" space is created when the skin of deep wounds is closed without deep or subcutaneous sutures to eliminate the dead space.
- The final sutured wound should have all of the knots aligned to one side of the wound. This appearance inspires confidence in the patient and, more important, prevents the knots from interfering with laceration healing.

Each wound and laceration has technical requirements that have to be met to repair a wound effectively. By understanding the basic principles that underlie the technical requisites of wound care, lacerations and wounds can be closed with the best chance for an optimal result. During actual closure, every attempt is made to match each layer evenly and to produce a wound edge that is properly everted. Proper knot-tying technique is paramount to facilitate eversion and to prevent excessive tension on the wound edge. When necessary, dead space is closed, and finally, sutures are spaced and sequenced to provide the best and most gentle mechanical support.

DEFINITION OF TERMS

Several techniques and maneuvers used in wound care are referred to by terms that can be confusing. These terms are defined so that the reader thoroughly understands the material contained in this chapter.

- *Bite:* A bite is the amount of tissue taken when placing the suture needle in the skin or fascia. The farther away from the wound edge that the needle is introduced into the epidermis, the bigger the bite.
- *Throw:* Each suture knot consists of a series of throws. A square knot is fashioned with two throws. Because of nylon's tendency to unravel, several additional throws are necessary to secure the final knot when this material is used.

- *Percutaneous closure (skin closure):* Sutures, usually of a nonabsorbable material, which are placed in skin with the knot tied on the surface, are called percutaneous closures. They also are referred to as skin closures. Recent clinical studies have shown that, in certain circumstances such as lacerations of the face and fingertip, absorbable sutures can be used to close skin.[1,2]
- *Dermal closure (deep closure):* Sutures, usually of an absorbable material, which are placed in the superficial (subcutaneous) fascia and dermis with the knot buried in the wound, are called deep closures.
- *Interrupted closure:* Single sutures, tied separately, whether deep or percutaneous, are called interrupted sutures.
- *Continuous closure (running suture):* A wound closure accomplished by taking several bites that are the full length of the wound, without tying individual knots, is a continuous or running suture. Knots are tied only at the beginning and at the end of the closure to secure the suture material. Continuous closures can be percutaneous or deep.

BASIC KNOT-TYING TECHNIQUES

Several knots can be used to tie sutures during wound closure. The most common is the surgeon's knot (Fig. 10-1). The advantage of this knot is that the double first throw offers better knot security, and there is less slipping of the suture material as the wound is gently pulled together during tying. The wound edges remain apposed while the second and subsequent single throws are accomplished. The knot-tying sequence shown in Figure 10-1 illustrates the proper instrument technique required to obtain a surgeon's knot. The instrument tie can be used for almost all knots, whether for deep or superficial closures.

PRINCIPLES OF WOUND CLOSURE

Layer Matching

When closing a laceration, it is important to match each layer of a wound edge to its counterpart. Superficial fascia has to meet superficial fascia. Dermis to dermis necessarily brings epidermis to epidermis. Failure to appose layers meticulously can cause improper healing with an unnecessarily large scar (Fig. 10-2).

Wound Edge Eversion

Just as important as layer matching is proper wound edge eversion during the initial repair. Because of the normal tendency of scars to contract with time, a wound edge slightly raised above the plane of the normal skin gradually flattens with healing and has a final appearance that is cosmetically acceptable (Fig. 10-3). Wounds that are not everted contract into linear pits that become noticeable cosmetic defects because of their tendency to cast shadows.

Techniques for Wound Edge Eversion

The key to achieving proper wound edge eversion is to use the correct technique for introducing the needle into the skin and for producing the proper suture configuration. As illustrated in Figure 10-4, the point of the needle should pierce the epidermis and dermis at a 90-degree angle before it is curved around through the tissues. To ensure a 90-degree angle, the needle holder has to be held in the manner described in Chapter 8. It is mechanically difficult to maneuver the needle correctly if the operator's fingers remain in the finger rings of the needle holder. Figure 10-4 illustrates the correct and incorrect final configuration of an interrupted suture to achieve wound edge eversion.

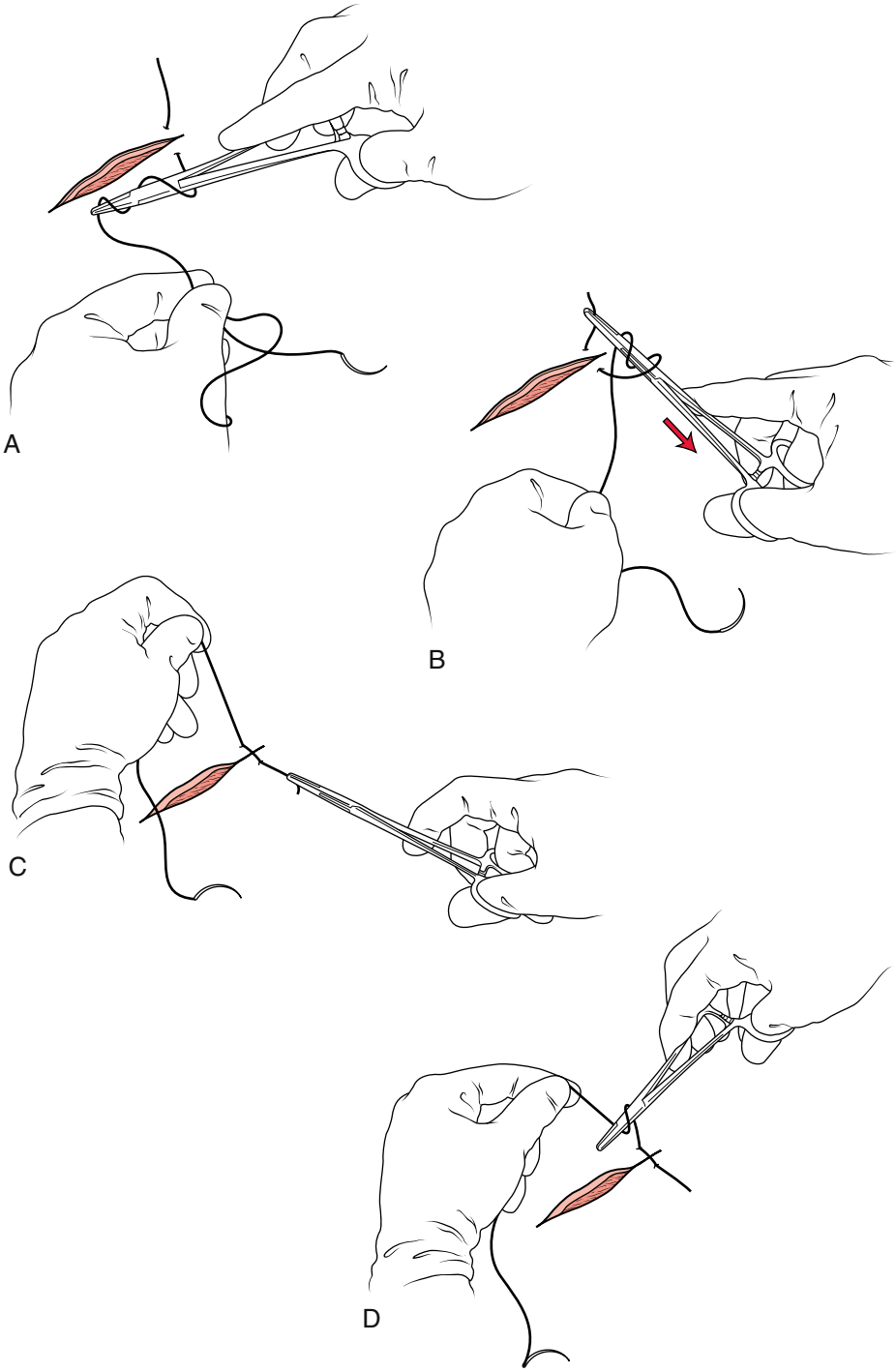

Figure 10-1. **A-G,** Sequence for instrument tie of a standard percutaneous suture closure. Note the surgeon's knot and final square knot configuration in the inset illustration in **G.**

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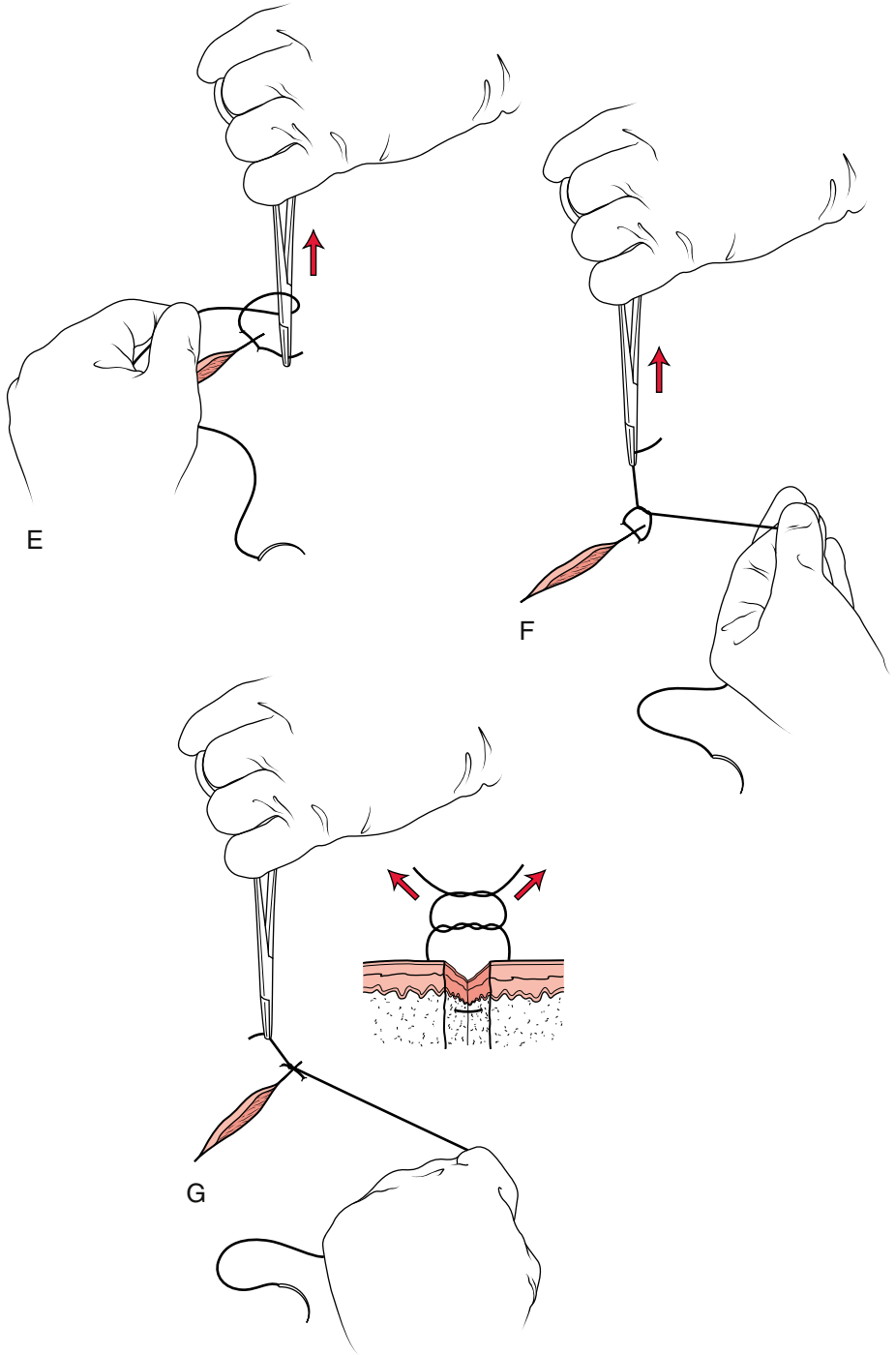

Figure 10-1, cont'd. For legend, see previous page.

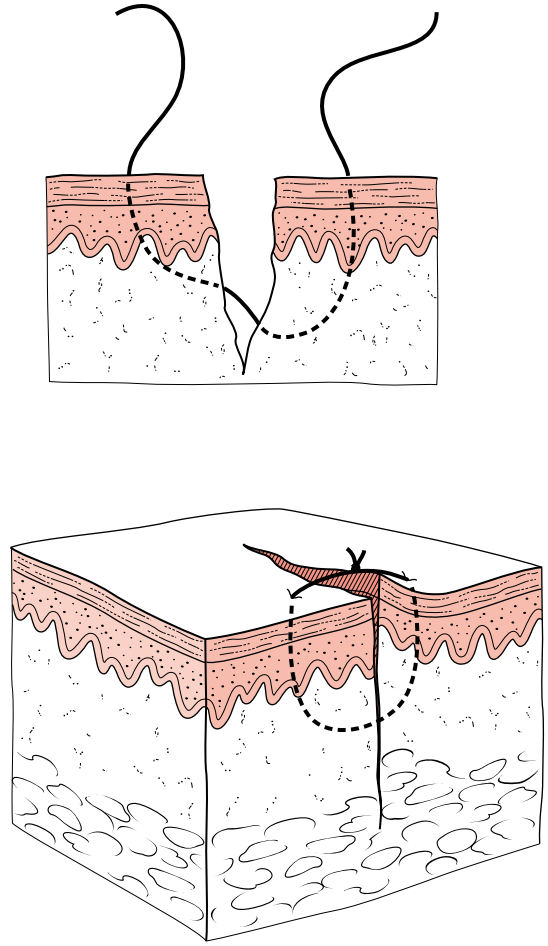

Figure 10-2. Incorrect technique to provide for layer matching.

Vertical Mattress Suture

Another useful method for wound edge eversion is the vertical mattress suture. This suture is placed by first taking a large bite of tissue approximately 1 to 1.5 cm away from the wound edge and crossing through the tissue to an equal distance on the opposite side of the wound. The needle is reversed and returned for a small bite (1 or 2 mm) at the epidermal/dermal edge to approximate closely the epidermal layer (Fig. 10-5). The vertical mattress suture is helpful in areas of lax skin (e.g., elbow, dorsum of hand), where the wound edges tend to fall or fold into the wound. Another advantage of the vertical mattress suture is that it can act as a deep and a superficial closure all in one suture. Some wounds are not deep enough to accommodate a separate, absorbable suture but still need some deep support to close dead space. This technique can meet that need.

A modification of the vertical mattress suture, the shorthand technique, allows the suture to be placed more rapidly.[3] Instead of taking the large bite first, as described earlier, the small bite is taken, then the large one. By placing simultaneous traction on

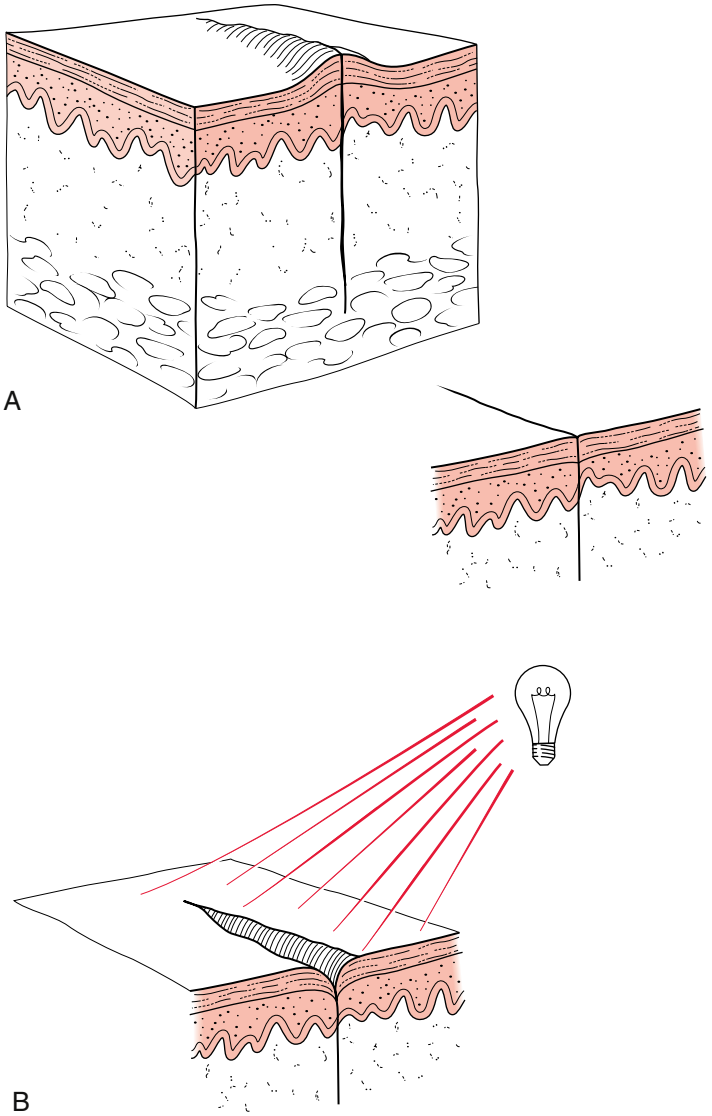

Figure 10-3. Wound edge eversion. **A,** Correct technique allows for a slight rise of the wound edges above the skin plane. These edges eventually contract to flatten out at the skin plane. **B,** Wound edges that are not properly everted contract below the skin plane and allow incident light to cause unsightly shadows.

the trailing and leading portions of the suture after the small bite, the wound edges are elevated so that the needle easily takes the large bite.

Horizontal Mattress Suture

Another technique, the horizontal mattress suture, can be used to achieve wound edge eversion (Fig. 10-6). The needle is introduced into the skin in the usual manner and is brought out at the opposite side of the wound. A second bite is taken approximately 0.5 cm adjacent to the first exit and is brought back to the original starting

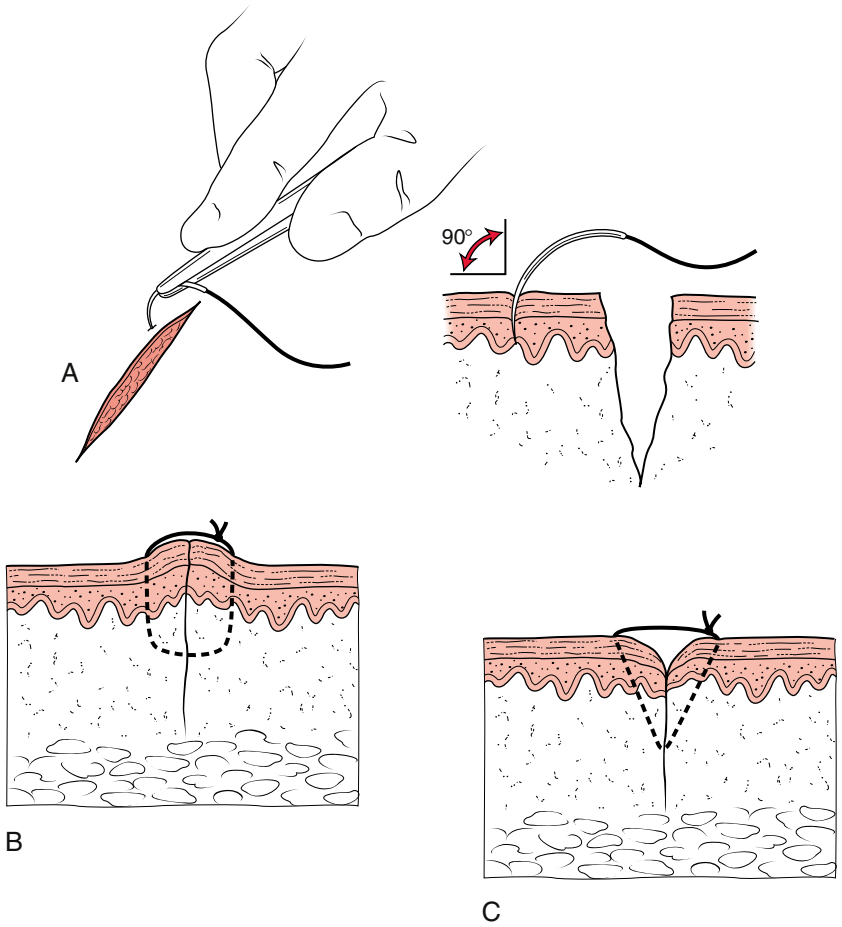

Figure 10-4. Technique for proper wound edge eversion. **A,** The suture needle is introduced at a 90-degree angle to the epidermis. **B,** The proper configuration of the suture should be square or bottle shaped. This configuration is difficult to achieve in practice; however, this figure illustrates the correct principle. **C,** The incorrect technique of needle placement and suture configuration leads to wound edge inversion, which leads to "pitting" of the eventual scar.

edge, also 0.5 cm from the initial entry point. The knot is tied, leaving an everted edge. This is a suture technique often used in closing hand (palm and dorsum) lacerations.

Wound Tension

Whenever wound edges are brought together by suturing, there is inevitable tension and pressure created in the tissue within the suture loop. It is important to minimize tension to preserve capillary blood flow to the wound edge. Excessive force exerted on the tissue leads to ischemia and can cause some degree of cellular necrosis.[4] Necrosis provokes a more intense inflammatory response with the eventual formation of an irregular, cosmetically unacceptable scar. When tying knots, the first throw is crucial. As the wound edges are brought together, they are allowed just barely to touch. Bringing the edges together more forcibly by making the first throw too tight promotes

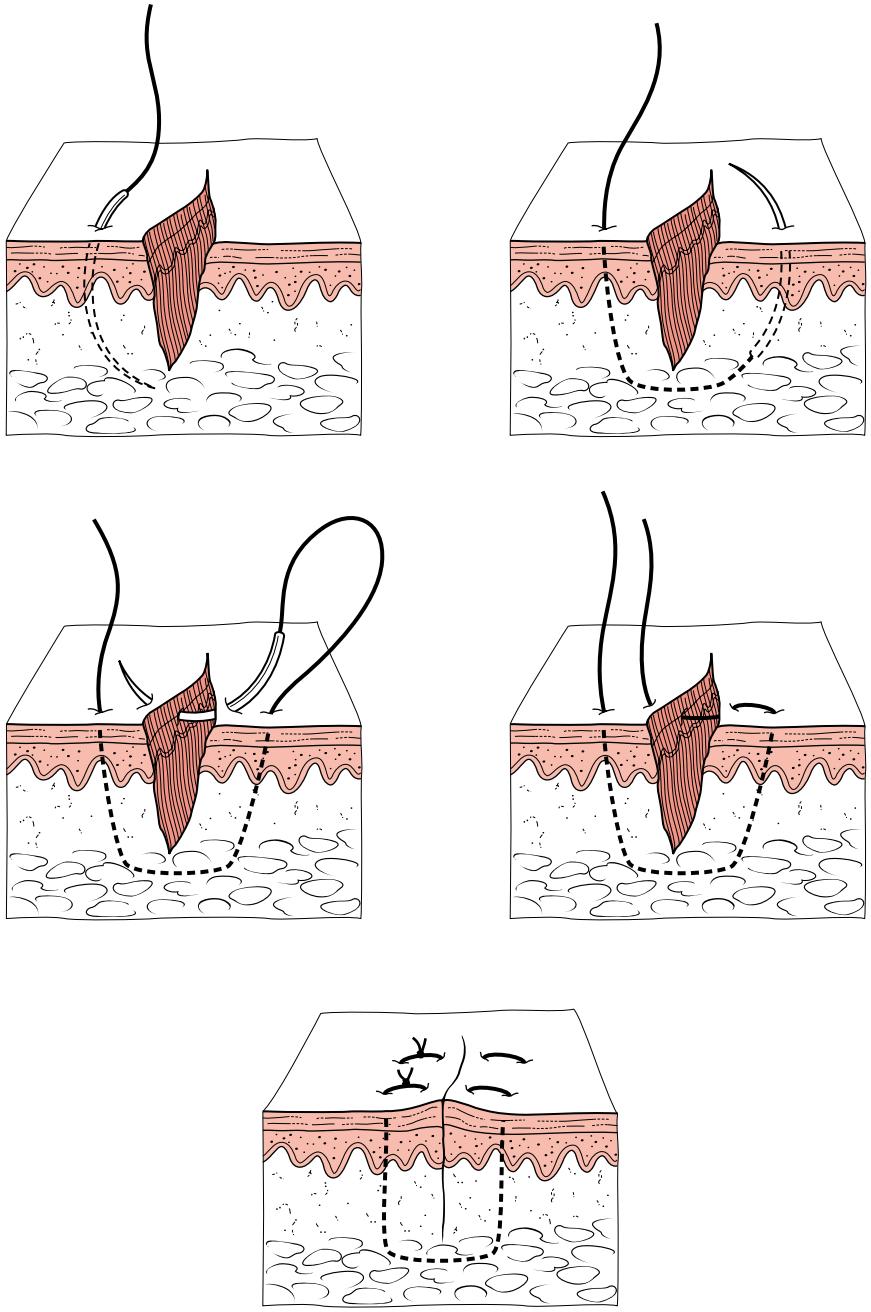

Figure 10-5. Technique for a vertical mattress suture. The second bite barely passes through the dermis to provide meticulous apposition of the epidermal edges.

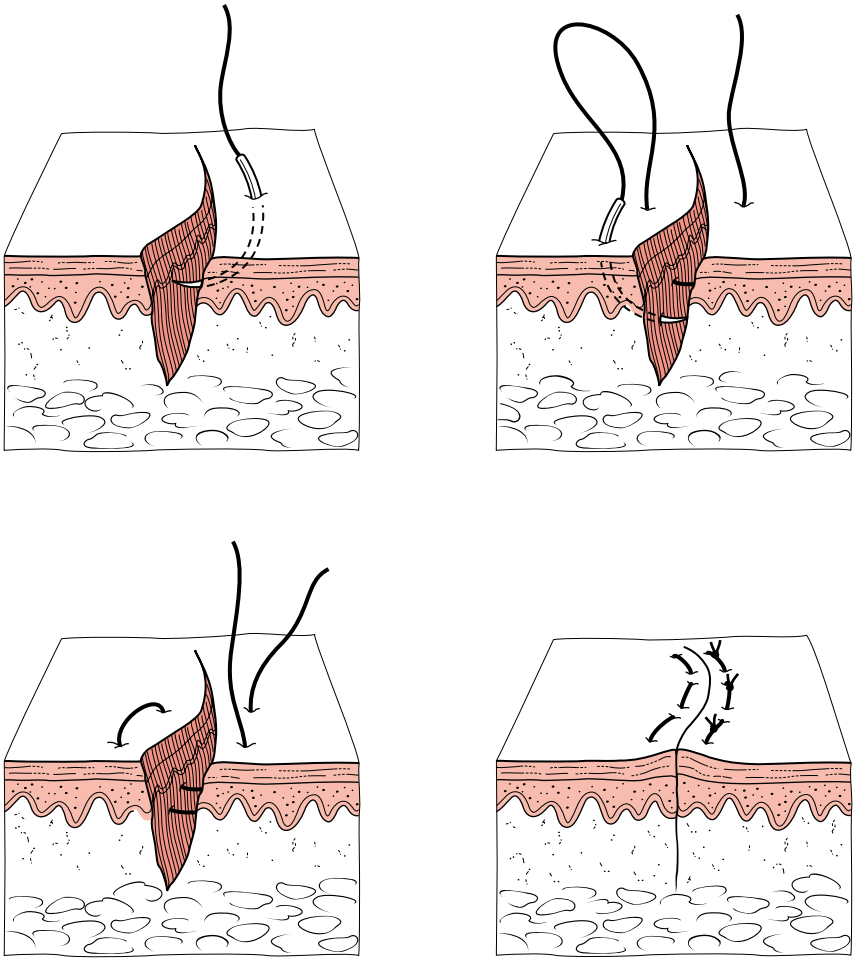

Figure 10-6. Technique for placing a horizontal mattress suture.

ischemia. Wound edges tend to become slightly edematous after repair; a small amount of slack between them disappears. The addition of edema to a suture line that already is too tight can be disastrous.

Techniques for Reducing Wound Tension

Deep Closures

Proper placement of deep closures to bring the dermis close together before suture closure reduces final wound edge tension. Figure 10-7 illustrates the method for placing and tying deep closures. To start this suture, the needle is introduced into the superficial fascia, close to the underside of the dermis. Then the needle is brought up through the dermis. At this point, the needle has to be rearmed with the needle holder. The needle is introduced into the dermis of the matching opposite wound edge and is carried down into the superficial fascia to complete the second bite.

Crucial to this technique is that the trailing and leading portions of the suture remain on the same side of the portion of the suture that crosses from dermis to dermis.

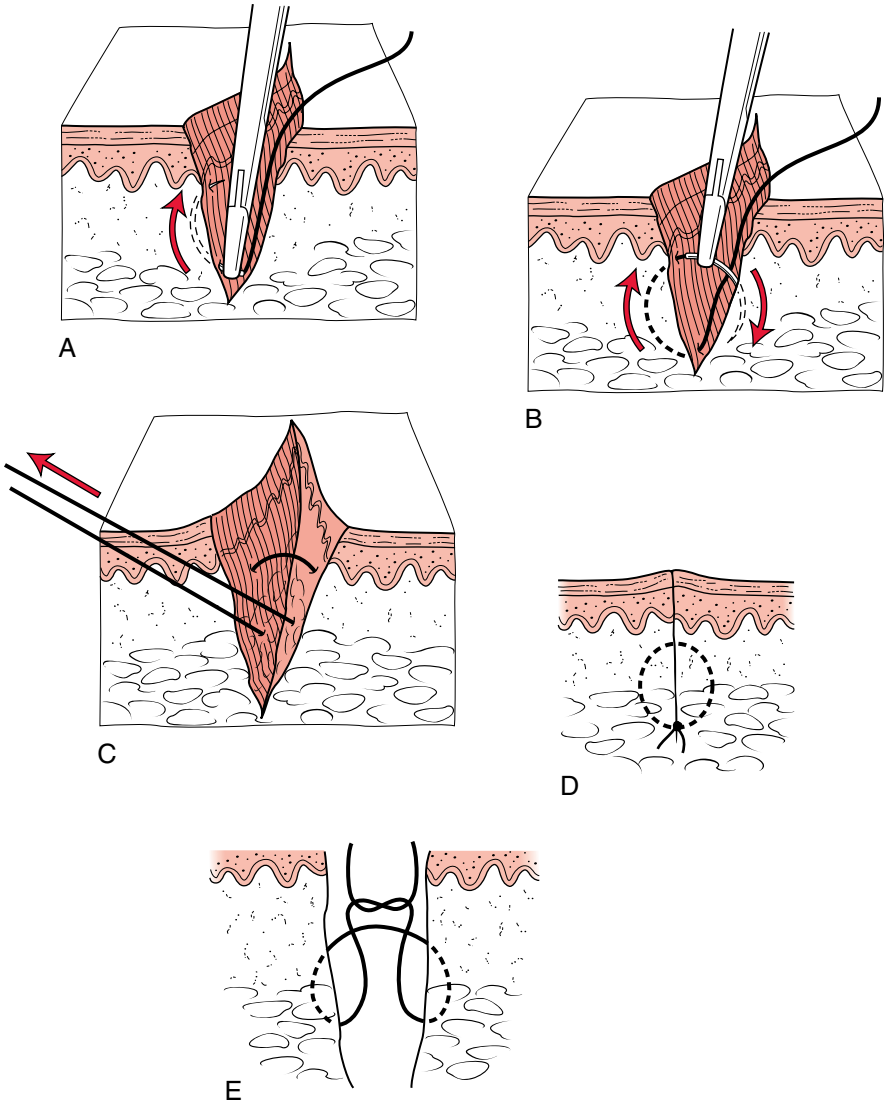

Figure 10-7. Technique for placing a deep suture. **A,** Suture placement is initiated by driving the needle from deep in the wound to superficial. **B,** The needle is driven superficial to deep on the opposite side of the wound. **C,** The leading and trailing sutures come out on the same side of the cross suture. **D,** This same-side technique allows for the knot to be tied deep and away from the wound surface. **E,** If the same-side technique is not followed, the knot is forced to the wound surface by the cross suture and may protrude out of the wound.

In this manner, when the knot is tied, it is buried. If the trailing edges are on opposite sides of the dermal crossing, the knot is pushed superficially and interferes with epidermal healing. Three or four throws are adequate to secure the knot, and the suture ends are cut close to the knot itself, leaving no more than 2-mm "tails." The temptation to place numerous deep closures must be resisted. These sutures act as foreign bodies and become a nidus for wound infection.[5] They also provoke a greater healing response and

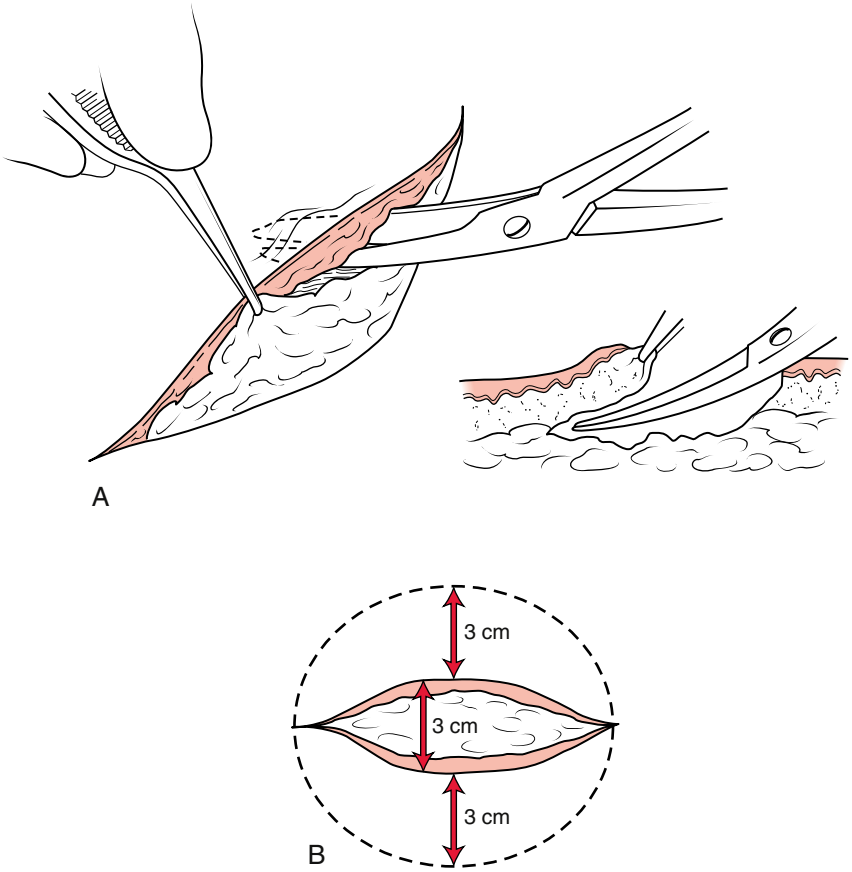

Figure 10-8. Technique for tissue undermining. **A,** Scissors are used for dissection at the dermal-superficial fascia level. Tissue spreading is preferred to cutting the sharp edges. **B,** The zone of undermining.

can increase the total bulk of a scar. Only as many sutures as are necessary to accomplish the task of reducing wound tension should be placed.

Wound Undermining

Another technique for reducing tension is wound undermining. Undermining releases the dermis and superficial fascia from their deeper attachments, allowing the wound edge to be brought together with less force. Anatomic areas where undermining is useful include the scalp, forehead, and lower legs, particularly over the tibia, where the skin is under a great deal of natural tension. Caution has to be exercised in deciding to undermine, because this procedure can spread bacteria into deeper tissues and can create a deeper, larger dead space.

The technique for undermining is illustrated in Figure 10-8A. For most minor wound care problems, the proper tissue plane for wound undermining is between the superficial fascia (subcutaneous tissue) and deep fascia overlying the muscle. Staying in this plane maintains the integrity of the blood and nerve supply to the skin (dermis and epidermis). Scissors can be inserted parallel to the deep fascia where it joins the superficial fascia. The instrument is spread gently to create a plane of dissection. Undermining also can be performed with a no. 15 blade on a standard knife handle. The blade is

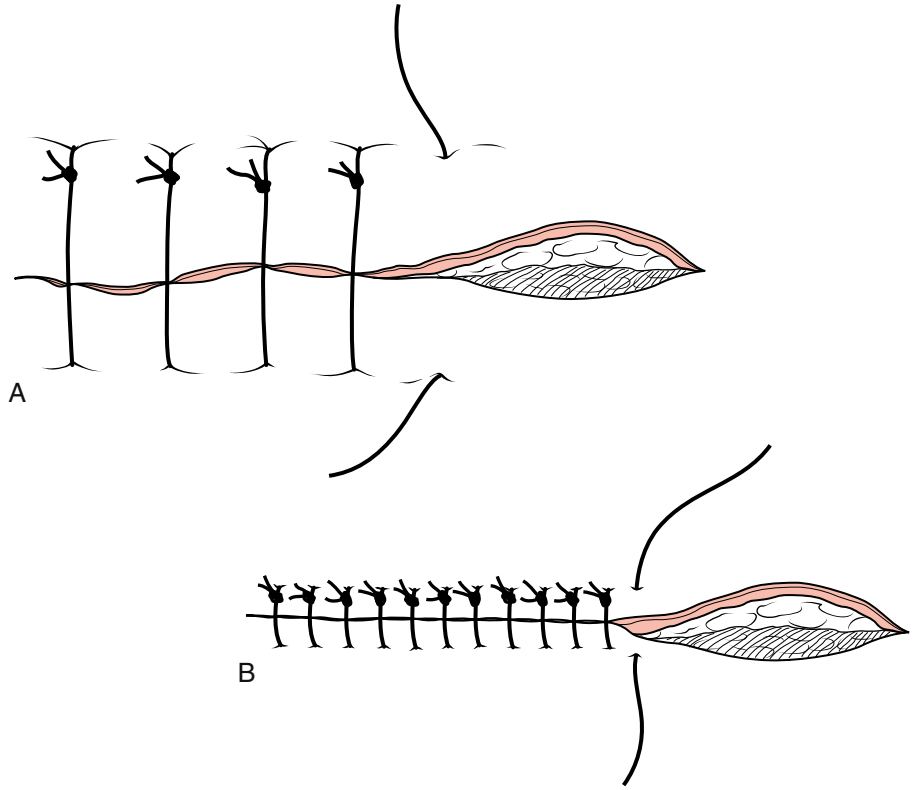

Figure 10-9. A technique for reducing wound tension. **A,** A few sutures, placed far apart and far from the wound edges, will increase wound tension. **B,** More sutures, placed closer together and closer to the wound edges, will reduce tension.

rotated away from the deep fascia and is used as a combination cutting instrument and probe. Actual cutting is kept to a minimum to prevent excessive bleeding.

Wounds are undermined from end to end, to a distance from the wound edge that approximates the extent of "gapping" of the wound edges. In other words, if a wound gaps open 3 cm from edge to edge, undermining is carried out to 3 cm under the dermis, perpendicularly away from the wound edge. A common mistake in using this technique is to fail to include the wound ends. Figure 10-8B illustrates the proper zone of undermining during dissection.

Additional Suture Placement

Placing more sutures closer together also reduces wound tension (Fig. 10-9). Mechanically, a greater number of sutures lessens the total force exerted on each suture, reducing potential tissue compression. The caregiver has to keep in mind, however, that sutures act as foreign bodies and can potentiate infection. When closing a wound, a balance has to be struck between the number of sutures used and the desired tension reduction.

Dead Space

In the past, it was axiomatic that no open or dead spaces should be left behind during wound closure. These spaces tend to fill with hematoma and can act as potential sites for wound infection (Fig. 10-10). Hematoma formation in these areas also can delay

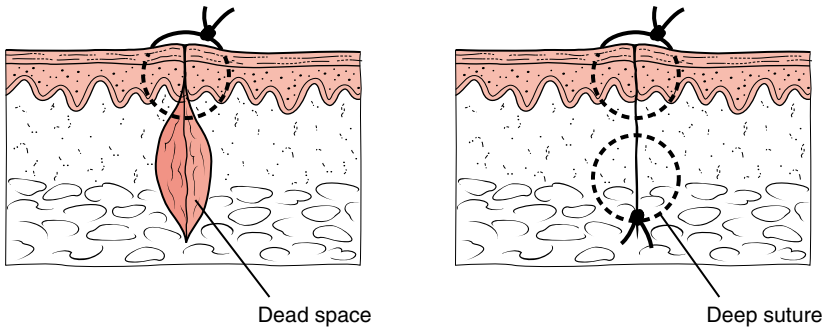

Figure 10-10. Example of dead space and a two-layered closure to obliterate that space.

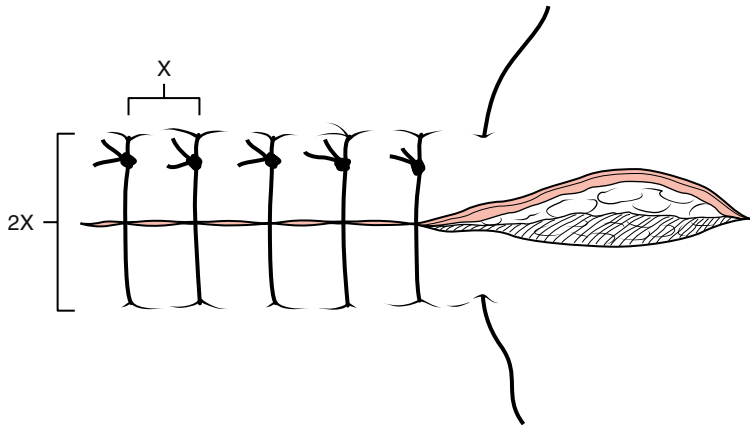

Figure 10-11. Example of closure style and sequence. The knots should be placed evenly on one side of the wound. Knots directly over the wound increase inflammation and scar tissue formation.

wound healing. There is experimental evidence, however, that suture closure of these spaces, when they are contaminated with bacteria, increases the chance of wound infection.[4] It is recommended that deep closures be used only to close dead space in clean, minimally contaminated wounds. Even in these cases, as few sutures as possible should be used.

Closure Sequence and Style

Students learning to care for wounds often ask how close together sutures should be placed. As a general rule, sutures should be placed just far enough from each other so that no gap appears between the wound edges. As a general guideline, the distance between sutures is equal to the bite distance from the wound edge (Fig. 10-11); however, the great variability of lacerations dictates that experience rapidly teaches the practitioner the proper distances at which sutures should be placed to close the wound.

The final appearance of a suture line should be neat and organized. The knots are aligned to one side of the laceration. In addition to appearing orderly, knots are placed away from the wound edge to prevent a further inflammatory response that can be provoked by an increased amount of foreign material directly over the healing surface. Aligning the knots to one side or the other contributes to wound edge eversion.

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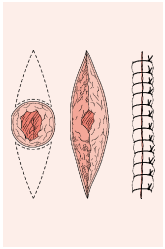

CHAPTER 11
Complex Skin Wounds: Advanced Repair Techniques

Key Practice Points

- Most lacerations can be closed with one or two simple techniques. However, some wounds and lacerations are more complicated and require advanced repair techniques to close.
- Long, straight lacerations can take a long time to close. Techniques to save time include running sutures, staples, and wound adhesives.
- The corner, or flap stitch, is an important suture technique for the surgeon to master to preserve the blood supply of the tip of the flaps or corners in an irregular wound.
- Injured fat in a laceration or in the underside of a flap has no value and can act as substrate for bacterial growth. Injured fat should be débrided before closing the wound with sutures.
- When closing a curving laceration, a "dog-ear" defect can be created. The "dog-ear" technique can repair that defect and can improve the cosmesis of the wound.

Most lacerations and wounds are straightforward and can be closed with the basic techniques described in Chapter 10. Some wounds are more complicated, however, and present with a variety of technical challenges. This chapter describes some of the more complicated wound problems that can be encountered in a wound care setting. Techniques for "solving" these "puzzles" are suggested.

RUNNING SUTURE CLOSURE

Description

Lacerations, usually caused by simple shearing forces, can be quite long and time consuming to close. Lacerations often are caused by slash wounds from a knife or a piece of glass. The continuous "over-and-over" (running) suture technique can be used when a shortage of time is a factor.[1] Wounds longer than 5 cm can be considered for this technique. The time saved is beneficial to the person repairing the wound, because he or she can return quickly to other emergency-department duties. There are drawbacks to this technique. If one loop of the suture breaks or is imperfectly positioned, the whole process has to be repeated. Wound edge eversion can be difficult to control with this technique. Continuous sutures are reserved for straight lacerations in healthy, viable skin that would not collapse in with suturing. If this technique is applied to curved lacerations, it can create a "purse-string" effect that bunches up the wound. Another technique that can be used for long, straight lacerations is wound stapling (see Chapter 14).

Technique for Continuous Over-and-Over (Running) Suture

The technique for continuous over-and-over suturing is shown in Figure 11-1A. The closure is started with the standard technique of a percutaneous interrupted suture, but the suture is not cut after the initial knot is tied (see Fig. 11-1A). The needle is used to make repeated bites, starting at the original knot and making each new bite through the skin at a 45-degree angle to the wound direction (Fig. 11-1B through 11-1F). The cross stays of suture, on the surface of the skin, are at a 90-degree angle to the wound direction. The final bite is made at a 90-degree angle to the wound direction to bring the suture out next to the previous bite exit (Fig. 11-1G). The final bite is left in a loose loop. The loop acts as a free end of suture for knot tying. The first throw of the final knot is made by looping the suture end held in the hand around the needle holder, then by grasping the free loop (Fig. 11-1H). The first throw is snugged down to skin level (Fig. 11-1I). The knot is completed in the standard instrument-tie manner with several more throws at skin level (Fig. 11-1J and 11-1K).

BEVELED (SKIVED) WOUNDS

Description

A common problem in layer matching is the beveled-edge, or "skived," laceration. Beveled edges are created when the striking angle of the wounding object is not perpendicular, but the angle and force are not acute enough to create a true flap deformity.

Technique for Closure of a Beveled Edge

A common misconception about the repair of a beveled-edge wound is that a larger bite is taken from the thin edge of the laceration rather than from the bigger edge. The opposite technique is the solution to proper layer matching. The technique for closing a beveled laceration is shown in Figure 11-2. By taking unequal bites as shown, the edge is brought into correct apposition with the opposite edge. If sufficient tissue redundancy exists in the wound area, excision of the edges can equalize the wound so that simple sutures can close the wound.

PULL-OUT SUBCUTICULAR CLOSURE

Description

A favorite technique of plastic surgeons is the pull-out subcuticular stitch using a nonabsorbable suture material, such as polypropylene (Prolene). This suture material is stiffer and stronger than nylon and allows for easier removal.[2] A newer, nonabsorbable suture material, polybutester (Novafil), is also useful for this technique.[3] The pull-out closure is limited to straight lacerations less than 4 cm long, because the suture would be too difficult to extract at removal time. Children have naturally higher skin tension, so this technique is thought by some clinicians to be superior for children because it prevents suture marks. Despite this fact, the pull-out subcuticular closure has no distinct advantage over percutaneous closure when final wound and scar appearance is compared.[4] Another use for this technique is for closure of lacerations over which splinting materials or plaster will be placed. It also can be used in patients who are at risk for keloid formation to prevent keloid formation at the needle puncture sites.

Technique for Pull-Out Subcuticular Closure

Before placement of a pull-out subcuticular closure, the superficial fascia (subcutaneous tissue) has to be apposed adequately with absorbable suture to bring the dermis

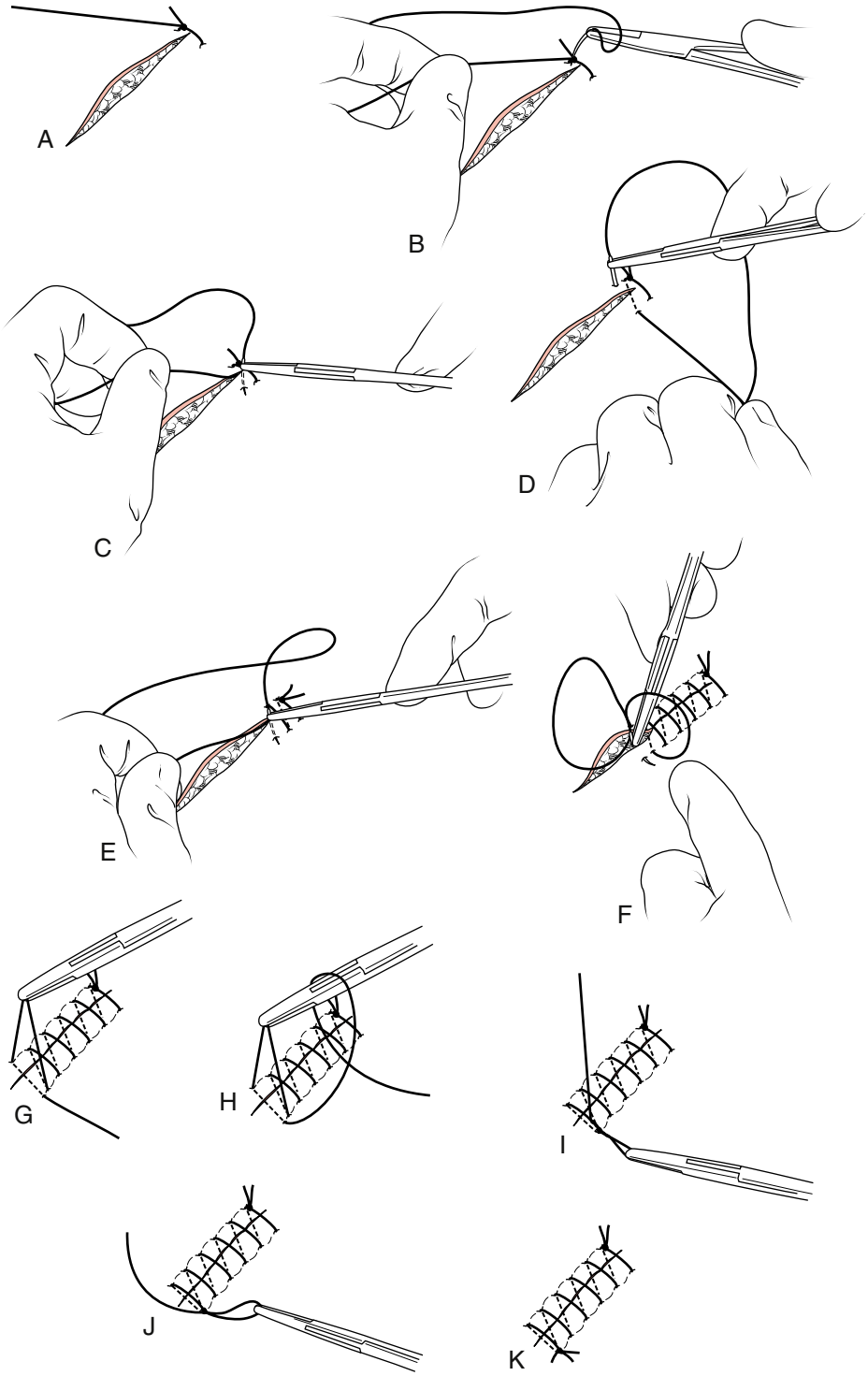

Figure 11-1. **A-K,** Technique for continuous over-and-over suture (running suture). The needle bites are made at a 45-degree angle to the axis of the wound. By taking bites at this angle, the cross stay of the suture at the skin surface is at a 90-degree angle to the wound axis. See text for complete description of technique.

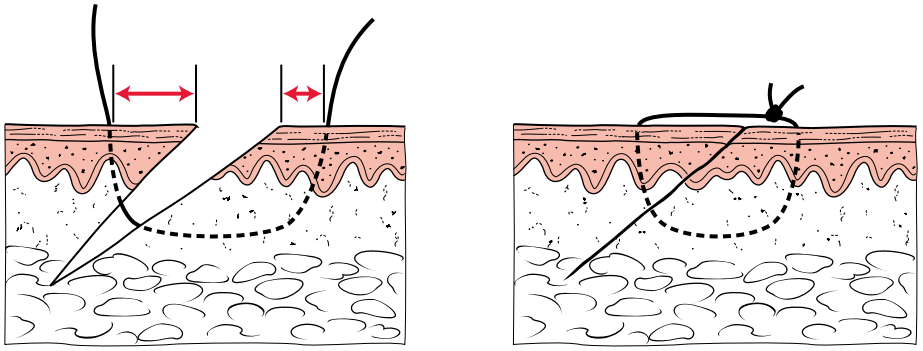

Figure 11-2. Technique for closing a beveled edge. There is a larger bite taken on the larger wound edge; there is a smaller bite taken on the flap portion of the wound edge.

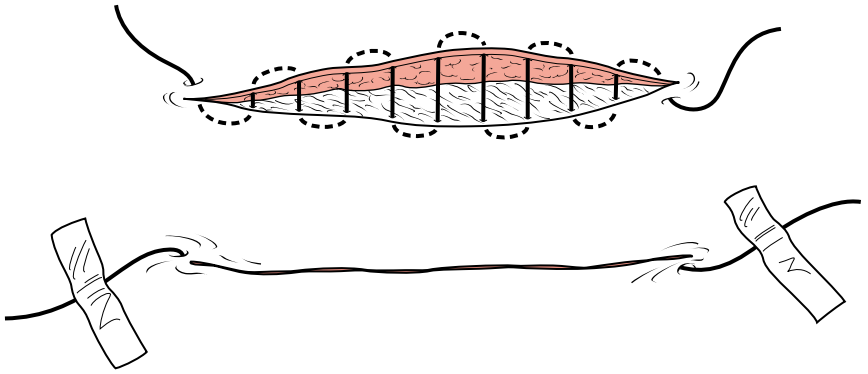

Figure 11-3. Technique for pull-out dermal closure. See text for complete description of technique.

close to approximation. The actual closure is begun by passing the needle of 4-0 or 5-0 nylon or polypropylene 1 to 1.5 cm from the wound end through the dermis layer and bringing it out of the wound parallel to and through the plane of the dermis. Subsequent bites are made (Fig. 11-3) parallel to the dermis at a depth of 2 to 3 mm into the dermis. Each bite should "mimic" the other with regard to bite size and dermal depth on each side of the wound until the "tail" is brought out at the opposite end of the wound. The beginning and final tail can be secured by wound tape. In the face, this suture can remain in place for 7 days. This technique often is used in conjunction with wound taping to match dermal and epidermal layers accurately. The suture is removed merely by pulling on one end with forceps or a needle holder and sliding the suture out of the dermal layer.

SUBCUTICULAR RUNNING CLOSURE

Description

Surgeons often use a subcuticular running closure to close straight incisions. The subcuticular running closure can suffice to close the wound alone, or it can be supplemented with interrupted skin sutures. In wound care, this closure should be reserved for straight, clean lacerations with sharp, nondevitalized wound edges. It can be used to close wounds that have been excised or trimmed where the edges are left fresh and straight.

Technique for Subcuticular Running Suture

An absorbable suture material (e.g., Dexon, Vicryl, PDS, Maxon, or Monocryl) can be used. One strand is used, without interruption, for the entire laceration. As shown in Figure 11-4, the suture is anchored at one end of the laceration. The plane chosen is either the dermis or just deep to the dermis in the superficial subcutaneous fascia. While maintaining this plane, "mirror image" bites are taken horizontally the full length of the wound. The final bite leaves a trailing loop of suture (see Fig. 11-4) so that the knot can be fashioned for final closure. This technique commonly is supplemented with wound tapes, particularly if some degree of gapping of the edges remains.

CORNER STITCH

Description

Many wounds are irregular and jagged, with corners that need to be secured during closure. Corners and flaps are particularly vulnerable because they receive their blood supply only from an intact base. Improper suturing of the tip of a corner can compromise an already tenuous vascularity.

Technique for Closing a Corner

A simple technique to secure a corner without interrupting the small capillaries at the tip is shown in Figure 11-5. The technique used is the half-buried horizontal mattress suture. A nonabsorbable (nylon, Prolene) suture is introduced percutaneously through the skin in the noncorner portion of the wound. The needle is brought through the dermis, is then passed horizontally through the corner dermis, and is brought back to the same plane of dermis on the opposite side of the noncorner portion. Finally, it is led out through the epidermis.

The key to this suture is that the flap portion of the suture passes horizontally through the dermis and not vertically through the epidermis and the dermis. When the tip is in place with the corner stitch, the remainder of the flap can be closed with interrupted percutaneous or half-buried horizontal mattress sutures, which should be placed far enough from the tip to allow for unrestricted dermal circulation.

A single corner stitch can encompass several corners of stellate lacerations by capturing all of the corners of flaps (Fig. 11-6) until the final percutaneous reexposure is completed to tie the knot. The corner suture is one of the most useful suture techniques in emergency wound and laceration care for complex wound closure.

PARTIAL AVULSION, FLAP WOUNDS

Description

Flap lacerations are the result of forces that tear up, or avulse, a flap of skin from the subcutaneous tissue. The vascular supply of a complicated flap is even more tenuous because it derives blood from only its intact dermal attachment. A general rule for viability is that the flap base should exceed flap length by a ratio of 3:1.[5] Flaps with lower ratios are less likely to survive. The rule varies according to anatomic site and other considerations. A long, narrow-based flap is in greater jeopardy than a short, broad-based flap.

Flaps that are distally based have the tip pointing opposite to the natural cutaneous arterial flow. These flaps rely solely on venous backflow for oxygen and nutrients. The repair technique has to be meticulous and gentle, and has to be dictated by the condition of the flap, the width of the total wound, and the anatomic location. Flaps that are proximally based usually have adequate perfusions, but the repair has to be handled no less carefully.

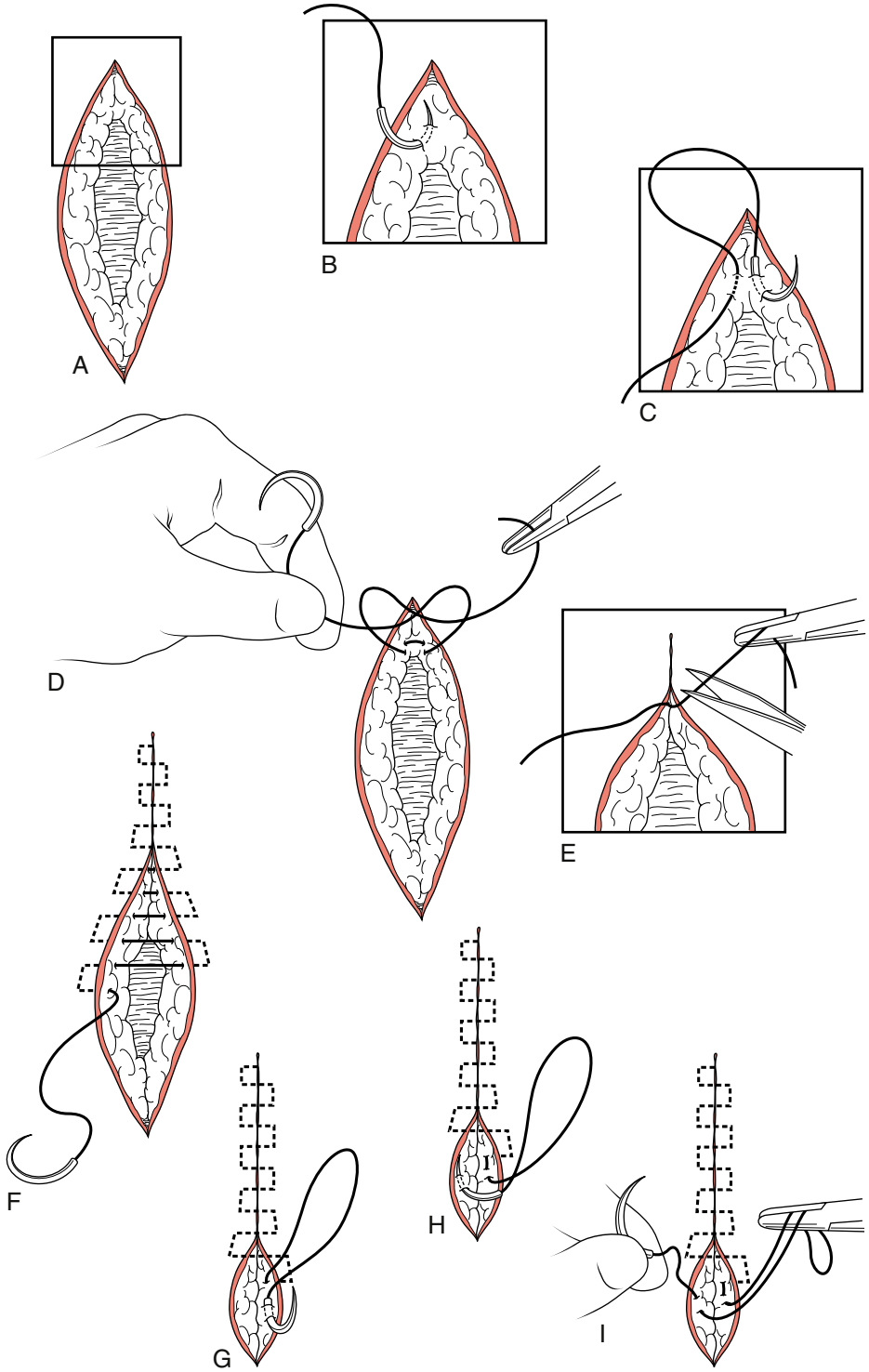

Figure 11-4. **A-I,** Technique for subcuticular running suture. See text for complete description of technique.

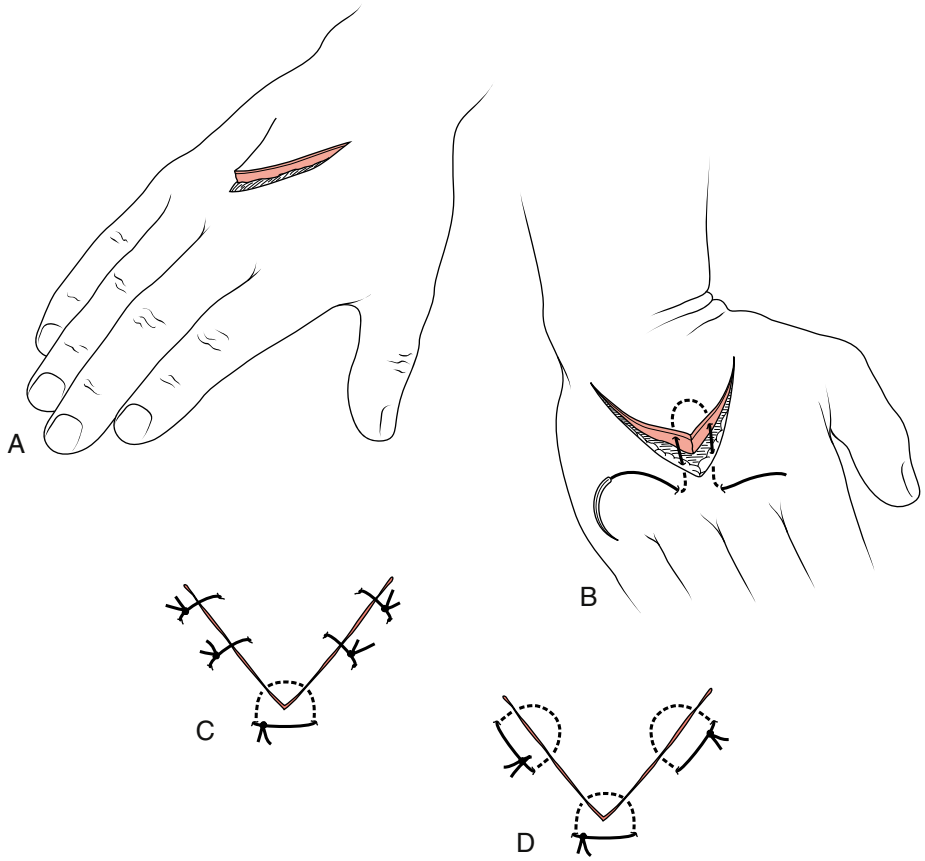

Figure 11-5. **A-D,** Technique for closing a corner (flap stitch). See text for complete description of technique.

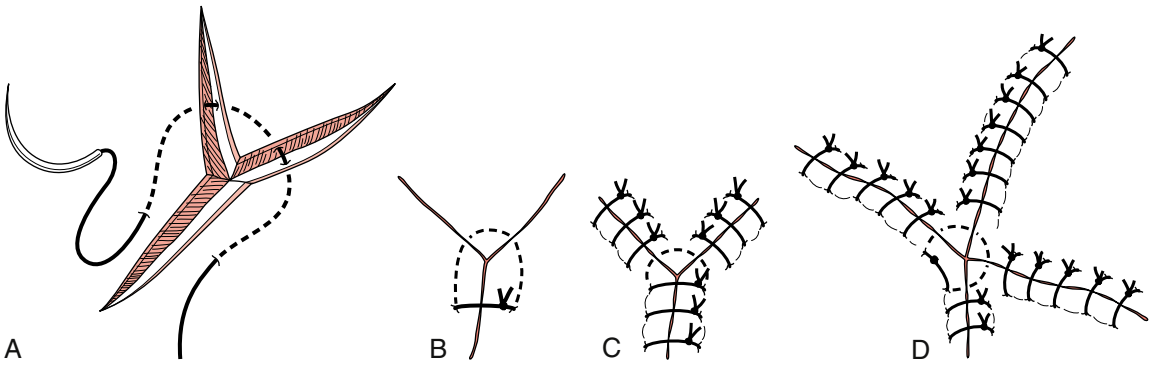

Figure 11-6. **A-D,** Technique for using the corner stitch to close a stellate or multiflap laceration.

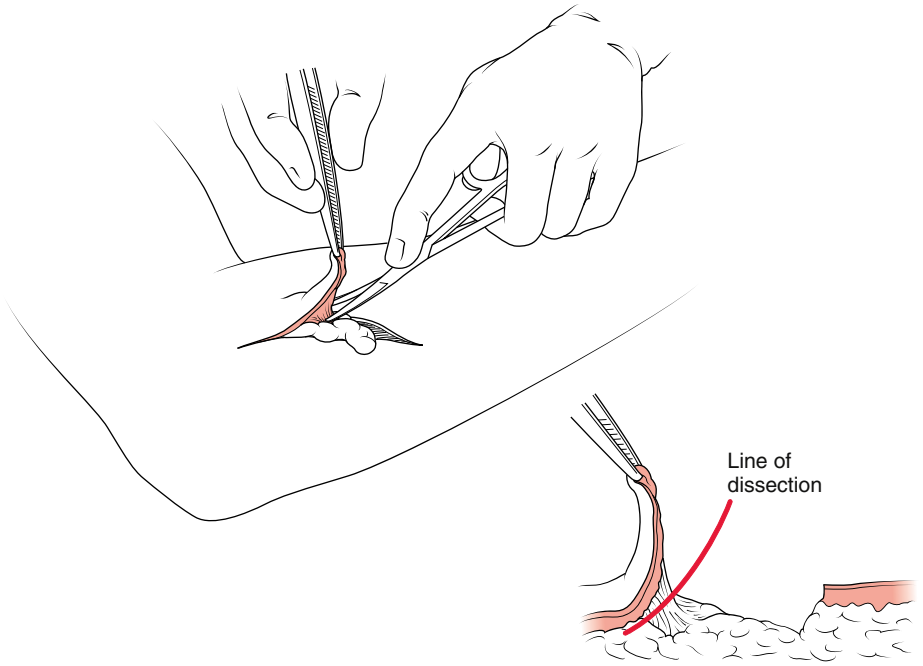

Figure 11-7. Technique for defatting the base of a flap for better union and vascularization to occur after suture anchoring. Fat is removed at the dermal–superficial fascia plane.

Technique for Preparing and Repairing a Complicated Flap

Excessive fatty superficial fascia (subcutaneous tissue) on the underside or dermal part of the flap can impair healing when it is secured with sutures. A raw dermal surface is preferable to damaged fat when the flap is replaced in the laceration defect. In this sense, flaps are similar to grafts. To improve the chance of flap survival during early healing, it is best to remove the excessive fat from the flap before suturing (Fig. 11-7). Iris scissors can be used to trim the fat until only a fresh tissue surface remains.

If the flap is otherwise in good condition with viable edges, the initial suture is the half-buried mattress suture described earlier for corner closure. The remainder of the flap can be closed with the same suture technique for the corner closure with simple interrupted percutaneous sutures.

Technique for Closing Flaps with Nonviable Edges: V-Y Closure

Often flaps have damaged edges that are not viable, in which case the edges can be excised to create a smaller but more viable flap. Figure 11-8 shows how this flap is secured by converting a V closure to a Y closure to accommodate the smaller amount of tissue available. With iris scissors, the edges of the flaps are trimmed back to viable tissue. The remaining flap is not large enough, however, to accommodate the resultant defect. By using a modified corner stitch technique, the flap tip can be brought together with the wound edges in a Y configuration. The remainder of the wound is closed with small-bite percutaneous interrupted sutures. Similar to the previously mentioned complicated flap, defatting also is recommended if appropriate.

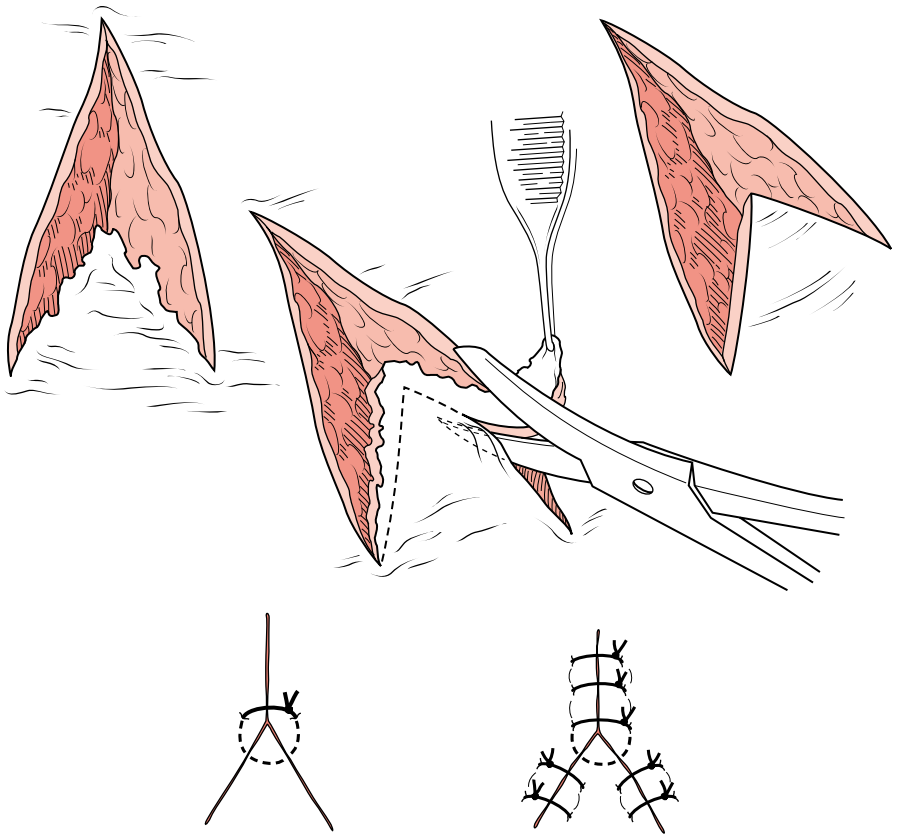

Figure 11-8. Technique for closure of flaps with nonviable edges: the V-Y closure. The edges of the flap are excised. The remaining flap is not large enough to fill the defect; a corner stitch is placed to close the wound as a Y instead of its original V configuration.

Technique for Closing a Wound with a Completely Nonviable Flap

Some flaps are beyond revision or repair. In this case, closure can be achieved by "ellipsing" the flap (Fig. 11-9) and completely closing the wound by following the 3:1 length-to-width ratio rule for ellipse closure (see Chapter 9). In some cases, there is insufficient tissue redundancy so that ellipsing is not feasible, and the wound has to be considered for open healing (secondary intention) or grafting.

GEOGRAPHIC LACERATIONS

Description

One of the most challenging wounds is the geographic laceration, a wound that can be irregular in configuration and depth. These lacerations are caused by differential forces occurring at the same time to create a complex wound. Closure requires some creativity.

Technique for Closure of Geographic Wounds

The first principle in closure of geographic wounds is to appose the natural geographic points (Fig. 11-10). After that, simple percutaneous interrupted sutures might suffice, but a creative mix of different techniques and suture sizes ultimately might be required.

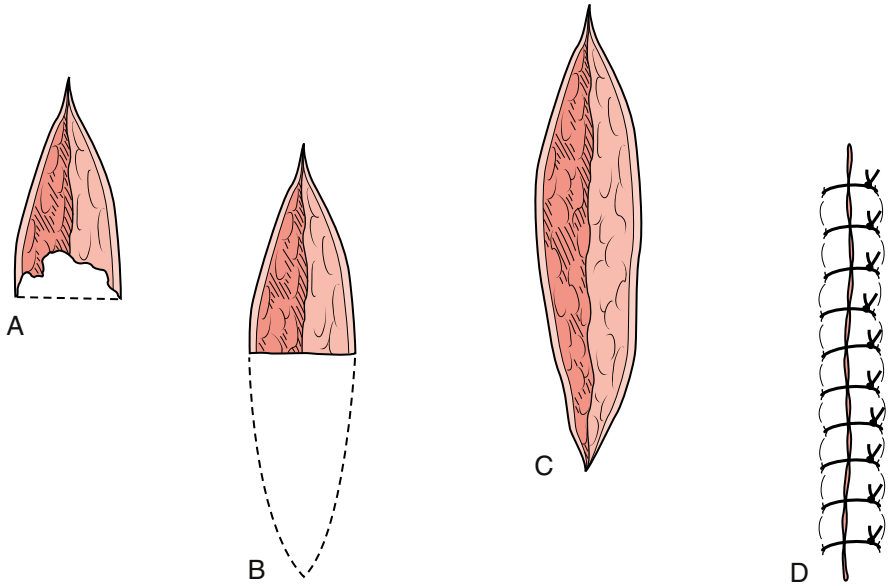

Figure 11-9. **A-D,** Technique for closure of a wound with a completely nonviable flap. In this case, a complete ellipse can be fashioned and closed primarily.

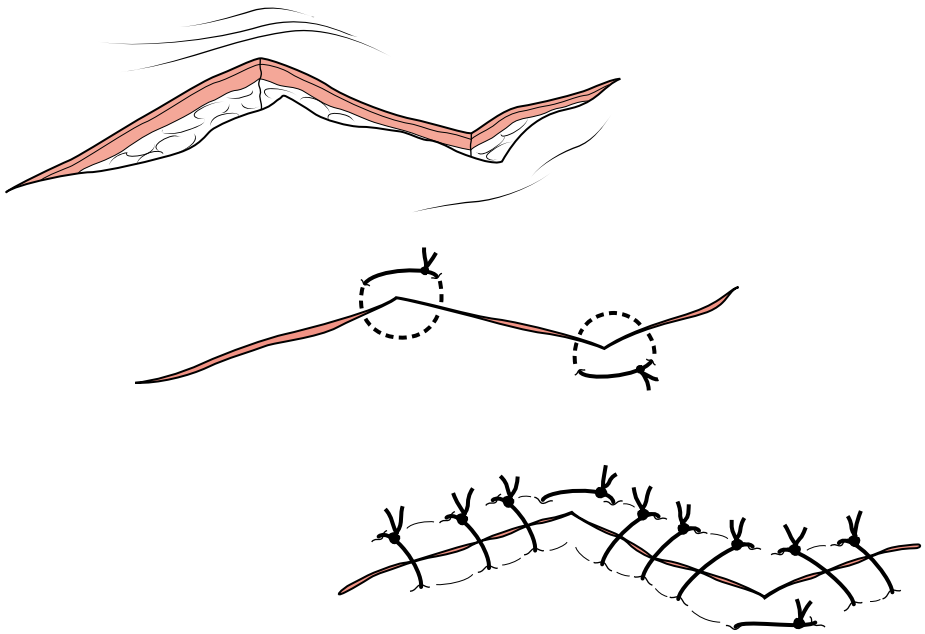

Figure 11-10. Technique for closure of geographic wounds. Obvious geographic points are apposed first with either simple percutaneous sutures or with corner sutures.

Closure techniques may appear unorthodox, but for traumatic wounds, the maxim "whatever works" should be followed to obey basic closure principles and to achieve the best possible result.

COMPLETE AVULSIONS

Description

When tissue is lost or avulsed through the primary wounding event, several considerations have to be addressed. Full-thickness losses are identified by the complete loss of dermis. Superficial fascia (subcutaneous fat) "shows" through the wound. Partial-thickness losses are identified by the raw appearance of underlying dermis without its covering epidermis. Partial-thickness losses, especially when intact dermal elements are visible, heal well without aggressive intervention. Generally, any full-thickness defects, less than or equal to 1 to 2 cm^2 in area, can be left to heal by open healing (secondary intention). This rule also applies to wounds on fingertips.

Full-thickness gaps or defects that are greater in area than 2 cm^2 need to be considered for grafting. Whenever questions arise about the possibility of grafting, consultation with a specialist is recommended. Some defects can be closed primarily, without grafting, and suggested techniques are described subsequently.

Technique for Converting a Triangle to an Ellipse

If the avulsion defect is configured as a triangle, conversion of that defect to an ellipse can be made by extending with excision the "defect" (see Fig. 11-9B through 11-9D). If the basic 3:1 length-to-width rule can be maintained during this process, the whole defect can be closed with a few dermal (deep) supporting sutures and a line of percutaneous sutures with the result of a simple, single suture line. Undermining may be required to bring the wound edges together to reduce wound edge tension. There must be sufficient tissue redundancy to perform this closure successfully (see Chapter 10).

Technique for Closing a Circular or Irregular Defect

The simplest way to close a circular or irregular defect is to turn it into an ellipse as shown in Figure 11-11. If the defect is too great, a double V-Y closure technique can be used. In this case, the defect is covered by two sliding pedicle flaps created by a no. 15 blade (Fig. 11-12). It is crucial not to disturb the fascial attachments of the flaps and not to interrupt the blood supply. The dermis is incised without including the subcutaneous tissue to allow the flaps to move forward on their vascular base into the gap.

DOG-EAR DEFORMITIES

Description

Trying to close a laceration evenly, particularly if it has a curving configuration, can lead to bunching of one or both of the wound edges as the suture closure proceeds. One edge of the wound can become redundant and can lead to the creation of a "dog ear."

Technique for Closing a Dog Ear

To correct a dog-ear deformity, an incision is made with a no. 15 blade, beginning at the end of the wound and at a 45-degree angle from the direction of the laceration on the side of the redundancy (Fig. 11-13). The redundant tissue flap is excised along an imaginary line that directly corresponds with the incision. The remaining

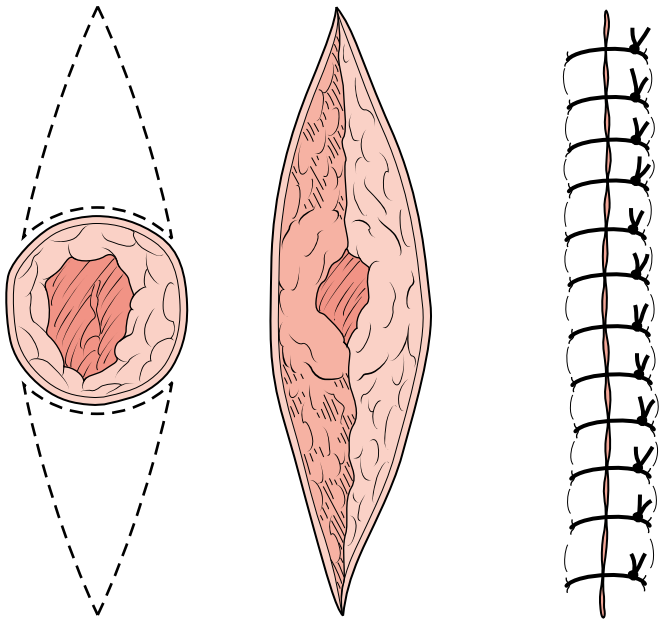

Figure 11-11. Technique for closure of a circular defect by the ellipse method.

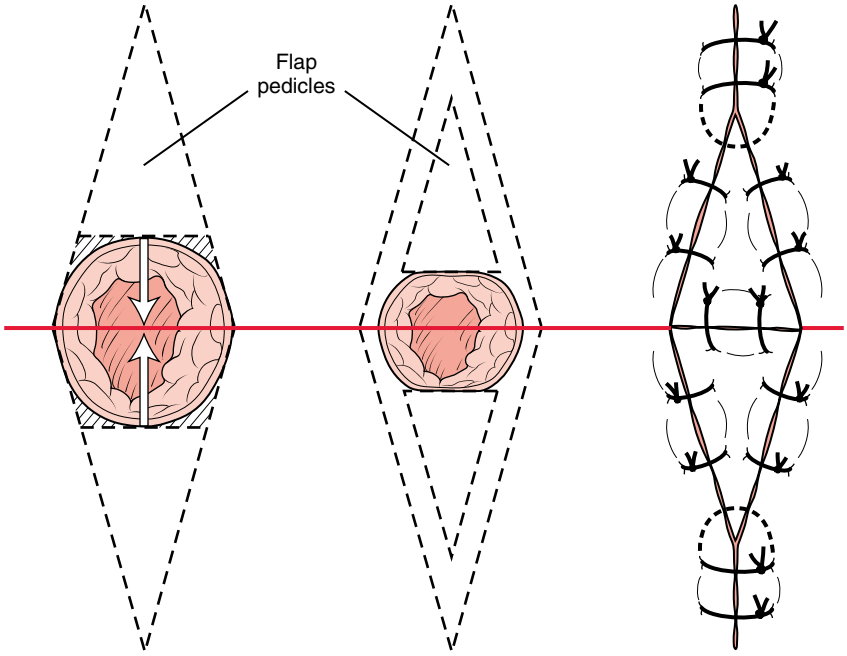

Figure 11-12. Technique for closure of a circular or irregular defect by advancing flap pedicles to effect a double V-Y closure. (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

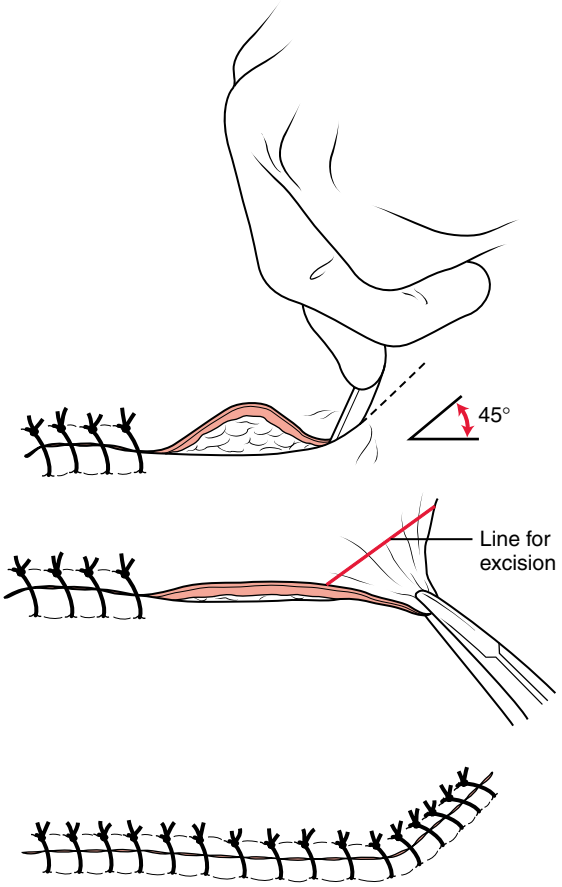

Figure 11-13. Technique for closure of redundant tissue, or a dog ear. The incision is made at an approximately 45-degree angle from the original axis of the wound. See text for complete description of technique.

portion of tissue fits the new configuration of the laceration incision and is appropriately sutured. The final outcome is a slightly angulated wound with a "hockey-stick" appearance.

PARALLEL LACERATIONS

Description

Two or more parallel lacerations that are in close proximity are often the result of self-inflicted wounds on the wrists or forearms. They are usually superficial, but because of the nature of the anatomic site, these wounds can result in significant injuries to the underlying flexor structures of the wrist. Careful functional testing of nerves and tendons with wound exploration often is necessary before closure.

Technique for Closure of Parallel Lacerations

After close inspection and exploration to rule out tendon or nerve damage, the caregiver will choose from several methods for closing parallel lacerations without compromising the blood supply to the tissue "strips" between lacerations. Some wounds can be closed with the horizontal mattress suture, modified to cross all lacerations

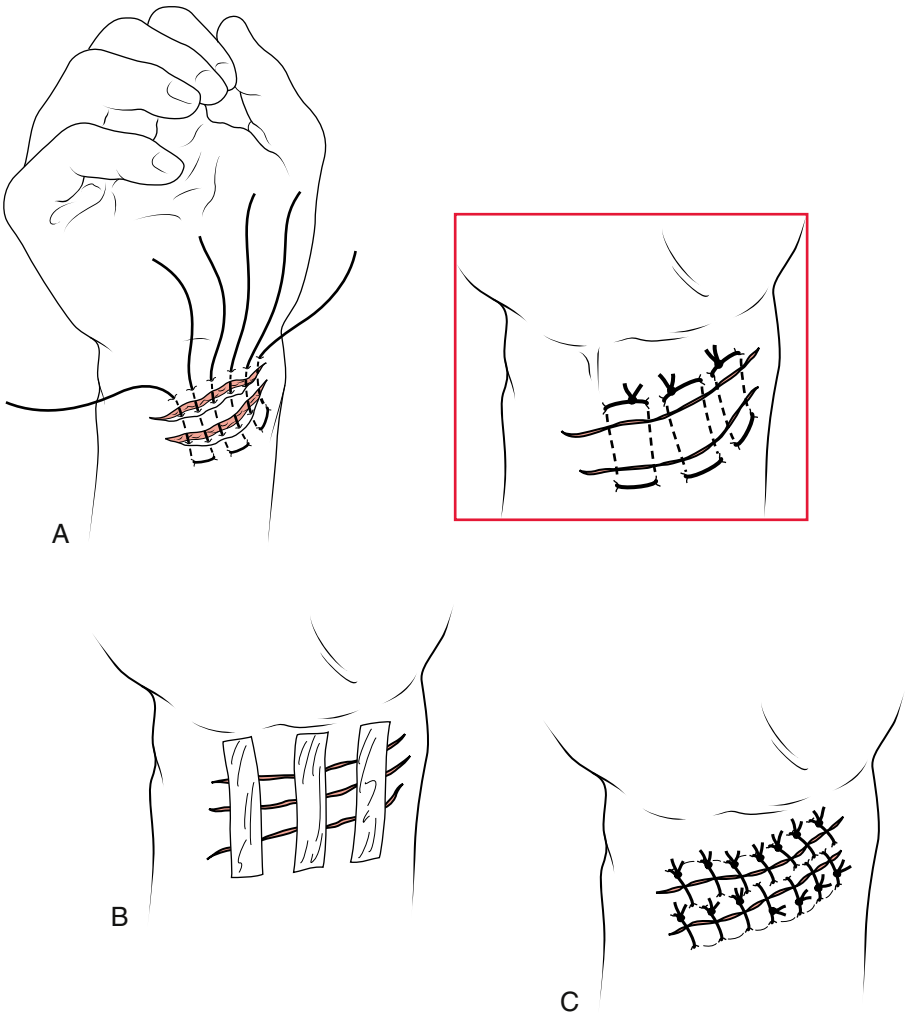

Figure 11-14. Three techniques for closure of parallel lacerations. **A,** The horizontal mattress technique is used to cross all lacerations for closure. **B,** Wound tapes can be used to close these lacerations. **C,** If the island of tissue is wide enough, alternating sutures can be used on each laceration. It is necessary, however, to be careful not to compromise vascular supply when using this technique. (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

(Fig. 11-14A). Wound tapes are particularly effective if the lacerations are superficial (Fig. 11-14B). Finally, the alternating percutaneous approach can be used if the vascular supply of the tissue would not be compromised (Fig. 11-14C).

THIN-EDGE, THICK-EDGE WOUNDS

Description

Occasionally a wound can be created in which the thickness of one edge is markedly different from the other wound edge. There is unequal dermal loss during injury. To appose the two edges properly, simple percutaneous interrupted sutures do not suffice. The thin edge has to be elevated to meet the appropriate layers of the full-thickness edge.

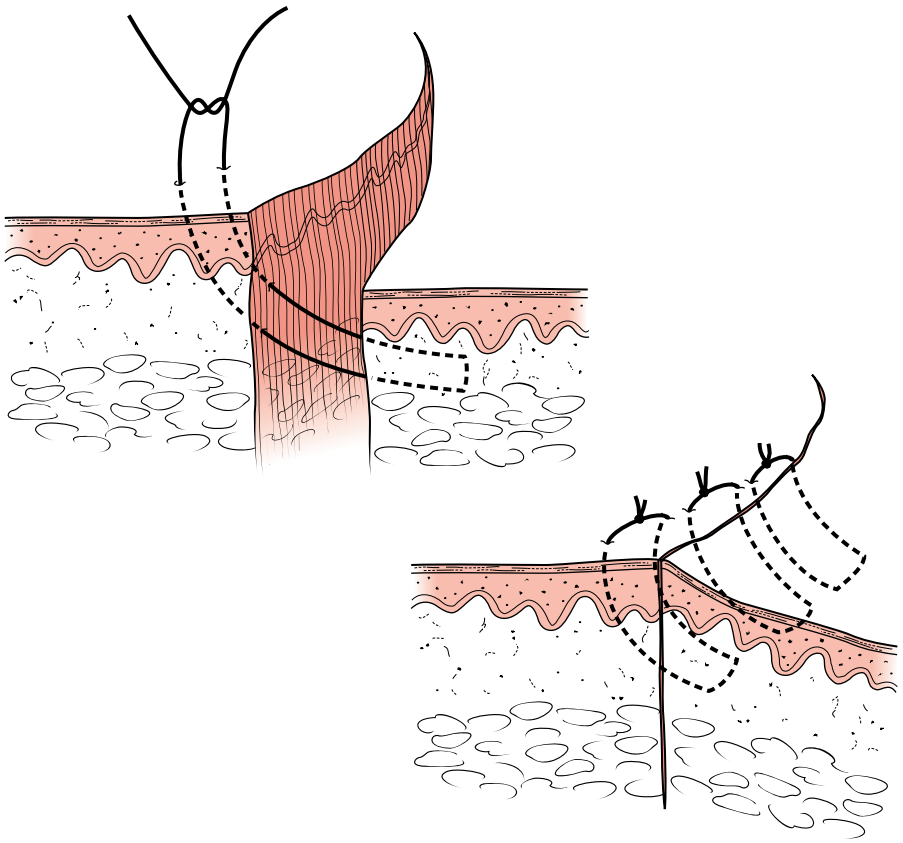

Figure 11-15. Technique for closure of a thin-edge, thick-edge laceration. The horizontal mattress technique is used; however, one portion is buried and is not brought through the opposite side of the wound surface.

Technique for Closing a Thin-Edge, Thick-Edge Wound

A technique for closing a thin-edge, thick-edge wound is to use the half-buried horizontal suture in the manner shown in Figure 11-15. The thin edge (dermis lost) is captured by the suture and is brought up to match the thick edge (dermis preserved).

LACERATION IN AN ABRASION

Description

Another complex wound is the loss of surface skin accompanied by a laceration in the defect.

Technique for Closing a Laceration in an Abrasion

The laceration can be repaired by using the deep (dermal) closure with the knot buried under the wound surface (see Chapter 10). When the laceration is closed (Fig. 11-16), the defect can be managed by allowing it to close by secondary intention or grafting.

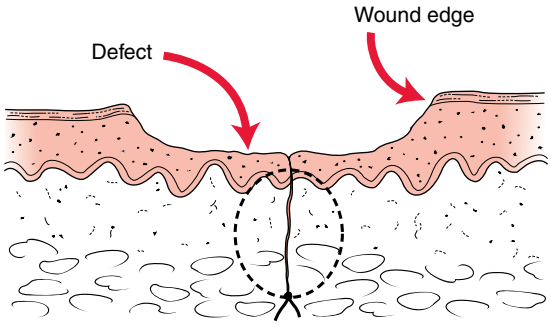

Figure 11-16. Technique for closure of a laceration within a deep abrasion. The deep-suture technique is used, and the abraded surface is avoided.

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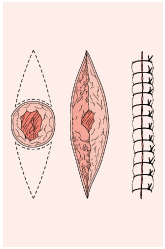

CHAPTER 12
Special Anatomic Sites

Key Practice Points

- Although scalp lacerations can appear small and innocuous, they can bleed profusely to the point of hypotension.
- Hair does not increase the risk of wound infection. Shaving hair increases the risk of wound infection. Hair can be clipped or cleaned to prepare the laceration for closure.
- Closing scalp lacerations with absorbable sutures, particularly in children, avoids the need for the patient to return for suture or staple removal.
- The forehead has little redundant tissue. Débride as little as possible to preserve skin for later revision if necessary.
- Face lacerations do not require dressings. Have the patient apply a small amount of antibiotic ointment daily to the sutured laceration to facilitate easy removal of sutures.
- Lacerations near the eye can cause several serious complications, such as hyphemas, tear duct injuries, and other problems. Carefully examine the eye and its structures before closure.
- Never shave an eyebrow. Eyebrow hair does not grow back in some patients, or it grows abnormally.
- Lacerations to the side of the face can injure the parotid gland or the seventh nerve. Examine these structures before repair.
- Injuries to the nose can cause a septal hematoma. Use an otoscope to look in the nares to detect hematoma of the septum or exposed cartilage or bone.
- Lacerations to the ear can involve cartilage. However, it is not necessary to suture cartilage. Closure of skin over the cartilage will bring cartilage into proper position.
- Alignment of lacerations through the vermilion border of the lip is critical to avoid a noticeable cosmetic defect.
- If a tooth is knocked out, the prognosis for salvage worsens by the minute. If not replaced within 30 minutes, it is not likely to remain viable.

Although the wound closure principles and suture techniques discussed in Chapters 10 and 11 can be applied to all lacerations and wounds, several areas of the body have unique anatomic considerations that require special attention. Particular emphasis is placed on facial wounds because of cosmetic concerns. Initial management and wound closure are crucial to the way that scars eventually form and to the final appearance of the injury. Table 8-3 in Chapter 8 presents a reference guide for sutures and closure

materials for each anatomic region of the body. Because of the importance and complexity of the hand, this anatomic feature is covered separately in Chapter 13.

SCALP

There are five layers of the scalp: skin (epidermis, dermis), dense superficial fascia, galea aponeurotica, loose areolar connective tissue, and periosteum (Fig. 12-1). The skin is densely covered with hair. Ragged lacerations often are closed without regard to cosmetics because of the assumption that hair will hide the scar. Most men experience some balding in their lifetimes, however, a fact that must be taken into consideration during wound closure.

Underlying the skin is a dense layer of connective tissue that corresponds to the superficial fascia. This layer is richly invested with arteries and veins. Although this profuse vascularity protects against the development of infection, the denseness of the connective tissue tends to hold vessels open when the scalp is lacerated. For this reason, even small lacerations can cause considerable bleeding, leading to hypovolemia, hypotension, and even death.[1] Hemorrhage is worsened if alcohol is present in the blood, which is a finding in 50% of patients with scalp lacerations.[2]

The next layer of skin is the galea aponeurotica (Fig. 12-2). It is a dense, tendon-like structure that covers the skull and inserts into the frontalis muscle of the forehead anteriorly and into the occipitalis muscle posteriorly. Failure to repair large, horizontal lacerations of the aponeurosis can cause the frontalis muscle to contract

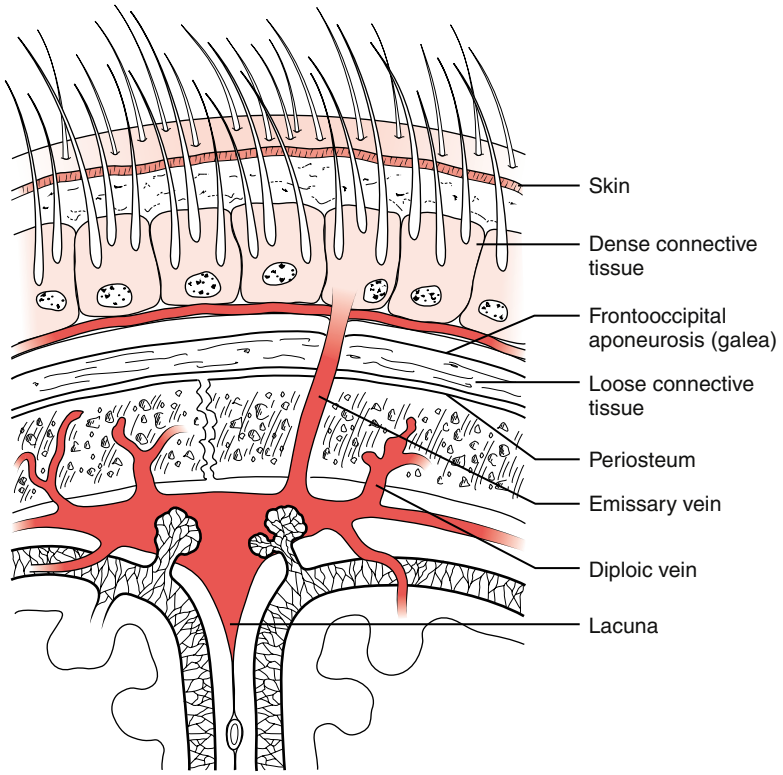

Figure 12-1. Cross-sectional anatomy of the scalp. Note the emissary vein; it can act as a conduit for bacteria to brain tissues if the scalp wound becomes infected.

asymmetrically, which can cause a significant cosmetic deformity of the forehead. Closure of galea lacerations also is important for protection of the loose connective tissue that is vulnerable to infection.

Blood and bacteria can spread easily from a laceration of the skin through the injured galea to the loose connective tissue. Within this layer are emissary veins that drain into the skull and intracranial veins. Infection of this space can lead to osteomyelitis or brain abscess. Beneath the loose connective tissue layer is the periosteum of the skull itself. The periosteum can be mistaken for the galea but is not as dense, and it does not readily accept sutures without the risk of tearing.

Preparation for Closure

Visual inspection and digital palpation of large wounds are recommended to identify galeal or bone injuries. The periosteum frequently is injured during trauma. Injuries to this layer often can be seen or palpated through a laceration. Because of its close adherence to the bone, a laceration of the periosteum can be mistaken for a skull fracture. Computerized tomography is recommended to rule out a true fracture, even if the published criteria for computerized tomography in minor head injury are not met.[2,3]

Hair removal before closure is necessary only if hair interferes with the actual closure and knot tying. Hair is not contaminated with high levels of bacteria and can be cleansed easily with standard wound preparation solutions.[4] In a study of 68 patients with traumatic scalp lacerations, no wound infections were documented in patients whose hair had not been removed before closure.[5] If removal is necessary for mechanical reasons, clipping with scissors or shaving with a recessed blade razor suffices.[6] Shaving at skin level can increase the chance for wound infection.[7,8] Another method to expose the laceration before closure is to apply ointment such as Vaseline or antibiotic ointment to the hair around the wound. The hair is then flattened away from the wound before closure.

Because of the scalp's propensity to bleed profusely, hemorrhage control is necessary before attempting closure. Trying to suture a bleeding scalp wound can be difficult and

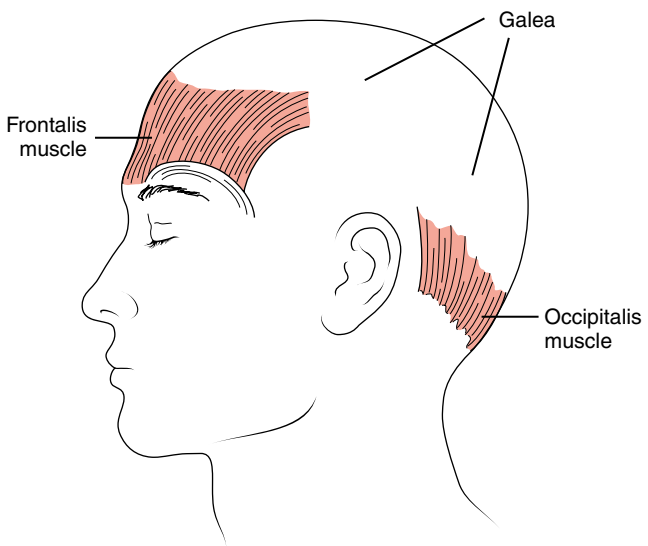

Figure 12-2. Lateral view of galea aponeurotica. Repair of large lacerations of the galea is required to maintain the integrity of facial structures.

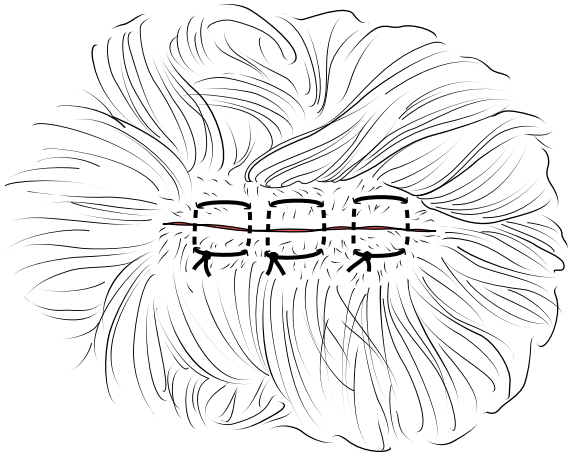

Figure 12-3. Horizontal mattress suture technique for closure of scalp wounds with uneven or macerated edges.

frustrating. The vessels do not lend themselves to easy clamping or ligation because they are encased in the dense connective tissue. Direct pressure, applied in the manner described in the following text, is an effective way to gain hemostasis. First, gross contaminants, if present, are removed immediately with a brief cleansing or irrigation. Then the wound is covered with sterile, saline-moistened sponges and is compressed with an elastic bandage. This bandage can be left in place for 30 to 60 minutes. After compression, significant bleeding is usually under control.

Injection of lidocaine with epinephrine can also control bleeding. It can anesthetize the wound before formal closure or the application of horizontal mattress (Fig. 12-3) or figure-of-eight sutures, which can also aid in controlling bleeding.

Another method to control scalp hemorrhage is the use of hemostatic agents. In a review of the available agents, oxidized cellulose (Surgicel) and gelatin foams (Gelfoam) are effective for use in skin and scalp wounds.[9] Hemostatic agents should be considered as a last resort. These agents can interfere with suturing of a scalp wound and can take 2 to 6 weeks to be absorbed.

Galeal Lacerations

Because the galea is a key anchoring structure for the frontalis muscle, large frontal galeal lacerations need to be repaired separately with 3-0 or 4-0 absorbable sutures to prevent a serious cosmetic deformity from developing. If the frontalis muscle loses its anchoring point at the muscle-galeal junction along the frontal scalp line, facial expressions dependent on that muscle appear distorted and asymmetric. Closure of large galeal lacerations in other areas of the scalp also is recommended to protect the loose connective tissue layer from infection.

Uncomplicated Lacerations

Uncomplicated, shearing lacerations can be closed with nonabsorbable 5-0 or 4-0 monofilament nylon, staples, or fast absorbable gut suture. The fast absorbable gut material often is preferred for children, because suture removal becomes unnecessary. Some practitioners find this strategy equally effective for adults. Absorbable irradiated polyglactin-910 (Vicryl Rapide) also can be used to close scalp wounds, obviating the need for later suture removal.[10,11] Closure outcomes with this material are similar to

outcomes for other methods, in that low rates of dehiscence and infection result.[12] The use of staples is common for scalp wounds. Stapled wounds heal in the same way as wounds treated with standard closure methods.[13,14] In children, the cosmetic outcome of stapled scalp lacerations is no different from the outcome of lacerations closed with standard sutures.[15] In an analysis of stapling versus suturing, stapling was significantly faster and less costly.[16]

A simple, "low-tech" approach to scalp laceration closure is hair braiding. Because hair removal is not necessary for scalp laceration cleansing and repair, the hair itself can become the closure material.[17] This technique works best for straight and superficial lacerations with enough hair to tie in small knots. The wound is cleansed and irrigated (see Chapter 7). About 10 to 20 hairs on each side of the wound are moistened with saline or water and are clumped together to form a "thread." The two threads are tied together in a simple square knot. Forceps can be used to tighten the knot to prevent slippage. A small amount of cyanoacrylate glue (Dermabond) can be applied to the knot to increase security. Sutures and staples provide more overall wound security, but patients must return for removal of these closures.

Compression Lacerations with Irregular Margins

Lacerations of the scalp are often caused by blunt rather than sharp shearing forces. In these cases, the wound and its edges are irregular and macerated. Simple closure with percutaneous, interrupted sutures can be difficult under these conditions. The scalp does not have excessive tissue redundancy, so débridement has to be kept to a minimum, or the wound cannot be approximated without abnormally high tension. The rich vascularity of the scalp allows for eventual successful healing even if less than optimal tissues are brought together. After judicious wound edge trimming, the horizontal mattress suture technique is recommended to approximate the remaining edges (see Fig. 12-3). This technique also is useful for closing an excessively bleeding wound.

Compression injuries can result in complex, stellate lacerations. Judicious débridement is advised. The corner closure (flap) technique, described in Chapter 11, often approximates all of the corners and flaps in one suture. The remainder of the repair is performed with simple percutaneous or half-buried mattress sutures.

Avulsion or Scalping Lacerations

High-speed forces that are delivered in a tangential manner to the scalp can cause large flaps or complete loss of portions of the scalp. Associated intracranial injury also can occur. These wounds are best managed by a consultant. Preserved portions of complete scalp avulsions, similar to other amputated parts, are wrapped in saline-moistened gauze, are placed in plastic bags, and are cooled over ice. It is possible that they might be reimplanted in the defect by grafting or microvascular anastomosis techniques.

Aftercare

After repair, it is sometimes necessary to place a temporary (24-hour), light-pressure compression wrap with an elastic bandage over the scalp dressing of large lacerations to prevent formation of wound hematoma. The patient can be instructed to remove the bandage after the recommended compression period.

Most scalp lacerations do not require dressing, just a thin layer of an antibacterial ointment. Scalp sutures are left in place for 7 to 9 days for adults and for 5 to 7 days for children. Gentle bathing of the scalp can commence 24 hours after closure. Daily application of ointment after cleansing is recommended.

FOREHEAD

The forehead is a common site of injury in children and adults. The forehead is also of paramount cosmetic importance because of its visibility. Three principles govern the initial repair of a forehead injury, as follows:

- Skin tension lines that parallel skin creases play a major role in the outcome of any laceration. A laceration that is perpendicular to dynamic skin tension lines tends to heal with a more visible scar than one that is parallel to these lines (see Chapter 3).
- The forehead has little excess tissue to permit extensive revisions and excisions. The temptation to excise ragged wounds has to be assessed carefully or resisted. A small defect can inadvertently become larger by overaggressive repair efforts.[18] It is often best to preserve as much tissue as possible just by "tacking down" ragged tissue tags so that later cosmetic revisions can be made when conditions are more favorable.
- Whenever possible, avoid the use of dermal (deep) absorbable sutures. Excessive tissue reaction with increased scar size can result from deep sutures.

Preparation for Closure

Anesthesia for small or single lacerations of the forehead can be accomplished by the direct or parallel injection techniques, using an anesthetic with epinephrine to decrease bleeding. Large or multiple lacerations often are managed best by a forehead block (see Chapter 6). This block reduces the number of needle-sticks and prevents distortion of the tissues to allow for more accurate wound edge approximation.

When anesthesia is achieved, the wound can be explored for any bony abnormality or foreign body; radiographs are recommended when the suspicion for either is raised. Large pieces of glass can be discovered under small and innocuous-appearing wounds. After gentle scrubbing with a sponge, after irrigation, and after débridement with the tip of a no. 11 blade, most foreign material should have been removed. Any remaining permanent material can be surgically removed. Every effort is made to remove potential tattooing tar or grit at the time of the first repair. When in doubt, consultation with a specialist should be considered.

Uncomplicated Lacerations

Most lacerations can be closed with the simple percutaneous technique using a 6-0 monofilament nonabsorbable suture. Absorbable sutures, such as Vicryl Rapide, can be used for superficial skin closure as well.[19] Deeper lacerations may require placement of a few supporting dermal (deep) 5-0 absorbable sutures. The percutaneous technique in any laceration should be performed by taking small bites (close to the wound edge) with several sutures rather than large bites with few sutures. This technique reduces wound edge tension and allows for more accurate wound edge apposition.

Complex Lacerations

Multiple Small Flaps, Lacerations, and Abrasions (Windshield Injury)

One of the most daunting wounds is a "windshield" injury, characterized by multiple lacerations, abrasions, gouges, and small flaps. The anesthetic technique of choice is the forehead block. Flaps that are smaller than 5 mm in width and length are tacked down with single 6-0 percutaneous nonabsorbable sutures (Fig. 12-4). Larger flaps can be closed using the corner technique. Partial-thickness abrasions and shallow gouges (<5 to 10 mm wide and 1 to 2 mm deep) can be left to heal by secondary intention. Other lacerations are closed as necessary with percutaneous sutures. A petroleum-based antibiotic ointment applied three times a day suffices as a dressing. Because of cosmetic concerns, a consultant might be helpful, especially if the wounds are severe.

Figure 12-4. Small abrasions/lacerations, caused by a windshield injury, often can be closed by using simple, single, percutaneous sutures or single corner sutures.

Consultation also is appropriate if the estimated time of repair would interfere with an emergency physician's other duties, even if there is little technical challenge.

Ragged-Edge Lacerations, Large Flaps, and Tissue Defects

Lacerations with ragged and macerated edges can be trimmed as described in Chapter 9. If the unevenness or maceration is not extensive, complete excision is an option if the laceration is parallel to the skin tension lines and there is sufficient tissue redundancy. Lacerations perpendicular to skin tension lines have less tissue redundancy and cannot tolerate wide excision. The principle of tissue preservation has to be kept in mind when considering excision. When there is any doubt about tissue availability for excision, the caregiver should try to preserve what is viable or should obtain a consultation.

Large avulsion flaps and near-scalping injuries are prone to what is called the trapdoor phenomenon, in which congestion and lymphedema lead to unsightly bulging of the flap after repair. The flaps are U-shaped with the base in a superior position on the forehead. These injuries are best managed by a consultant.

Aftercare

Facial lacerations usually do not require dressings. Daily application of an antibacterial ointment after gentle cleansing is recommended for protection and to allow for easier suture removal (by reducing crusting). Cotton swabs moistened with a mild soap and water solution are useful for cleaning in and around facial lacerations. A small amount of antibiotic ointment applied to the laceration after cleaning makes it much easier to remove the sutures. Facial sutures are removed within 3 to 5 days to prevent suture mark formation. Larger lacerations (>2 cm) are supported by wound tape for 1 week after suture removal.

EYEBROW AND EYELID

The eye and periorbital tissues are susceptible to serious injury by relatively minor trauma. Figure 12-5 illustrates various structures that must be checked for damage before repair proceeds. If any of the important anatomic parts discussed here are involved, immediate referral to a consultant is recommended.

Lacerations of the medial lower lid can injure the tear duct apparatus (lacrimal canaliculus and nasolacrimal duct) or the medial palpebral ligament at the medial canthus. Copious tears running down the cheek of the patient are a sign of possible tear duct injuries. A laceration of the medial palpebral ligament displaces the lid apparatus laterally, giving the appearance that the patient is "cross-eyed."

The levator palpebrae muscle is responsible for maintaining the eyelid in its normal position when open. Interruption of the muscle causes traumatic ptosis. Injury to the muscle is suspected when periorbital fat can be seen to extrude from a laceration of the upper lid. Periorbital fat signifies that the orbital septum has been violated. The levator muscle originates from the septum; any septum injury risks this muscle.

Close inspection of the eye itself is necessary to rule out a hyphema, corneal abrasions, blow-out fracture, and foreign bodies. A complete examination of the eye includes

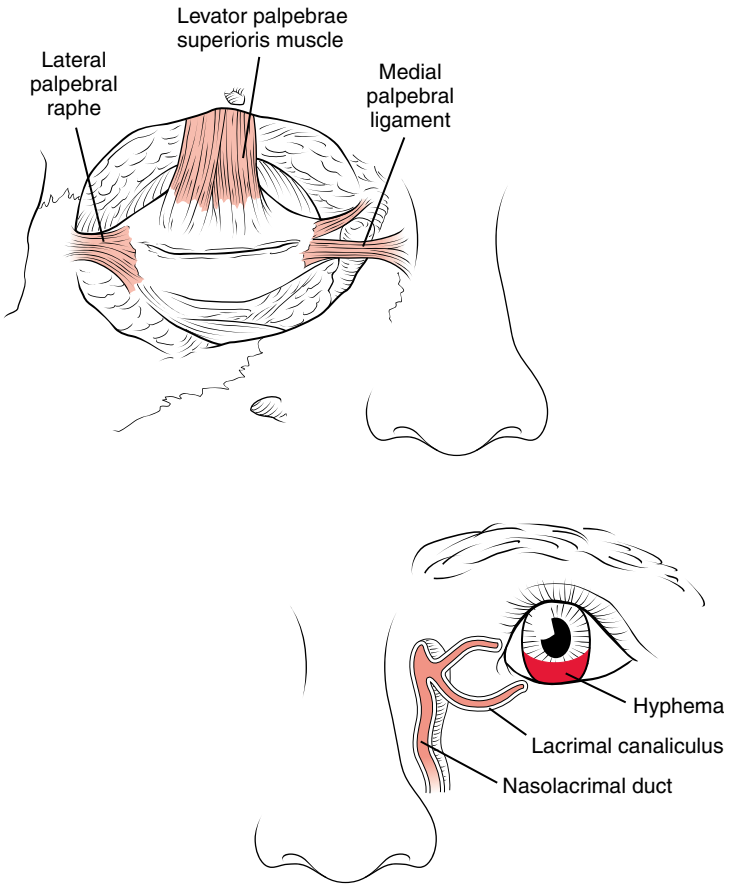

Figure 12-5. Important anatomic structures that can be injured during eye trauma. The integrity of these structures must be confirmed before the closure of any laceration (see text).

extraocular muscle function, pupil reaction, and corneal staining. Of these injuries, hyphema is the most serious. It is caused by a direct blow to the eye and is recognized by a blood layer in the anterior chamber of the eye in patients in the upright position. In patients who are supine, blood distributes evenly in the anterior chamber over the iris and gives the iris a color different from the opposite iris. The patient also complains of decreased vision in the affected eye. Having the patient sit up reveals the hyphema as the blood settles with gravity.

Preparation for Closure

It is best to deliver an anesthetic to the eyelid by direct wound infiltration, using a small 27-G or 30-G needle. Epinephrine-containing anesthetics are not necessary. For the eyebrow, the same technique is used, but epinephrine in the anesthetic can be useful to control minor bleeding. Special care is taken to minimize spillage of cleansing agents into the eye to prevent unnecessary corneal irritation. Povidone-iodine solution (not a detergent-containing solution) diluted 1:10 with saline and nonionic surfactants (Shur-Clens) are the cleansing agents of choice.[20] Inadvertent spilling of these preparations can be prevented by holding a folded 4 × 4 sponge over the closed eyelid margin to absorb free solution. The caregiver should never shave the hair from the lid margin or brow because of the unpredictability of hair regrowth in these locations.

Closure of Extramarginal Lid Lacerations

Extramarginal lacerations are usually horizontal and occur most commonly in the upper lid. If extramarginal lacerations are simple and superficial, they can be repaired with a single layer of 6-0 nonabsorbable suture material (Fig. 12-6). No dressing is applied. These lacerations heal well enough that scars become virtually unnoticeable with time.

Until more recently, nonabsorbable suture was the only material recommended for skin closure of the face. In practice, some physicians have started closing face and eyelid lacerations with rapidly absorbable polyglactin-910 (Vicryl Rapide).[21] The principal advantage of these sutures is that a return visit to the physician for removal is not required. The rapid resorption property of this material causes the sutures to fall away naturally within 7 to 10 days. In a study of periophthalmic skin wounds closed with 7-0 Vicryl Rapide, healing was observed to be equal to healing with nonabsorbable nylon.[22] No suture marks were present at 2 months in the Vicryl Rapide group.

Closure of Intramarginal Lid Lacerations

Intramarginal lacerations involve the lid margin and, similar to lip lacerations, require extremely precise repair to ensure proper alignment. Abnormal eversion (ectropion) or inversion (entropion) is a complication of improper alignment. Intramarginal injuries probably are best left to a consultant for repair (Fig. 12-7).

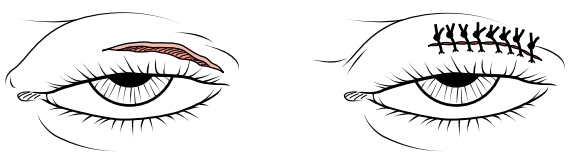

Figure 12-6. Extramarginal lacerations of the upper lid are usually horizontal and can be closed with a simple row of percutaneous closures.

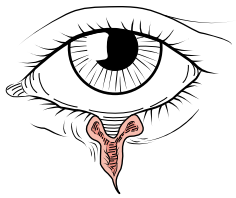

Figure 12-7. A vertical, intramarginal lid laceration is best left to a consultant to repair.

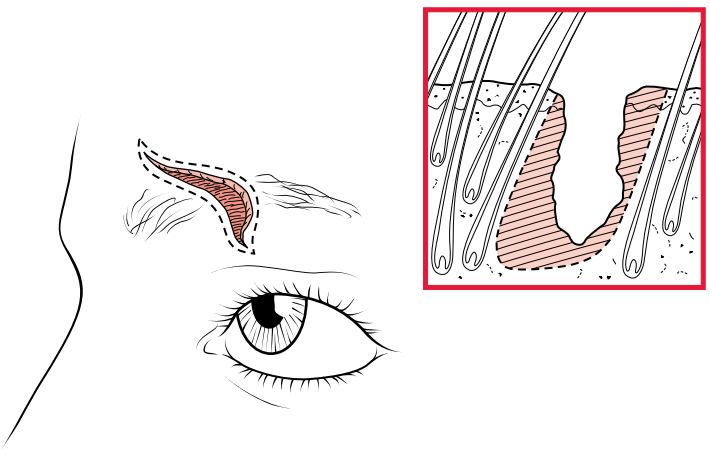

Figure 12-8. Most eyebrow lacerations can be closed without tissue débridement. If macerated or devitalized tissue must be removed, however, it is important to excise this tissue parallel to the hair shaft. This excision technique prevents an unsightly cosmetic defect.

Closure of Eyebrow Lacerations

Simple, uncomplicated eyebrow lacerations can be closed with a 5-0 nonabsorbable monofilament. As previously mentioned, the eyebrow is never shaved or trimmed. Occasionally, one or two dermal (deep) closures are necessary to approximate the superficial fascia. Great care is taken to align the brow margins properly to prevent a cosmetic deformity. Alignment sutures at the superior and inferior margins of the brow hair are placed to initiate closure. Deep sutures, if required, can be placed after the alignment sutures.

If the laceration has particularly ragged or macerated edges, trimming or careful excision can be performed. A basic principle to observe is that any débridement has to be parallel to the brow hair shafts (Fig. 12-8). Failure to observe this principle can lead to an unnecessary defect after the repair.

Aftercare

No dressing is necessary for lid or brow lacerations. Daily cleansing followed by application of an antibacterial ointment is recommended. Sutures are removed in 3 to 5 days in children and adults.

CHEEK OR ZYGOMATIC AREA

There are two major structures underlying the cheek area, just anterior to the ear, that can be injured by penetrating lacerations: the parotid gland and the facial nerve (Fig. 12-9). If the parotid gland is injured, salivary fluid can be seen leaking from the wound. Inspection of the inside of the mouth often reveals bloody fluid coming from the opening of the parotid duct located on the buccal mucosa of the cheek at the level

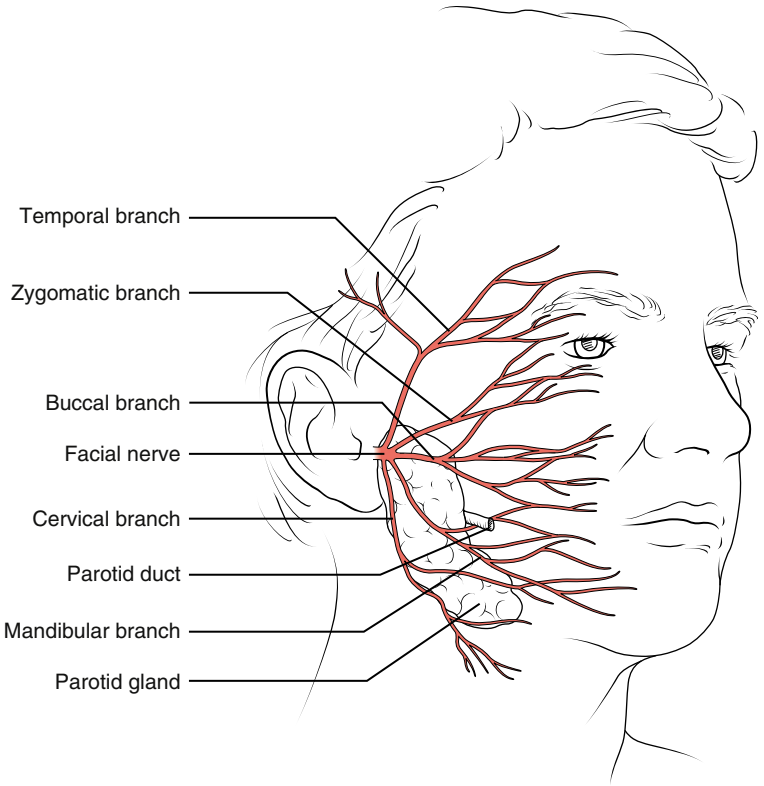

Figure 12-9. The parotid gland and facial nerve underlie the zygomatic and cheek areas. Any lacerations anterior to the ear must be assessed carefully for injuries to the various branches of the facial nerve, parotid gland, or parotid duct.

of the upper second molar tooth. The parotid gland is approximately 1.5 cm beneath the skin.

Lacerations of this region also can injure the facial nerve. It is necessary to test all five branches of the nerve to ensure that each one is intact. The temporal branch is tested by asking the patient to contract his or her forehead to elevate the brow. The function of the zygomatic branch is observed by asking the patient to open and shut the eyes. The act of sniffing with flaring of the nasal alae is also evidence for preserved function of that branch. Buccal and mandibular branches innervate the lips during the acts of smiling and frowning. Finally, the cervical branch is tested by requesting that the patient shrug the neck through contraction of the platysma muscle.

Preparation for Closure

The cheek is anesthetized and cleansed in the standard manner described earlier in this chapter and in Chapters 6 and 7. Care is taken to avoid spilling cleansing solutions onto the eye.

Closure of Uncomplicated Cheek Lacerations

The standard percutaneous technique using 6-0 monofilament closes most lacerations. Uncomplicated lacerations can be closed with absorbable gut sutures. These sutures usually dissolve within 7 days. If they do not, the patient is instructed to rub them

off gently to prevent the formation of suture marks. In linear low-tension lacerations, wound adhesives are an option. Many people have natural creases in the skin of the cheek and face. These creases have the same importance cosmetically as the vermilion border of the lip. Proper alignment of the creases requires special attention. Often the initial percutaneous suture is placed in alignment with the crease before proceeding with the remainder of the closure.

Deep or Through-and-Through Lacerations

Complex lacerations that travel deep into the soft tissues of the cheek, or those that penetrate the oral cavity, are at risk for injuring the parotid gland or facial nerve as mentioned earlier. If neither the parotid gland nor the facial nerve is injured, repair can proceed. If there is any doubt, a consultant is required. The oral cavity portion of a penetrating laceration is left open unless it is large (>3 to 5 cm). Large mucosal lacerations are closed with 5-0 chromic gut suture. The external wound is irrigated and is closed with 6-0 monofilament.

Aftercare

Dressings are usually unnecessary for lacerations in the cheek area. Daily cleansing and application of an antibacterial ointment allow for easier suture removal at the 3- to 5-day interval for children and adults.

NASAL STRUCTURES

The nose is composed of a bony and a cartilaginous skeleton. Similar to the ear, direct blows to the nose can cause the formation of a hematoma and a late abscess that compress and injure the nasal infrastructure, including the septum[23] (Fig. 12-10). If not drained, a hematoma can lead to collapse through pressure necrosis of the septum. Lacerations of the nose are common and are often associated with fractures. Radiographs do not always identify fractures, and palpation is a more sensitive indicator of bone injury and displacement.

The skin of the nose is inflexible with little redundancy. It also tears easily with percutaneous suture placement. Consequently, repairs must be performed with great care. Any débridement should be considered only in consultation with a facial specialist.

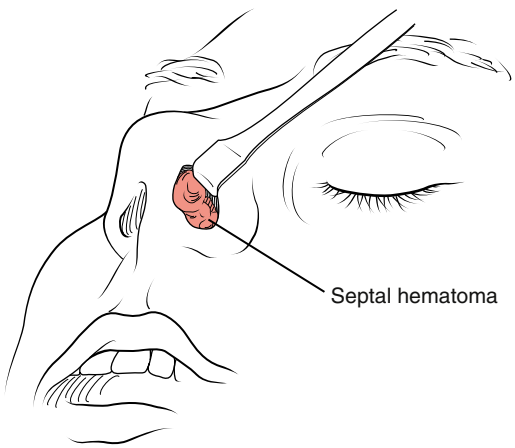

Figure 12-10. Septal hematoma in the area of the anterior nasal septum. Failure to drain this hematoma leads to septal necrosis and collapse.

Preparation for Closure

Before preparation and closure, the nose is inspected for the injuries mentioned in the previous section. Septal hematoma is recognized by its bluish, bulging appearance in the anterior septal area (Kiesselbach's area). The preferred method of examination is with a nasal speculum and an appropriately powerful light source. Penlights and otoscopes may be inadequate.

Anesthesia of the nose is best accomplished by the direct wound infiltration technique with a 27-G or 30-G needle, using an agent without epinephrine. Nasal blocks are difficult to achieve and usually are reserved for major repairs. Cleansing of the nose is done using povidone-iodine solution and saline irrigation.

Skin Lacerations

Most skin lacerations can be repaired with 6-0 nonabsorbable percutaneous monofilament sutures. Sutures are placed with small bites because nasal skin tends to invert. The skin also is torn easily, so great care must be used to avoid creating excessive tension. If tension is present, the placement of one or two deep 6-0 or 5-0 absorbable sutures supports the percutaneous sutures. Complex and irregular skin wounds have to be handled carefully. Because there is little redundancy of nasal skin, débridement must be minimal. The best strategy is to "tack down" small tags or flaps percutaneously or to obtain consultation.

Nostril and Cartilage Wounds

Nostril lacerations involve the rim with skin, cartilage, and mucosal injuries. Alignment of the rim is crucial to prevent "notching." The skin is closed with 6-0 nonabsorbable suture, and the mucosa is sutured with 5-0 or 6-0 absorbable suture. Placement of sutures in the cartilage is not necessary during repair. Closing the skin and mucosa over the cartilage ensures adequate healing. Complete coverage of cartilage is mandatory because of its tendency to develop chronic chondritis if exposed. Avulsion and mutilating injuries of either the skin or the cartilage are best managed by a consultant.

Septal Hematoma

A hematoma over the septal cartilage is drained with a hockey-stick or a crescent-shaped incision (Fig. 12-11). The incision is always made in the dependent portion of the hematoma. To prevent reaccumulation, an anterior nasal pack is placed with gauze that is impregnated with petroleum jelly (Vaseline), and the patient is referred to a consultant within 24 to 48 hours for follow-up. When packing is placed, antibiotics are often recommended to prevent sinus infection. Amoxicillin and trimethoprim-sulfamethoxazole (Bactrim) are reasonable choices.

Lacerations with Bone Involvement

Uncomplicated lacerations of the skin over nondisplaced nasal fractures can be closed using previously described techniques. Complex lacerations with fracture displacement, mucosal injury from bone fragmentation, or extensive cartilage involvement are best managed by a consultant. An uncommon but serious complication of nasal injuries is cerebrospinal fluid leak. It can be detected if clear fluid or diluted blood is seen dripping from the nose. A drop of this fluid placed on filter paper will leave a clear "halo" around a central bloody point.

Aftercare

Dressings are optional for nasal lacerations. Often a simple Band-Aid suffices. Percutaneous sutures are removed in 3 to 5 days in children and adults. The value of antibiotics for nasal lacerations is unclear. The natural vascularity of the face is protective against

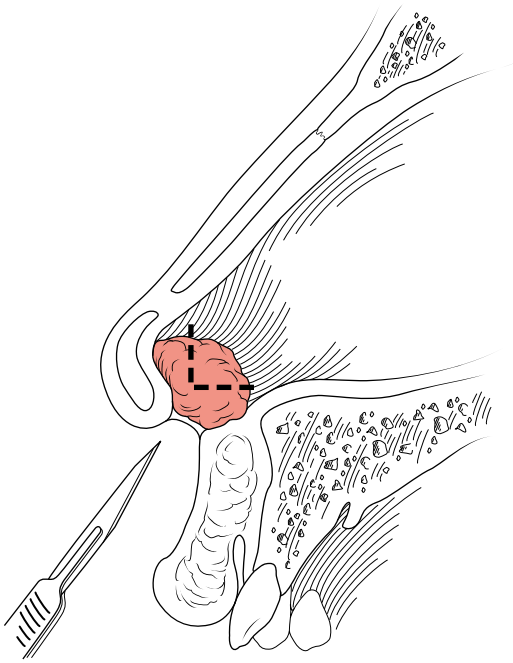

Figure 12-11. Technique to drain a septal hematoma. A no. 11 blade is used to create a hockey-stick incision. After drainage, the nose is packed with gauze impregnated with petroleum jelly (Vaseline). (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

infection. Any decision to use antibiotics is based on the circumstances of individual cases. Injuries with fractures should be referred to a specialist. If these injuries are edematous and the anatomy is obscured, referral is planned for 3 to 5 days following the injury.[24] When the underlying deformity and anatomy are revealed after the swelling is reduced, a more accurate repair of the broken nasal bones can be performed with a better cosmetic result.

EAR

The ear consists of a cartilaginous skeleton covered by tightly adherent skin with little intervening superficial fascia (subcutaneous tissue). A direct blow to the ear can cause a hematoma to form, usually in the area of the antihelix, with a resultant breakdown of the cartilage caused by pressure between the skin and cartilage (Fig. 12-12). The eventual result is the well-known "cauliflower" ear. The most important objective for repair of open wounds is the coverage of any exposed cartilage. Failure to do so leads to chondritis and breakdown.

Preparation for Repair

In addition to inspecting the external ear for hematoma formation and cartilage injury, the internal canal and tympanic membrane are visualized to complete the examination. Blunt injuries to the ear can cause perforations of the tympanic membrane. The most significant injury that can accompany lacerations to the ear is a basilar skull fracture, which can be recognized by hemotympanum or Battle's sign (ecchymosis of the mastoid area).

Small, uncomplicated lacerations to the ear can be anesthetized by direct infiltration with a 27-G or 30-G needle using an anesthetic solution without epinephrine.

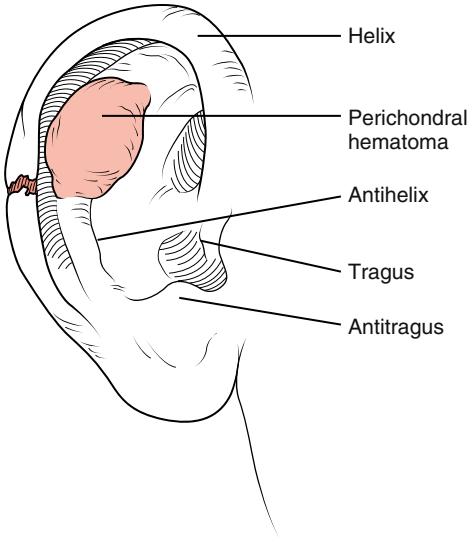

Figure 12-12. Anatomy of the external ear. Note the presence of perichondral hematoma; hematoma formation can occur after blunt trauma to the ear and can accompany lacerations.

The needle is introduced carefully between the skin and the cartilage, and only a small amount of anesthetic is deposited to minimize distortion of the wound edges. For large, complex lacerations and wounds, the ear block described in Chapter 6 can be used. Cleansing is done with povidone-iodine solution and irrigation. Because of the complicated topography of the ear, cotton-swab applicators can be particularly useful for cleansing and removing dried blood in crevices.

Uncomplicated Lacerations

Simple lacerations of the helix and lobule that do not involve cartilage can be closed with interrupted 6-0 nonabsorbable monofilament sutures (Fig. 12-13). To prevent wound edge inversion, small 1- to 2-mm bites are taken. If débridement is necessary, it should be kept to a minimum to prevent exposure of the cartilage. Sutures are removed 4 to 5 days after repair.

Lacerations Involving Cartilage

Sharp, shearing lacerations that penetrate cartilage can be managed by carefully apposing the skin overlying the cartilaginous interruption. The skin is sufficiently adherent and supporting so that sutures do not have to be placed through the cartilage itself to bring together the lacerated cartilage edges. In addition, cartilage tears easily and does not hold sutures well. Sharp, through-and-through lacerations can be managed by suturing the anterior and posterior portions of the laceration. The cartilage comes together without sutures. Care is taken to ensure that the skin over the helix rim is everted so that scar contraction does not cause notching.

Irregular wounds that involve cartilage must be managed with two principles in mind: (1) Débridement must be kept to a minimum, and (2) no cartilage must be left exposed. If cartilage is exposed and the skin cannot be brought together over it without undue tension, it can be débrided conservatively to match the skin and cartilage edges. A total of 5 mm of cartilage can be sacrificed without deforming the cartilaginous skeleton. No sutures are placed in the cartilage (Fig. 12-14). Complex cartilage injuries require consultation.

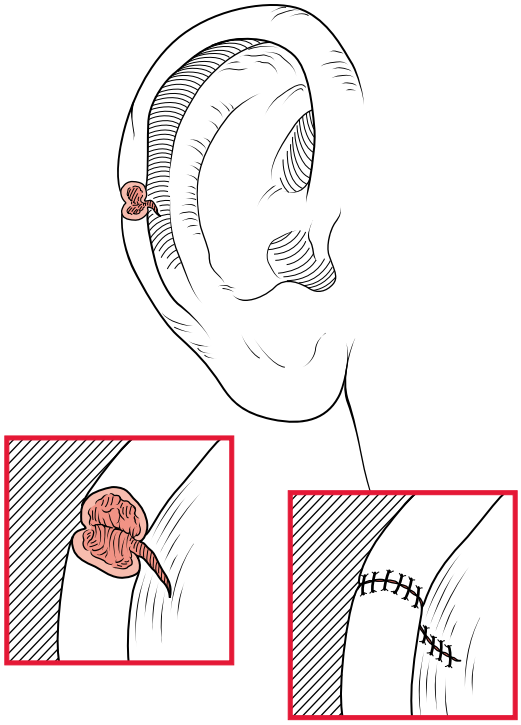

Figure 12-13. Simple noncartilaginous lacerations of the ear are closed with either interrupted or running percutaneous skin sutures.

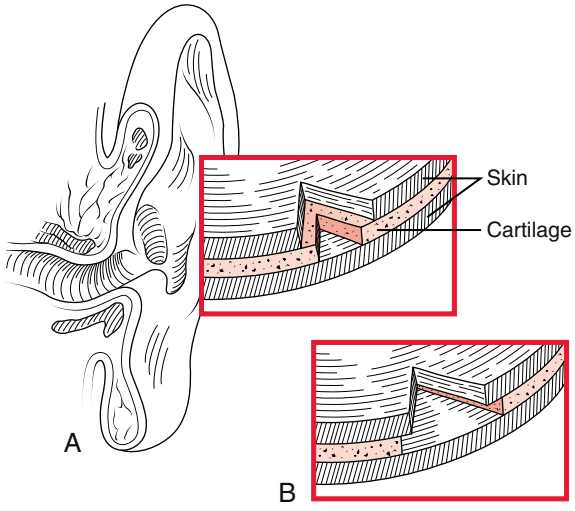

Figure 12-14. **A,** Cartilage that extends beyond the margins of the skin injury can be trimmed back, using tissue scissors, to ensure complete coverage anteriorly and posteriorly by skin. **B,** Skin is closed with simple percutaneous sutures. No sutures are necessary for the cartilage. (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

Perichondral Hematoma

When a perichondral hematoma is present, it has to be drained adequately. There is a 72-hour window for hematoma drainage beyond which the risk of cauliflower ear increases.[25] A small incision is made over the hematoma, and the hematoma is evacuated from the space between the perichondrium and the cartilage. Placement of a small rubber drain is optional. After drainage, a mastoid dressing is placed (see Chapter 20). The dressing is removed within 24 hours, and the site is inspected for reaccumulation. More often than not, complex lacerations and hematomas of the ear are best cared for by or under the guidance of a consultant.

Aftercare

Because the ear is difficult to dress, it is often left open. Daily gentle cleansing, followed by application of an antibacterial ointment, is recommended. If there is any question of possible perichondral blood accumulation after the patient is discharged, a mastoid dressing is recommended (see Chapter 20) as discussed above. Sutures are removed after 4 to 5 days for adults and after 3 to 5 days for children. When cartilage is involved or a septal hematoma has been drained, antibiotic prophylaxis is recommended. Choices include dicloxacillin, a first-generation cephalosporin, or amoxicillin with clavulanate. Erythromycin or clindamycin can be used in a penicillin-allergic patient. Uncomplicated, noncartilaginous injuries do not require antibiotics.

LIPS

Lacerations of the lip can cause devastating cosmetic defects if not properly and meticulously repaired. A misalignment by 1 mm of the vermilion border, or "white line," can be noticed by a casual observer. It is a defect that cannot be revised easily after primary healing has taken place. Other important anatomic structures include the mucosal border (the portion of the lip that divides the intraoral and extraoral portion of the lip) and the underlying orbicularis oris muscle. Each of these structures requires careful and exact apposition to achieve the best structural and cosmetic result. Vertical through-and-through lacerations often violate all three of these structures.

Preparation for Closure

Although the mouth is replete with bacteria, and a lip laceration would not remain clean during the repair procedure, cleansing is performed only to remove gross debris and dirt. If any teeth are broken, a careful search is made in the wound for teeth fragments. Retained tooth particles can cause marked inflammation and infection leading to a complete breakdown of any attempted repair. Whenever a portion of a tooth cannot be accounted for, a lateral radiograph of the face using the soft tissue technique can reveal the missing fragment.

Anesthesia for lip repairs is best accomplished by either an infraorbital nerve block for the upper lip or a mental nerve block for the lower lip (see Chapter 6). Direct infiltration of the laceration can cause excessive distortion of the lip and can create difficulties when an attempt is made to align wound edges properly.

Uncomplicated Lacerations

Most lip lacerations do not require extensive revision or débridement. The key to closure is proper alignment of the anatomic structures listed previously. If the vermilion border is violated and the laceration is superficial, the repair begins with placement of the first suture, with careful precision, through that border on each side of the

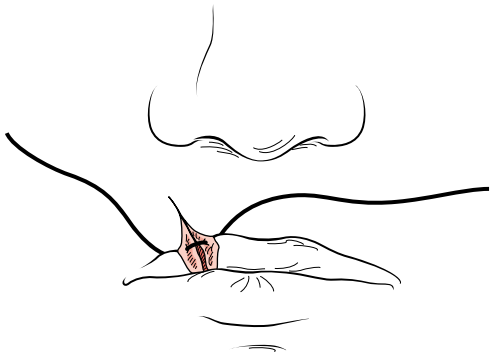

Figure 12-15. The major goal when closing any lip laceration is to align the appropriate borders. Initial suture placement and alignment of the vermilion border are shown. When the vermilion border or white line is aligned, the remainder of the laceration is closed.

wound (Fig. 12-15). When alignment is judged to be appropriate, the remainder of the wound is closed with 6-0 nonabsorbable monofilament sutures. If the mucosal border is violated, it also is aligned meticulously. As a general rule, if the laceration extends beyond the mucosal border into the oral cavity, 5-0 absorbable suture, such as chromic gut, is used to close that portion. Irradiated polyglactin 910 (Vicryl) is also recommended because it does not "stiffen" as much as gut, and it is absorbed rapidly.

Complicated and Through-and-Through Lacerations

In contrast to many other structures of the face, the lip can be revised, and significant portions of devitalized tissue (25% of the upper or lower lip) can be excised in a V shape without causing significant deformity except for the area of the upper lip just below the nose, the philtrum, and the oral commissures. Considerable judgment is required to handle these cosmetic problems in image-conscious patients who have high expectations for excellent results. Consultation is advised for lacerations and injuries that would affect the patient's appearance.

Repair of a vertical through-and-through laceration is illustrated in Figure 12-16. The repair begins with closure of the vermilion border. Next, the orbicularis oris muscle is reapproximated carefully with deep 5-0 absorbable suture material, such as polyglycolic acid. The deep sutures should include the fibrous covering of the muscle to ensure anchoring. The remainder of the repair proceeds with 6-0 nonabsorbable sutures for the skin and exposed lip. For the oral cavity portion inside the mucosal border, 5-0 absorbable sutures are used.

Aftercare

No dressing is placed on the lips. The patient is reminded not to bring excessive pressure to bear on the suture line while the sutures are in place. Rinsing the mouth after eating is recommended to prevent small particulate matter from penetrating the suture line. Extraoral sutures are removed after 4 to 5 days in adults and after 3 to 5 days in children to prevent the formation of suture marks. A controlled study of intraoral lacerations suggests that there is some benefit to administering oral penicillin V potassium (Penicillin VK) four times daily for 5 days as prophylaxis against infection.[26] Erythromycin or clindamycin may be considered as alternatives for a penicillin-allergic patient.

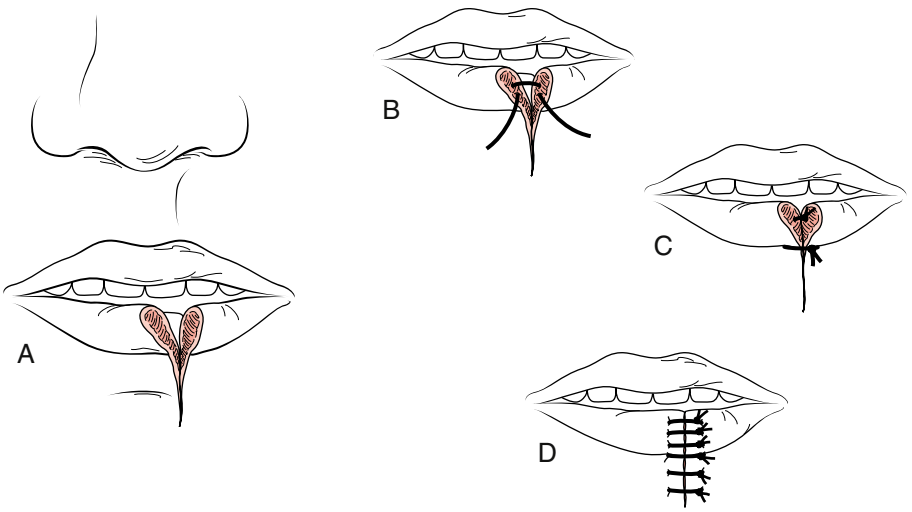

Figure 12-16. **A,** Demonstration of a through-and-through laceration of the lip involving the orbicularis oris muscle. **B,** Closure of the orbicularis oris muscle is performed by the use of absorbable deep sutures, such as polyglycolic acid. **C,** When the orbicularis oris muscle is approximated, the vermilion border or white line is approximated. **D,** The remainder of the laceration is closed with simple percutaneous monofilament nylon sutures.

ORAL CAVITY

The oral cavity consists of several structures, each of which requires separate considerations during management and repair. These are the buccal mucosa, gingiva, teeth, salivary glands and ducts, tongue, mandible, and alveolar ridge of the maxillary bone. Injuries to the oral cavity can be a potential threat to airway patency.

Preparation for Repair

Other than airway considerations, the most important part of the evaluation of the oral cavity is the determination of the integrity of salivary structures, bone, and teeth. Visual inspection and palpation are necessary to complete the examination. Particularly troublesome are teeth, fragments of which must be accounted for if possible. They can lodge easily in the mucosa and the deep tissue of the lip, where they can cause severe inflammation and infection if not removed before closure. If there is any question about the location of a tooth or fragment, radiographs of the soft tissues should be obtained.

Buccal Mucosal and Gingival Lacerations

As a general rule, lacerations of either the buccal mucosa or the gingiva heal without repair if the wound edges are not widely separated or if flaps are not present. Wounds that gape open (usually ≥2 to 3 cm) need only one to three sutures for closure. Flaps that interpose between teeth can be excised or closed; 5-0 chromic gut or another absorbable material can be used. The oral cavity tissues heal remarkably quickly, and most lacerations, even large ones, close without sutures. After repair, the patient is instructed to eat soft food and to rinse the mouth gently after each meal.

Occasionally a flap of tissue overlying the mandibular or maxillary ridge is created during injury to the gingiva. Because of the lack of support provided by thin supporting tissues, the gingival flap cannot be sutured easily. A technique illustrated in Figure 12-17 shows how sutures are brought circumferentially around teeth to

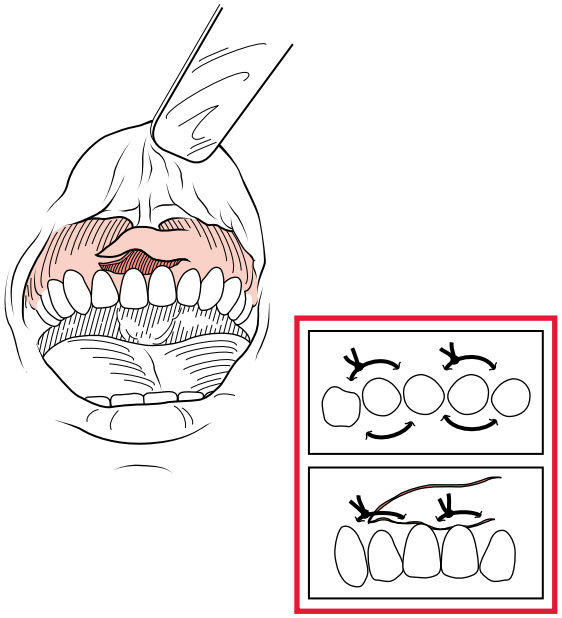

Figure 12-17. Avulsion of gingival/mucosal tissue. The technique to close this injury is shown. The sutures are brought around the teeth and through the avulsed tissue flap. (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

provide the necessary anchor for the repair; 4-0 or 5-0 chromic gut or other absorbable material is used.

Tongue Lacerations

Repairing a lacerated tongue can be challenging. Small lacerations ≤1.5 cm, which do not gape widely when the tongue is extended, heal without intervention. Lacerations that gape widely, actively bleed, are flap shaped, or involve muscle probably need closure. The key to repairing these lacerations is to gain the confidence of the patient. With frightened children, gaining confidence is often difficult, and the patient may be best served in a surgical setting where sedation and anesthesia can be delivered. An assistant is required to control the tongue with dry gauze sponges, or a towel clip is placed in the previously anesthetized tip. A bite-block can be fashioned to prevent injury to the assistant or to the operator. The wound area is anesthetized by direct infiltration without epinephrine. The tongue heals rapidly and can be closed with an absorbable suture (e.g., 4-0 chromic, polyglycolic acid, or Vicryl). The sutures are placed in large bites to include the mucosa and muscle.

Aftercare

For the first 2 or 3 days after repair of an intraoral laceration, soft foods and liquids are recommended. Rinsing the oral cavity after eating also is helpful.

Dental Trauma

Teeth often are loosened by trauma to the oral cavity. Minimal loosening (<2 mm), as determined by gentle "rocking" of the tooth between the examining fingers, usually reverses without intervention. Marked loosening or subluxation with an accompanying fracture of the alveolar ridge needs to be repaired with dental stabilization.

Intact teeth also can become avulsed. These teeth can be replaced in an anatomically intact socket, but the prognosis for salvage decreases with each minute that passes. On arrival in the emergency department, an attempt should be made to insert the avulsed tooth in the socket if possible.[27] If the socket contains debris, gentle removal is tried. Vigorous intervention should be avoided. The tooth can be handled by the crown but not by the root. To avoid damage to the periodontal ligament, cleaning of the tooth is not recommended. Even saline may be harmful to ligament cells.

If the tooth cannot be reinserted easily, it can be "stored" in one of three ways until a dentist or an oral surgeon can be consulted. The three storage methods are (1) between the buccal mucosa and gum of the patient's mouth, (2) in Hank's solution, or (3) in milk.[28] Saline is avoided. After 30 minutes outside of the socket, the prognosis for salvage worsens rapidly. Even if the periodontal ligament survives and the tooth reattaches, later root canal intervention is necessary to deal with the sequelae of the loss of neurovascular supply.

PERINEUM

Injuries to the perineum (i.e., penis, scrotum, and female introitus) can involve important structures that need special attention. During the examination of wounds of the perineum, the urethra, corpora, testicles, and rectum must be assessed. Blood coming from the urethral meatus, or difficulty urinating, suggests urethral injury. The shaft of the penis is covered by thin skin; violation of the corpora cavernosa or spongiosum often accompanies lacerations of the penis. The testicle is covered with a capsule-like fibrous covering called the tunica albuginea. Interruption of the corpora or tunica requires repair by a specialist. Most labial lacerations are uncomplicated, but occasionally the female urethra or rectum is involved.

Preparation for Closure

Wounds to the perineum are prepared with a cleansing agent and are irrigated with saline as previously described. Uncomplicated lacerations can be anesthetized directly with lidocaine or bupivacaine. Care is taken not to use epinephrine-containing solutions for anesthetizing the penis because of potential ischemia and constriction of end arteries.

Lacerations of the Penis and Scrotum

Because the skin of the penis is so thin, lacerations are closed with a single layer of nonabsorbable suture (e.g., 5-0 nylon). Closure of the scrotal skin is carried out with chromic gut sutures that fall out within 10 days. If chromic material is unavailable, another absorbable suture material can be substituted, but it may not fall out as soon. Healing occurs rapidly, and removal of sutures from the rugated skin, which can be difficult, is unnecessary.

Lacerations of the Introitus

Lacerations of the labia can involve the deeper supporting muscles. In this case, closure must occur in two layers to ensure reapproximation of the muscles. The skin over the labia majora can be closed with a nonabsorbable material, such as nylon or polypropylene. The labia minora is covered with mucosa and can be closed with absorbable material. Uncomplicated lacerations of the vagina, unless they are extensive, heal without sutures. Extensive or complex wounds are best referred to consultants.

Aftercare

Dressings for the genital area are hard to fashion. Gauze sponges supported by an athletic supporter are an option for men. Perineal pads are suggested for women. Hygiene of the genital area is important; daily gentle cleansing with soap and water is acceptable.

Topical antibiotic ointment (Neosporin) applied after bathing and before application of the dressing is recommended. Sutures of the penis are removed in 7 to 10 days for adults and 6 to 8 days for children.

KNEE

Careful examination of knee lacerations is important because of the structures that can be damaged. The peroneal nerve, patellar tendon, medial and lateral collateral ligaments, and patella all have to be tested for function and integrity before repair. Of particular importance is the joint space itself. If penetration is suspected, 50 mL of normal saline with a few drops of methylene blue is injected into the joint, in a sterile fashion, at a site distant from the laceration. Arthrocentesis technique is used. If the capsule is violated, the dye leaks out of the laceration. For more subtle injuries, fluorescein dye can be used with an ultraviolet light detection lamp.

Knee lacerations can be contaminated with grit and ground-in dirt. Although time consuming, meticulous cleansing, irrigation, and débridement are often necessary to render the wound ready to close. Uncomplicated, nonpenetrating lacerations are closed with monofilament nylon after local anesthetic infiltration. Occasionally, deep (dermal) sutures using an absorbable material are required.

Aftercare

The key to good healing of knee lacerations is proper immobilization and elevation for several days. Crutches can be used for at least 48 to 72 hours if the extensor surface of the knee is involved or if the wound is extensive. Knee flexion can be reduced by the application of a bulky dressing. Sutures are removed in 10 to 14 days for adults and 8 to 10 days for children.

LOWER LEG

The most vexing consideration related to lower leg (shin) lacerations is the significant tension that occurs at the wound edge. Skin overlying the tibia is under higher natural tension than most other regions of the body. Figure 12-18 illustrates a technique for approximating the wound edges with as little tension as possible; 4-0 monofilament nylon is passed through sterile, cotton-retaining pledgets obtained from the operating room. This technique allows for even distribution of tension along the wound edge without tearing. This pledget technique is particularly useful for older and thinner skin. Undermining and deep suture placement can assist in reducing tension.

Another technique for the closure of avulsion/flap wounds of the shin in older patients is the use of wound tapes[29] (see Chapter 11). Tapes avoid the problem of skin tearing that can occur with sutures and staples. Tapes can be left on until they naturally fall off. This technique allows for minimal potential disruption of the healing wound.

Aftercare

Elevation is an important element for lacerations and wounds of the lower leg. Dependent edema should not be allowed to develop. Sutures are removed after 8 to 12 days for adults and 6 to 10 days for children.

FOOT

The foot is anatomically complex and in that way is similar to the hand. Complete lacerations to the flexor tendons need to be repaired, as they also need to be repaired in hands (see Chapter 13). Extensor tendons can be treated with primary skin closure and splinting. Consultation is recommended under these circumstances. Anesthesia for the plantar surface of the foot is best achieved by a posterior tibial nerve or sural nerve

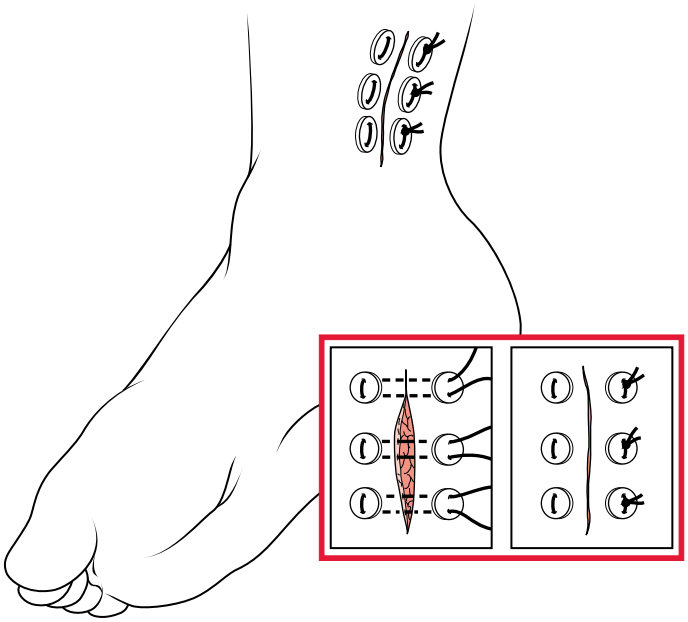

Figure 12-18. Because of the high tension usually associated with lacerations in the lower leg (shin area), sterile cotton pledgets can be used as support for 3-0 or 4-0 monofilament nylon sutures. (Adapted from Zukin D, Simon R: *Emergency wound care: principles and practice*, Rockville, Md, 1987, Aspen Publishers.)

block (see Chapter 6). Occasionally, this method of administering anesthesia needs to be supplemented by local infiltration. Superficial dorsal lacerations are closed with 4-0 or 5-0 monofilament nylon. Lacerations of the plantar surface, or sole, can be closed with 3-0 monofilament. Lacerations of the web spaces between the toes have the same significance as lacerations of web spaces of the hand. There are no crucial structures passing through these areas, and repair of the skin alone should suffice.

Aftercare

Similar to any lower extremity injury, elevation is an important adjunct to care. Crutches are useful, particularly for wounds on the plantar surface. Sutures are removed in 10 to 12 days for adults and 8 to 10 days for children.

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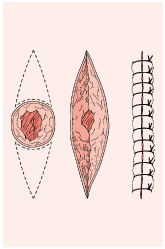

CHAPTER 13
The Hand

Key Practice Points

- Patients with hand injuries are treated in the supine position to prevent syncopal falls induced by pain.
- Remove all jewelry from the injured hand to prevent constriction and ischemia secondary to swelling.
- The "golden period" for repair of hand lacerations and wounds is 6 to 8 hours from the time of injury. Beyond that period, the risk of infection rises.
- Although two-point discrimination is the standard test to measure sensation following possible nerve injuries to the hand, a normal test does not rule out nerve injury if the patient has a subjective feeling of numbness.
- Innocuous-appearing wounds, such as punctures, can cause significant wounds to tendons and nerves. Careful testing is still necessary.
- Tendons can appear to function normally after wounding because of partial injury or cross-linking of extensor tendons. It is prudent to explore wounds over tendons to detect these types of injuries.
- Absorbable sutures are becoming more common in the closure of hand wounds, because they produce the same results as nonabsorbable sutures.
- If the nail is attached firmly to the nail bed, subungual hematomas (even if the subungual hematoma is >50% of the nail surface) can be treated with trephination alone without nail removal or nail bed repair.
- Fingertip avulsions, without nail bed disruption or bone exposure, heal well without surgical intervention or grafting.
- Tendon or nerve injuries can undergo delayed repair. The skin is closed at the time of injury and the patient is referred to a specialist for nerve or tendon repair of the hand.
- Infections and antibiotic prophylaxis of hand wounds have recently become more complicated because of the appearance of community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA).

INITIAL TREATMENT

Before a thorough and careful examination of a patient with an injured hand can take place, certain preparatory steps must be taken. Except for the most trivial injuries, the patient is best managed by placement on a stretcher on arrival at the medical care facility. Hand injuries often are painful and provoke anxiety. Placing the patient in a supine

position prevents unexpected vasovagal syncope. The recumbent position allows for easy placement of the hand in an elevated position to decrease the swelling that occurs after injury.

Any rings or constricting jewelry are removed to prevent ischemia of a digit. Most rings can be removed by using a lubricant and applying gentle, persistent traction. Ring removal from swollen fingers can be accomplished by using a specially designed ring cutter and spreading the ring open with two Kelly clamps applied to the edges of the cut portion (see Fig. 2-1). Patients who are concerned about damaged rings can be reassured that jewelers can restore rings to their original condition. Another method for the removal of rings is shown in Figure 13-1. Umbilical tape or O-silk suture can be wrapped firmly around the finger and passed under the ring with a small forceps. The ring is extracted as the tape or suture is unwound proximally to the ring.

Occasionally, a patient arrives with a ring or band made of hardened steel or even titanium. If routine removal procedures, including cutting, do not succeed in removing the ring, the following procedure can be tried[1]:

- Wrap elastic tape, 1 inch in width, tightly around the finger starting from the tip of the finger and moving toward the ring. Extra wraps adjacent to the ring may be needed, because more edema accumulates in that area.
- Elevate the hand above heart level for 15 minutes. Securing the arm gently to an IV pole will help. Apply an ice pack to the finger as well.
- After 15 minutes, apply a blood pressure cuff to the upper arm and inflate it to 250 mm Hg to prevent blood refilling the arm and finger.
- Quickly remove the tape, apply a light coating of lubricant to the finger, and remove the ring.
- If this procedure does not work the first time, there may be residual edema. The procedure can be repeated.

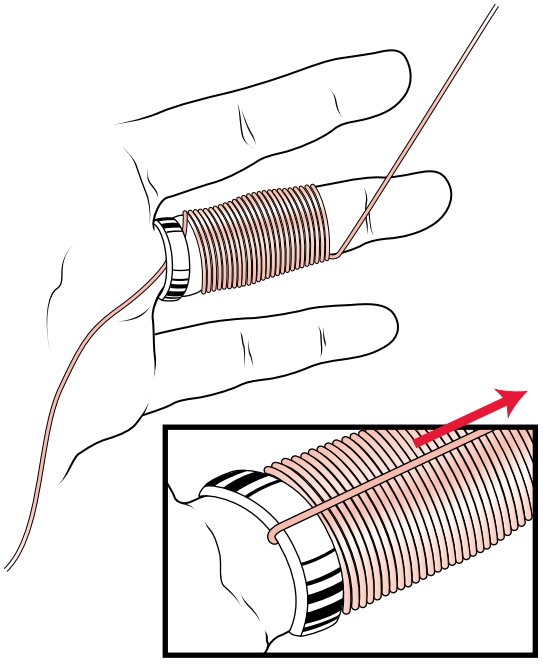

Figure 13-1. The technique to remove a ring by finger wrapping with large silk suture or umbilical tape. The suture is begun distally over the distal interphalangeal joint and is brought back to the ring. The tail end portion of the wrap is brought under the ring, usually with a small hemostat. The removal of the ring is begun by unraveling the wrap and tugging on the string that is proximal to the ring portion. As it unravels, the ring gently travels forward distally over the finger.

Most patients attempt to bandage the injured hand before proceeding to a medical care facility. These hastily fashioned, unsterile dressings should be removed carefully. Until treatment can be administered, sterile sponges moistened with normal saline should be applied, followed by a 2- or 3-inch gauze wrap. Any active bleeding requires manual pressure with gauze sponges. An extremity tourniquet rarely is needed to stop excessive hemorrhage.

If the wound is grossly contaminated with soil or other debris, and if there will be a delay before treatment can be administered, the hand is cleaned gently with a wound-cleansing agent followed by irrigation with normal saline.[2] The chance of infection increases with each passing hour from the time of injury to repair. Early cleansing and irrigation can extend this safe period.

It is a common but unsupported practice to soak hand injuries in a wound-cleansing solution before repair. Soaking is believed to loosen debris and to help kill contaminating bacteria, but there is no scientific evidence to support these beliefs.[3,4] Brief extremity immersion is recommended only to help remove gross soil and debris from the area surrounding the wound before proper skin cleansing and wound irrigation is undertaken.

TERMINOLOGY

Knowledge of conventional terminology is required to properly document and communicate information about injuries to the hand and fingers. All lacerations and wounds can be located accurately by the use of appropriate terms. A ½-inch laceration on the back of the index finger at the first knuckle is described accurately as "a 1-cm superficial laceration of the index finger on the dorsal surface at the proximal interphalangeal joint." Figures 13-2 and 13-3 illustrate the various descriptive landmarks and joints. The back of the hand is the *dorsal* surface, whereas the palm side is the *palmar* or *volar* surface. Common landmarks of the palm are the thenar and hypothenar eminences. The digits are best remembered and recorded, when necessary, as the thumb, index, middle, ring, and little finger. Each segment of the finger is named for the underlying bony phalanx. Although the joints are descriptive of their location, it is the convention to use the abbreviations noted in Figure 13-2.

Instead of using terms such as *inside* and *outside* or *medial* and *lateral,* the sides of the hands and fingers are referred to as *radial* and *ulnar*. This convention eliminates the confusion elicited by the other terms. Any injury to any surface on the side of the hand or finger corresponding to the radius is so described. A laceration of the side of the little finger is either radial or ulnar depending on whether it is on the side of the ulna or on the side of the radius (see Fig. 13-3).

PATIENT HISTORY

Certain key historical facts help determine the timing and choice of repair and other supportive treatment. As previously discussed, the amount of time that has elapsed from the time of injury influences the decision of when to repair the wound. Clean wounds that are caused by shearing forces probably can be safely repaired 6 to 8 hours after the injury. Wounds caused by tension and compression mechanisms are more vulnerable and should be considered for closure sooner. Severely contaminated wounds, or wounds caused by mutilating forces, are best left for consultation and possible delayed closure. This decision is made on a case-by-case basis.

A seemingly innocuous mechanism of injury is the puncture wound of the hand. Although the entry point is quite small and appears innocent, special care has to be taken not to miss a transected nerve or tendon. In addition, the possibility of a foreign body being retained in a puncture wound has to be considered, and a radiographic examination should be performed when the suspicion is raised.

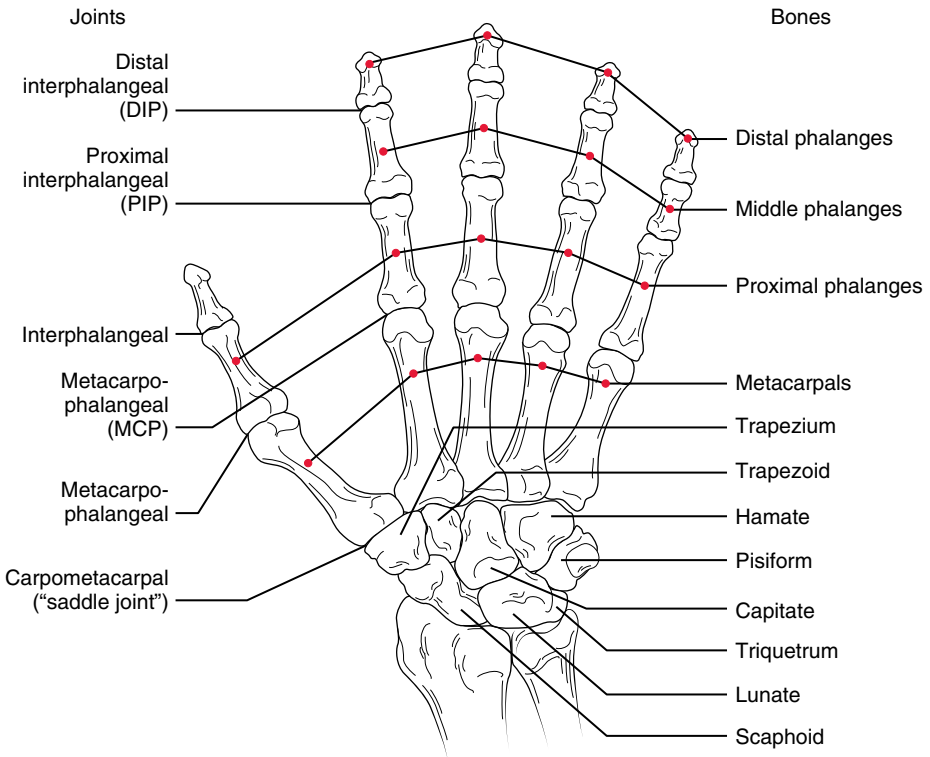

Figure 13-2. Descriptive anatomy of the joints and bones of the hand.

Other historical points of importance are the patient's hand dominance, history of previous hand deformities, profession, and hobbies. Although these considerations are seemingly not very important for patients with emergency lacerations and wounds, a simple matter of a mismanaged fingertip injury can significantly affect an activity such as playing the guitar. For a guitar player, every step is taken to preserve the nail matrix. Preservation attempts might not be as crucial for an individual who does not require this anatomic part for either a job function or for a hobby.

Any allergies the patient may have should be verified when taking the history. Many drugs, including tetanus toxoid, local anesthetics, pain medications, and a variety of antibiotics, are administered to patients with hand injuries.

EXAMINATION OF THE HAND

The actual examination of the injured hand consists of careful inspection of the wound and thorough functional testing. Nerve function is evaluated by assessment of motor and sensory components. The integrity of tendons most often can be determined by specific functional maneuvers. Because tendons often are only partially severed, and function is preserved, direct visualization by exploration may be necessary. For wounds in emergency situations, circulation is so profuse that severed, bleeding vessels, which travel in neurovascular bundles, often are better indicators of nerve injury than actual threats to perfusion of the hand or finger. When necessary, radiographs are obtained to assist in the examination to rule out fractures or foreign bodies. Finally, there is no substitute for exploration and direct visualization to discover if there is structural damage of any type.

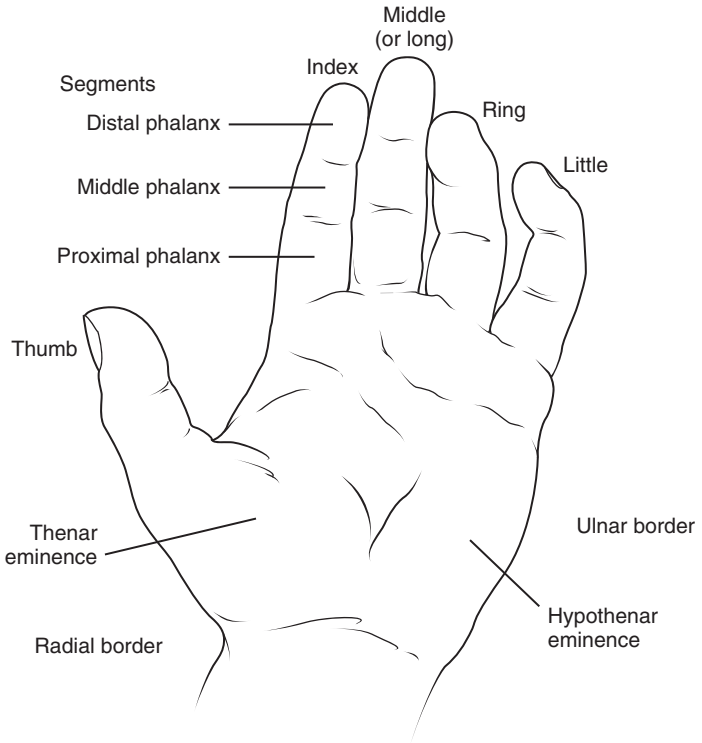

Figure 13-3. Descriptive anatomy of the surface of the hand. Note the ulnar and radial borders.

Nerve Testing

Motor Function

Three major nerves are responsible for motor and sensory function of the hand. The radial nerve innervates the extrinsic muscles of the forearm that are responsible for extension of the wrist and fingers. This nerve does not innervate any muscle within the confines of the hand itself. The motor function of this nerve is tested by having the patient dorsiflex his or her wrist and fingers against a resisting force, such as the examiner's hand (Fig. 13-4). Intact motor strength, as provided for by an intact radial nerve, should prevent the examiner from overcoming the dorsiflexed wrist when a good deal of counterforce is applied.

In addition to the flexor carpi ulnaris and part of the flexor digitorum profundus, the ulnar nerve innervates most of the intrinsic muscles of the hand itself, including all of the interossei muscles and the little and ring finger lumbricals. The motor portion of this nerve is responsible for the ability of the fingers to spread and close in a fanlike manner. A specific test for ulnar motor function is to have the patient adduct (close) the fingers against an object, such as a pen (Fig. 13-5). With an intact nerve, the examiner cannot easily remove the object. Each finger can be tested in this manner.

The median nerve provides motor innervation to wrist flexors, the flexor digitorum superficialis, part of the flexor digitorum profundus (shared with the ulnar nerve), and the remaining intrinsic muscles of the hand, most notably the muscles of the thumb

Figure 13-4. Testing for radial nerve function. With the patient's fist dorsiflexed, the examiner tries to "break" the resistance created by the dorsiflexion.

Figure 13-5. Testing for ulnar nerve function. The patient is asked to resist the examiner's attempt to pull an object, such as a pen, from between the adducted fingers.

Figure 13-6. Testing for median nerve function. The thumb is apposed to the little finger to form a tight ring. This ring should not be easily broken by the examiner.

that are responsible for opposition. To some degree, opposition also is mediated by the adduction component of the interossei as supplied to the ulnar nerve. The testing maneuver is completed by having the patient oppose his or her thumb with the tip of the little finger. A properly made "ring," consisting of the thumb and little finger, should be difficult to break by the examiner if the median nerve is intact (Fig. 13-6).

Sensory Function

A variety of stimuli can be delivered to the skin of the hand to test sensory function. Gross touch with a blunt object is the easiest but is the least specific. Gross touch can be useful, however, for rapid screening to assess the possibility of nerve damage, especially when comparison testing of the injured and noninjured hands is done. If there is a nerve injury, the patient often is able to report a difference in feeling. Pinprick stimulus is the most commonly used modality for testing. Pinprick is useful when alternated with blunt stimulus. In a complete nerve transection, the patient cannot tell the difference between a blunt and a sharp stimulus. Pinprick testing nevertheless is difficult to assess on the fingertips, especially in a manual laborer whose fingerpads are covered with thick calluses.

A more accurate method of assessing sensory function is two-point discrimination.[5] A paper clip can be fashioned so that two ends can be opened or closed to varying distances from each other (Fig. 13-7). Because the ulnar and radial side of each finger has separate innervation, testing each side of the finger is necessary. A patient with a normally innervated finger should be able to distinguish two simultaneously delivered stimuli that are 6 mm or more distant from each other. Most patients can tell a

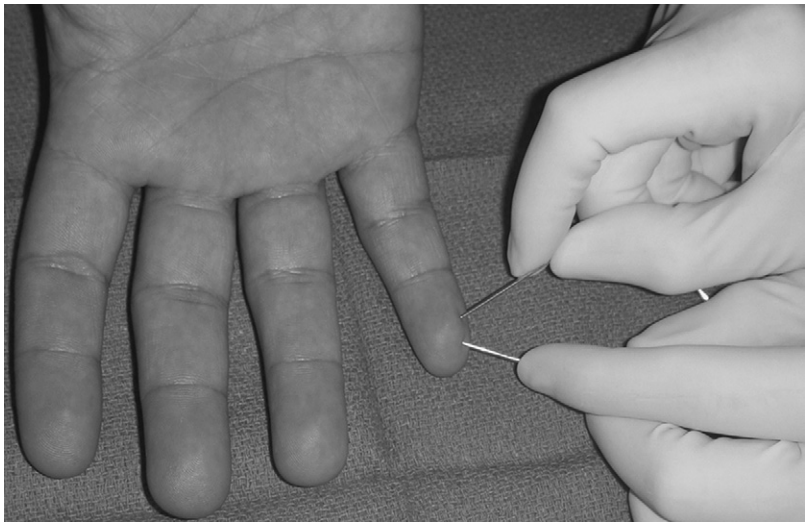

Figure 13-7. Technique for testing sensory nerve function by two-point discrimination. A paper clip is bent in a manner to provide variable distance stimuli. See text for a complete description.

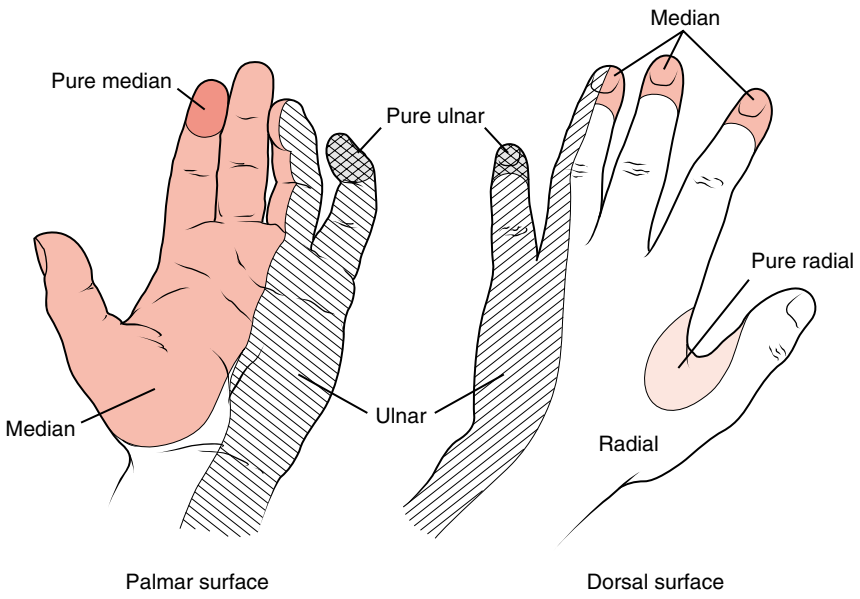

Figure 13-8. The distribution of the three major nerves providing sensory innervation of the hand. Note the areas of pure median, ulnar, and radial sensation.

difference down to 3 mm. When identification of separate stimuli is reported by the patient at 8 mm apart or more, the examination is clearly abnormal.

Of the major nerves, the radial nerve provides the least important sensory innervation to the hand. This nerve supplies sensation to the radial portion of the dorsum of the hand, the dorsum of the thumb, and the proximal portion of the dorsal side of the second and third digits and half of the ring finger (Fig. 13-8). To test gross radial

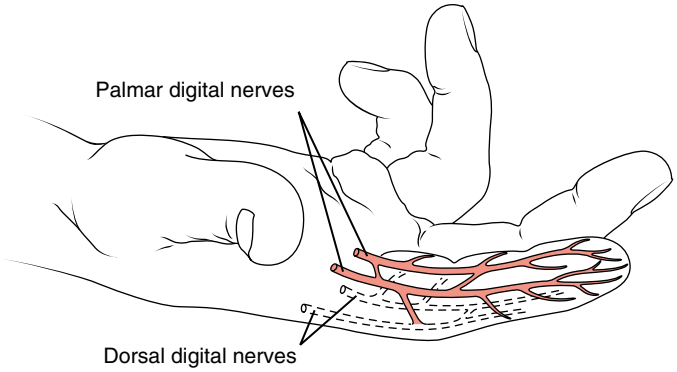

Figure 13-9. Each digit is supplied by four digital nerves. The palmar digital nerves predominate and provide most of the sensation to the volar aspect of the finger and fingertip proximal to the distal interphalangeal joint. The nail bed often is included in the palmar digital nerve distribution.

sensory function rapidly, a stimulus is supplied to the first web space, which is an area of pure radial distribution.

Sensory distribution of the ulnar nerve includes the dorsal and volar surfaces of the ulnar side of the hand, the entire fifth digit, and the ulnar half of the fourth digit. To test an intact sensory component of the ulnar nerve, an appropriate stimulus is delivered to the area of purest ulnar distribution: the tip of the fifth digit.

The remainder of the hand is innervated by the median nerve. The area of sensory distribution comprises the radial side of the palm; volar surfaces of the thumb, index, and middle fingers; and the radial half of the ring finger. As depicted in Figure 13-8, median nerve innervation extends to the fingertips of the thumb, index, and middle fingers, including the dorsal portion of the distal phalanges. Pure median sensation can be found at the tip of the index finger.

More common than injuries to the major nerves are injuries and lacerations to the digital nerves that lie within the hand itself. There are four digital nerves for each digit. The two palmar nerves (Fig. 13-9) are the largest and most important. (The others are the dorsal digital nerves.) Sensation is carried through these two nerves to the palmar surface and the nail bed area of the fingertip. A laceration or puncture wound to the palmar or dorsal surface of the hand or to any individual digit requires careful sensory testing of the digits distal to the injury.

As previously described, a variety of stimuli can be used for sensory testing. The most accurate method of detecting a nerve injury in this setting is the two-point discrimination test. Objective documentation of digital nerve injuries is not always possible at the time of the first examination immediately after injury. Patient pain, anxiety, and factors such as the presence of callused hands can interfere with two-point testing. Even though stimulus testing is inconsistent and does not clearly document nerve injury, any subjective "numbness" reported by the patient has to be taken seriously, and consultation with a hand specialist should be considered. Under these circumstances, it is common to close the skin and to refer the patient for evaluation within a few days after the initial care.

Tendon Function

Extensor Function

Extensor tendon function can be tested simply by having the patient extend his or her fingers against the force of the examiner (Fig. 13-10). Although this maneuver appears to be easy enough, there are complexities of the tendon anatomy that can cause confusion

Figure 13-10. Testing the extensor tendon function. Each finger is extended against a resisting force. This force should not be easily overcome.

when results of the examination are interpreted. The wrist itself has three main extensor tendons that are responsible for proper extension at the wrist. If these tendons are cut, the wrist can be extended by the finger extensors but with far less force, and that force can be overcome easily by the examiner. The thumb is served by an abductor and two extensor tendons. If one extensor is cut, the second still can function. Each finger has one main extensor tendon responsible for extension with power. The second and fifth digits, however, have small accessory tendons that can extend these fingers weakly if the main extensors are knocked out of action.

Another anatomic point that can possibly cause misinterpretation in the examination for extension of the digits is the fact that as extensor tendons cross the wrist, they flatten out and interconnect with other extensors over the dorsum of the hand (Fig. 13-11). Weak extension of a severed tendon can occur by the action of the adjacent interconnecting tendon. These interconnections also can prevent severed extensor tendons from slipping back into the forearm after they are cut. This anatomic property of extensors makes anastomosis easier for extensors than for flexor tendons, because the two severed ends can be readily retrieved during repair.

When there is doubt about extensor tendon function, careful exploration has to be performed through the laceration itself. Extensor tendons are superficial and can be identified easily with proper and gentle exposure. A key factor to remember is that the position of the hand at the time of examination and exploration may be different from the position of the hand during injury. If that should be the case, the actual laceration to the tendon may be at a location away from the laceration on the skin (Fig. 13-12). Active flexion/extension of the finger to cause the tendon to slide back and forth is encouraged during the exploration.

Flexor Function

The thumb has only one flexor tendon, but the index, middle, ring, and little fingers have two main flexor tendons. The volar surface of the wrist is a complex and vulnerable area, replete with important structures. As illustrated in Figure 13-13, the median

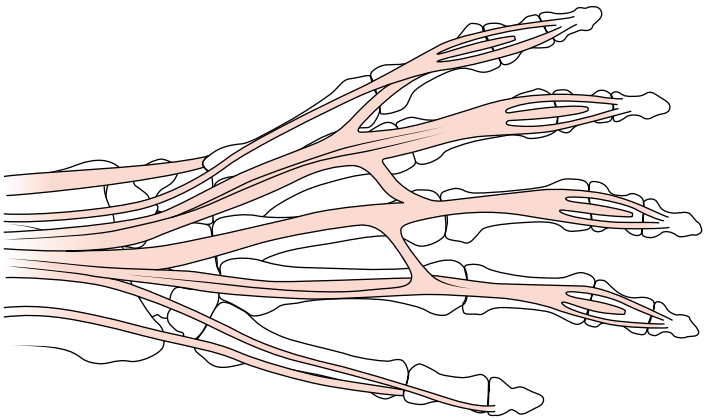

Figure 13-11. Extensor tendon anatomy of the hand. Note in particular the cross-linkages of extensor tendons at the distal metacarpal level. Severance of an extensor tendon proximal to these cross-linkages can give the examiner the false sense that the affected digit can be extended because of the help that cross-linkage provides through the adjacent tendon.

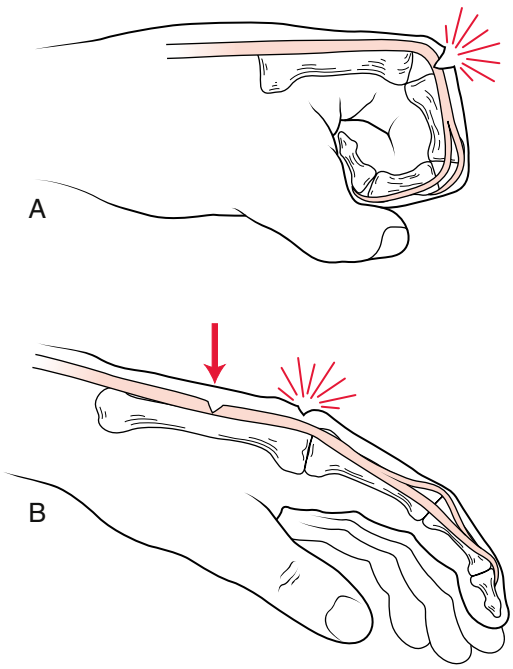

Figure 13-12. Tendon-skin wound mismatch. **A,** A tendon can be partially lacerated in one position, such as a closed fist. **B,** When the wound is explored, however, the tendon injury might be missed because the site of the tendon injury has retracted when the hand is extended for care. The examiner must perform the exploration by trying to re-create the position of the hand during injury.

nerve lies just deep and radial to the palmaris longus, the most superficial tendon. Even lacerations to the wrist that appear trivial can cause serious tendon and nerve damage.

The flexor tendons to each finger are paired. The flexor digitorum profundus tendons are responsible for power and mass action, such as is needed for gripping. These tendons run deep to the flexor digitorum superficialis tendons, but at the level of the middle phalanx, the profundus splits through the superficialis and goes on to attach to the distal phalanx (Fig. 13-14). To test profundus function, the action of the sublimis

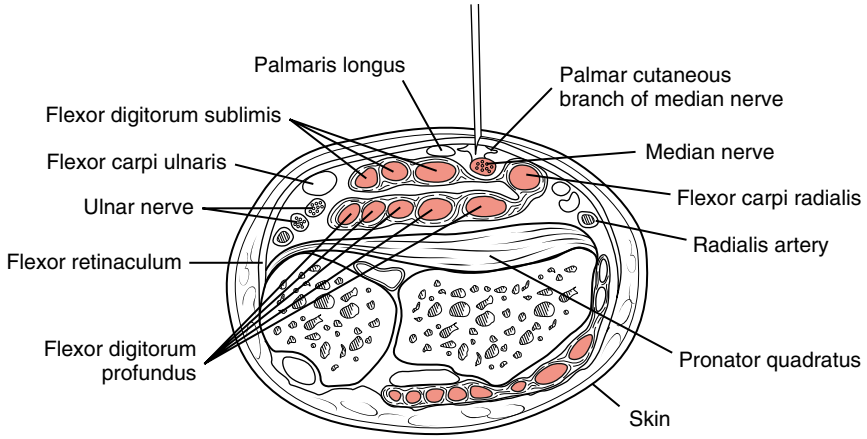

Figure 13-13. Cross-sectional anatomy of the wrist. Note in particular the superficial location of the median nerve. Any visible tendon laceration, such as to the palmaris longus, has to raise the suspicion of an injury to the median nerve.

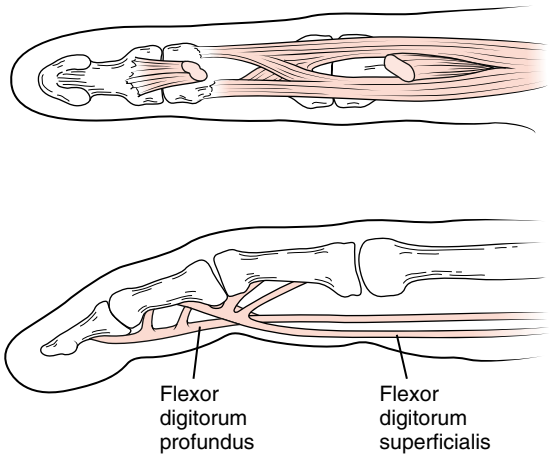

Figure 13-14. Note the relationship of the flexor digitorum profundus to the flexor digitorum superficialis. The profundus splits through the superficialis, which is attached on the middle phalanx. The profundus attaches to the distal phalanx.

tendon has to be blocked by holding each digit, one at a time, in extension at the middle phalanx (Fig. 13-15). The patient is asked to flex the distal phalanx, which now can be accomplished only through the action of the profundus. During this maneuver, 60 degrees of flexion is normal.

The flexor digitorum superficialis tendons are responsible for the positioning of the fingers so that power flexion can occur. These tendons run superficial to the deep tendons until they are split at the distal portion of the middle phalanx by the profundi. The superficialis tendons attach to the proximal portion of the middle phalanx. To test for superficialis action, the profundus group has to be blocked by the examiner. As illustrated in Figure 13-16, the examiner holds all the fingers in extension except the one being tested. The patient is asked to flex the finger fully at the metacarpophalangeal and proximal interphalangeal joint. If the superficialis is lacerated, the patient is unable to flex that finger.

Figure 13-15. Testing for function of the flexor digitorum profundus. The distal phalanx of the finger is forcibly flexed, while the action of the superficialis tendon is blocked. Only the profundus can flex the distal phalanx.

Figure 13-16. Testing for function of the flexor digitorum superficialis. The mass action of the profundus can be blocked by holding the nontested fingers in extension. The tested finger can be flexed only at the proximal interphalangeal joint by the superficialis tendon.

CIRCULATION

The circulation of the hand is extraordinarily rich and redundant (Fig. 13-17). Most people can have complete loss of either the radial or the ulnar arteries and can maintain adequate perfusion. Loss of perfusion because of damage to the vessels is usually the result of an extensive injury not ordinarily repaired by emergency wound care personnel, and consultation is obtained. Although pulses are always documented in any

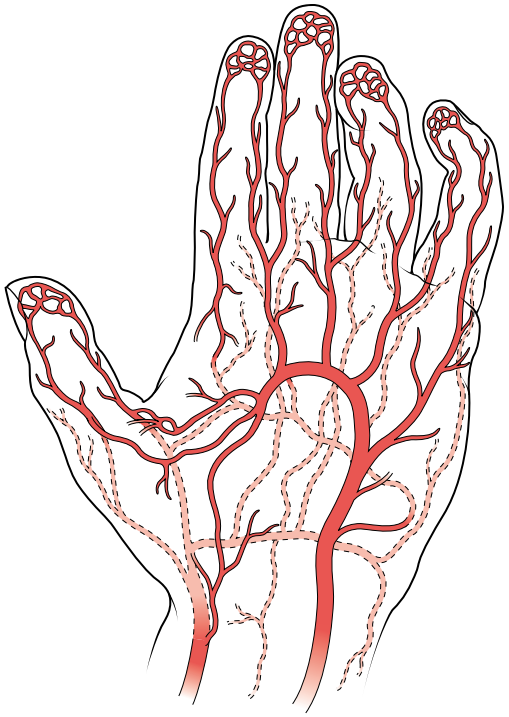

Figure 13-17. The profuse and redundant vascularity of the hand. It is common to be able to sacrifice either the radial artery or the ulnar artery and still have complete perfusion of the hand. Lacerations of the digital arteries arouse suspicion of a lacerated digital nerve.

hand injury, the best indicators of perfusion are color, skin blanching with pressure, temperature, and capillary refill at the nail bed. Because arteries travel with nerves in neurovascular bundles, profuse arterial bleeding of the digit should raise the suspicion of an accompanying digital nerve injury.

RADIOGRAPHY

Radiographs are used liberally to assist in the evaluation of the hand. For any blunt trauma associated with a laceration, underlying fractures must be ruled out. Not only do hand fractures require careful and sometimes specialized management, but also a fracture with a laceration has to be considered an open fracture. Open fractures usually are managed by consultants. Foreign bodies frequently are associated with hand injuries. Radiographic examinations are particularly useful to detect metal and other debris. Contrary to a common misconception among clinicians, almost all types of glass, in 90% of cases, are easily detectable by radiographs (see Chapter 16).[6]

WOUND EXPLORATION

Ultimately, each laceration of the hand should be explored gently and carefully just before repair. Despite normal functional testing, partial tendon lacerations and violation of joint capsules might remain undetected until exploration is performed. This procedure usually is accomplished by retracting the wound with an Adson forceps or a skin hook and using a mosquito clamp to spread open the deeper tissue for a good look, preferably in a bloodless field. Because small wounds can harbor serious injury to underlying structures, extension of the skin laceration sometimes is necessary to gain adequate exposure. Chapter 9 provides further details concerning tourniquet

application, wound extension, and exploration. If there is a doubt about an injury to an important structure of the hand, the advice of a specialist should be sought.

SELECTED HAND INJURIES AND PROBLEMS

Although there is a large variety of wounds and lacerations to the hand, the wounds and lacerations described here are those that are commonly managed and repaired by emergency wound care personnel. Serious, complex injuries, especially ones that cause functional deficits, are best cared for by specialists. Animal bites and burns to the hands are discussed in Chapters 15 and 17.

Uncomplicated Lacerations

The principles and techniques of wound repair discussed in Chapter 10 also apply to closing hand lacerations. Most lacerations of the dorsal and volar surfaces of the hand can be anesthetized by direct wound infiltration (see Chapter 6). Large lacerations can be managed by wrist blocks. Wounds beyond the proximal phalanx are best anesthetized with digital blocks.

Débridement of the hand, when indicated, is carried out with great caution. Excessive removal of skin can lead to failure of adequate coverage, eventual wound contraction, and a resulting functional deficit. Fat is a good substrate for bacterial growth, and less care has to be taken when débriding away contaminated and devitalized tissue. Injured fat does not regenerate, however, and the padding role that fat provides the volar surface of the hand can be endangered. In cases in which large amounts of fat must be sacrificed, the opinion of a consultant is recommended.

Because of the number of important structures that lie within the small confines of the hand, deep closures with any suture material are discouraged. Any "foreign" material can provoke inflammation and tissue scarring that might interfere with such important and vulnerable functions as tendon gliding. By closing the skin alone, little dead space is left behind in hand injuries. In addition, natural tension across the wound usually is minimal in hand lacerations, and deep closures are not needed to reduce that tension.

The recommended suture material for skin closure is 5-0 nonabsorbable monofilament nylon. The volar surface of hand lacerations can also be closed with absorbable sutures such as gut and rapidly absorbing Vicryl Rapide.[7] When compared to nonabsorbable sutures, the outcome is no different than closure with absorbable sutures. Nonabsorbable sutures are recommended for the dorsal surface of the hand, because flexion stress requires longer support.

Only as many sutures as are necessary to achieve appropriate wound edge approximation are placed. Hand lacerations heal with little scarring, and no purpose is served by excessive sutures in search of the perfect repair. Simple interrupted technique suffices for most wounds. Skin on the hand tends to invert with closure, however, particularly on the dorsal surface. In this case, the horizontal mattress technique is useful.

Fingertip Injuries

The management of fingertip injuries is controversial. There are few actual controlled studies of fingertip and fingernail problems. The strategies and choices of repair techniques vary considerably among personnel who care for these problems. The issue of whether to remove the nail after an injury evokes widely varying opinions. Certain principles guide the repair process, however. These are preservation of finger length, nail growth capacity, fingertip padding, and sensation.[8]

The fingertip and fingernail apparatus form a complex anatomic and functional unit (Fig. 13-18). The fleshy volar pad is replete with nerve endings and capillaries. There is

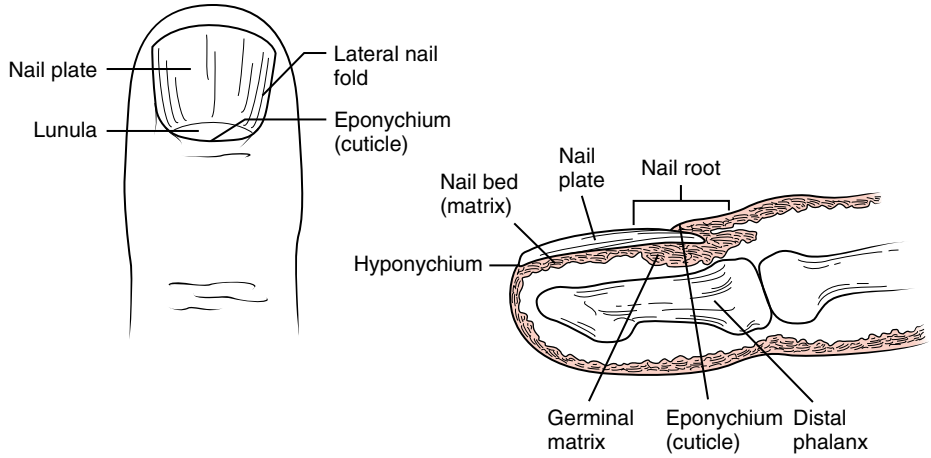

Figure 13-18. Anatomy of the distal finger and nail components.

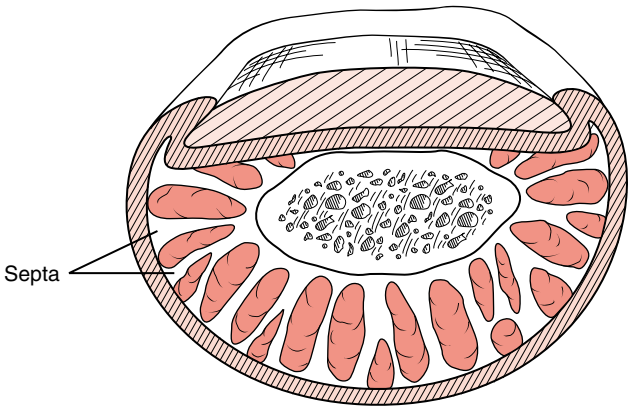

Figure 13-19. The fibrous septa that connect the skin to the underlying phalanges. The septa provide stability to the soft tissue of the finger.

sufficient soft tissue to pad the fingertip and distal phalanx effectively against undue trauma. Preservation of sensation of the fingertip is crucial to all manual activities. Even with full-thickness loss of the fingerpad, healing and regeneration of tissue usually can be relied on to restore a functional pad. Numerous fibrous bands called *septa* anchor the skin to the underlying bone structure (Fig. 13-19). These structures prevent sliding or slipping of the skin during use of the fingers. Septa should be kept anatomically intact whenever possible.

The nail apparatus has several components. The nail itself is divided into the nail root, which is the portion that lies under the eponychium, and the nail plate, which adheres to the sterile matrix. The matrix also has two parts, the germinal matrix, from which new nail is generated, and the sterile matrix, or nail bed, over which the nail passes during normal growth. The eponychium, commonly referred to as the cuticle, is the fold of skin that overlies the nail root. One of the main principles of nail management is to prevent the eponychium from adhering and scarring down onto the germinal matrix. Should this take place, nail regeneration can be impaired significantly. Techniques to prevent this occurrence are discussed in the following sections.

Fingertip injuries can be divided into three groups: (1) blunt injuries (subungual hematoma), (2) nail and nail bed lacerations, and (3) avulsion injuries with tissue loss. Foreign bodies lodged under a fingernail are discussed in Chapter 16.

Blunt Injuries (Subungual Hematoma)

It has been thought and taught that the presence of a large hematoma (>50% of the nail surface) signifies a probable laceration of the nail bed and the need for nail removal and repair.[9] Studies have shown, however, that nail plate removal and bed repair is not necessary when the nail is still intact over a large subungual hematoma. In a study of 45 patients with subungual hematoma who were followed for at least 6 months posttreatment, all patients, including 16 patients with a 50% hematoma and 14 with distal phalanx fracture, had trephination as their only treatment.[10] They were splinted for protection for 1 week. The outcome was uniformly good, with no wound infections, osteomyelitis, or significant later nail deformities. Excluded from the study were patients with nail disruption and previously existing nail deformities.

A more recent comparison of simple trephination versus nail removal and bed repair showed a better outcome in the simple trephination group.[11] There were more complications in the repair group, and the cost was four times that of trephination. Both of these studies are consistent with the author's experience. Regardless of the size of the hematoma or the presence of a tuft fracture, simple trephination is preferable if the nail remains well attached to the bed.

Nail trephination can be carried out by a variety of methods. A heated paper clip creates an appropriate-diameter drainage hole, but this technique requires considerable practice and skill. The clip has to be heated until it is red hot and transferred quickly to the nail. Heat is lost quickly, and the procedure commonly has to be repeated to gain full nail penetration. To create a drainage site, 18-G needles and no. 11 scalpel blades can be used by employing a rotating or drilling motion. The drainage holes are often small and close prematurely with a blood clot. There is considerable pressure brought to bear on the fingertip when applying this technique. More effective and less painful is a battery-powered drill.

The most efficacious and least painful device is the disposable electric cautery, which can be handled like a pencil and placed with ease and precision over the hematoma (Fig. 13-20). The drainage hole is adequate, and the patients tolerate the procedure well when they understand that the heat tip will not burn them. With appropriate technique, when the heat tip passes through the nail, heat is rapidly dissipated by the underlying hematoma.

The following guidelines are offered for the evaluation and management of subungual hematomas:

- Trephination alone is appropriate for subungual hematomas of any size in which the nail remains attached and there is no deformity of the fingertip suggesting a displaced fracture. Even if a nail bed laceration or nondisplaced tuft fracture is present, healing proceeds without event, and full function is restored to the finger with splinting.
- Nail removal is reserved for patients in whom the nail is already partially avulsed, torn, or deformed from this injury. Under these circumstances, when the nail is removed, as described in the following section, the bed is inspected, and lacerations are repaired with 6-0 absorbable suture.
- Although subungual hematomas with associated fractures technically can be considered open fractures, in reality they do not need to be treated as such. Antibiotics are not indicated if the nail is left in place.

Figure 13-20. Electric cautery to penetrate a nail to drain a subungual hematoma.

Nail Bed Lacerations

Exposed nail bed lacerations of the matrix, caused by blunt trauma, are repaired by careful reapposition of the wound edges and suturing with 5-0 or 6-0 absorbable suture material. If intact, an avulsed or removed nail can be replaced, for temporary splinting purposes, under the eponychium (Fig. 13-21). The main reason for using the nail as a splint is to prevent adhesions and granulation tissue buildup between the eponychium and the germinal matrix of the bed. The nail also serves to splint any accompanying fracture and to mold the healing wound site. To maintain the nail in place, two 5-0 nonabsorbable sutures can be placed through trephined holes (see Fig. 13-21). If the nail cannot be used, a small piece of nonadherent dressing, such as Adaptic or a Penrose drain, can be tucked under the eponychium (Fig. 13-22). The nail or packing is usually left in place for 7 to 10 days.

Crush injuries of the fingertip in children can be complicated, and the extent of the injury may not be evident during the first emergency-department visit.[12] The swelling, pain, and tissue distortion can make treatment decisions difficult. For these complex injuries, cleansing, tissue preservation, antibiotics, dressing, and referral are recommended. Closure can be delayed up to 2 weeks with good long-term results.[12]

In less complicated injuries, it is common for the nail root to avulse partially from the bed under the cuticle (eponychium). The nail root is excised, and the eponychium is packed with a nonadherent dressing material for 7 to 10 days for the same reasons described earlier (Fig. 13-23). A new nail eventually grows out and extrudes the remaining portion of the old nail.

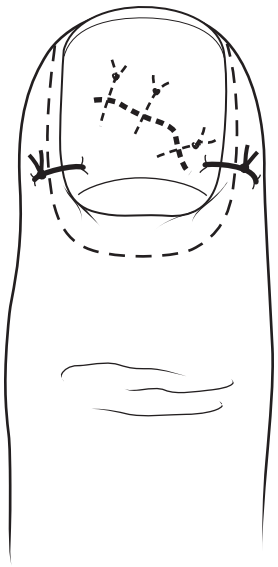

Figure 13-21. Nail bed injury. If the decision has been made to remove the nail, and a laceration of the bed is discovered, this laceration is repaired with 6-0 absorbable suture (e.g., polyglycolic acid). The nail, if removed intact, can be replaced as a splint for 7 to 10 days. The nail prevents adherence of the germinal matrix to the eponychium. The nail is anchored by placing sutures as shown in the lateral aspect of the plate.

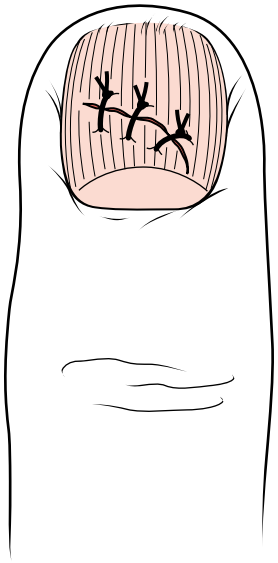

Figure 13-22. Nail bed injury. If the nail is not in a condition to be replaced, a small stent is fashioned to separate the eponychium from the germinal matrix. This stent or packing is removed within 5 to 7 days.

Lacerations of the fingertip and nail apparatus caused by sharp or shearing forces usually can be managed by simple suturing. Transverse lacerations through the nail plate and matrix can be repaired by removing the distal portion of the nail plate to expose the lacerated nail bed. Repair of the matrix is performed with 6-0 absorbable suture (Fig. 13-24). Maintaining the integrity of the nail root prevents nail growth problems with the germinal matrix.

Longitudinal lacerations through the matrix and eponychium require careful repair of both structures. The nail bed is repaired with 6-0 absorbable suture (Fig. 13-25). The eponychium and surrounding skin are closed with either nonabsorbable or absorbable material such as gut or rapidly absorbing Vicryl. If the nail plate is removed in its

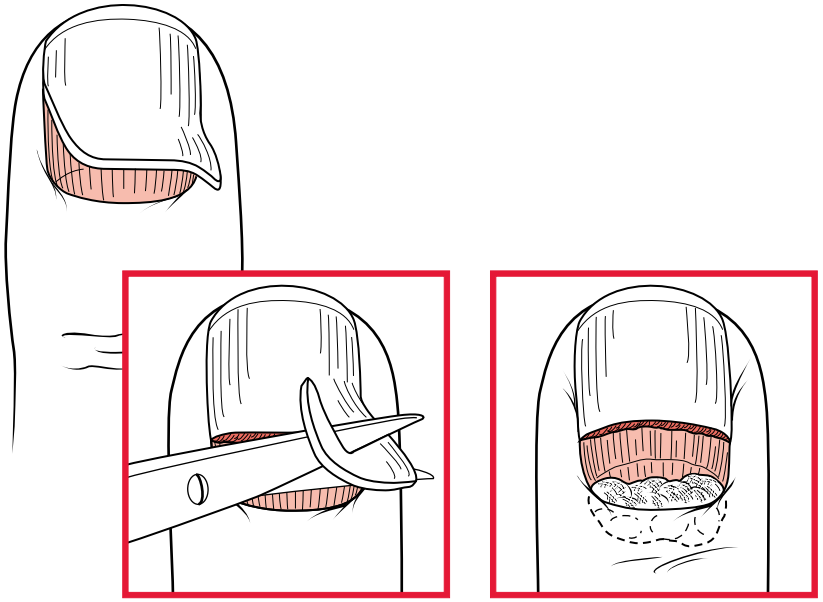

Figure 13-23. Nail root avulsion. If the nail root cannot be replaced, the nail root can be excised, and a small Penrose drain or Adaptic packing is placed under the eponychium for 5 to 7 days. A new nail germinates and extrudes the remainder of the old portion.

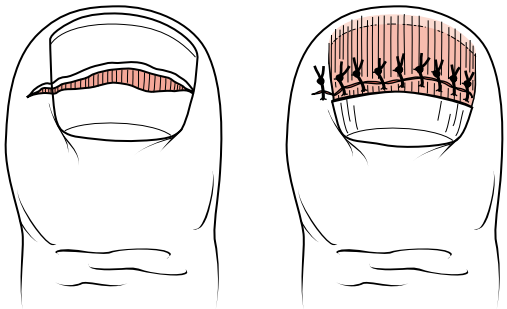

Figure 13-24. Transverse lacerations of the nail bed often can be managed by leaving the nail root intact. The proximal portion of the nail is excised with tissue scissors proximally to the injury. The nail bed is repaired with absorbable suture. The nail continues to grow over the suture line well after the sutures have been absorbed.

entirety, a nail replacement or packing for 10 to 14 days, as previously described, is necessary to prevent eponychial adherence to the germinal matrix. Only the nonabsorbable sutures are removed after 10 to 12 days.

Nail Removal Technique

When the decision is made to remove the nail, the techniques illustrated in Figure 13-26 are suggested. A small hemostat or iris scissors is inserted under the nail plate along the nail bed. The instrument is advanced slowly as it is spread open to lift the nail plate off the matrix. This process is carried back through to the nail root and germinal matrix area. Care is taken to avoid undue injury to the nail bed and germinal matrix. The eponychium also is gently pushed away from the nail plate. When the nail plate

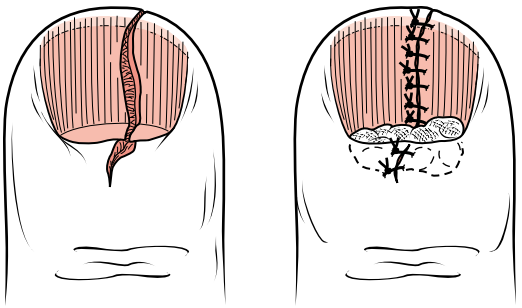

Figure 13-25. Longitudinal lacerations of the nail bed often are best closed by removal of the nail entirely. When the nail bed is repaired, a Penrose drain or Adaptic packing is used to separate the eponychium from the germinal matrix for at least 5 to 7 days.

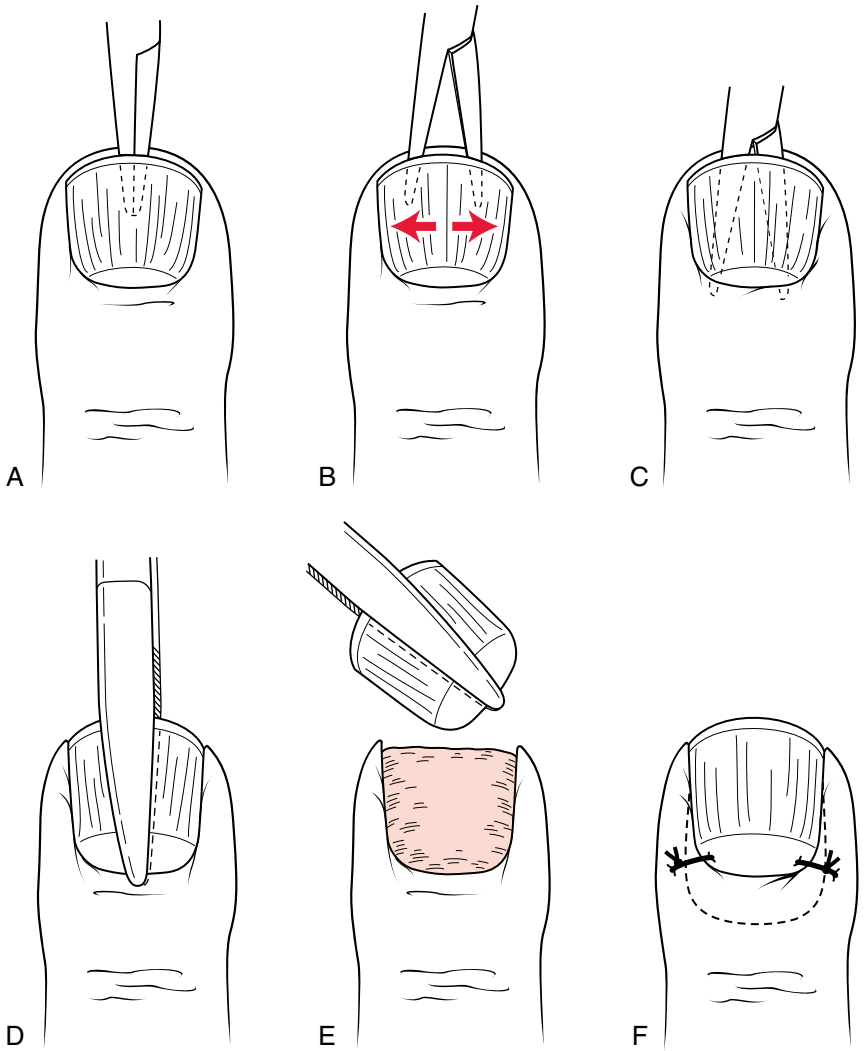

Figure 13-26. Technique for removal of a nail. **A,** Introduce a small hemostat or iris scissors between the nail and the nail bed. **B,** Gently dissect the nail from the nail bed. **C,** Extend the dissection all the way back to the germinal matrix. **D,** Grasp the nail firmly and remove it from the nail bed **(E). F,** If the nail plate remains intact, it can be replaced as a splint or stent and anchored as shown with two 5-0 nonabsorbable sutures.

has been loosened, a hemostat is used to grasp the nail plate firmly and pull it out from under the eponychium. The nail does not always come off easily, and some measure of force must be applied.

Avulsion Injuries

Another area of controversy in fingertip management surrounds avulsion injuries with loss of tissue (Fig. 13-27). At issue is whether to close these avulsions by grafting or whether to leave them to heal spontaneously. There is consensus that any fingertip avulsion with <1 cm^2 area of tissue loss and no accompanying bone or nail bed injury can be managed by allowing spontaneous healing to occur.[13] Also at issue are avulsion injuries of larger areas or bone exposure. Losses of 1.8 × 2.6 cm, even with bone exposed, in pediatric and adult age groups, have been treated successfully without grafting.[14-18] When bone was exposed, spontaneous soft tissue covering of the distal phalanx occurred with adequate pad formation.[18,19] When comparing complication rates and time lost from work, conservative management is comparable to grafting.[20] In one study, the infection rate of the conservatively managed group was markedly lower than that of surgically grafted patients.[21] To summarize, nonoperative management of fingertip avulsions heal in 20 to 30 days; the regrown pulp is of high quality with good size, bulk, and function; two-point discrimination returns to an average of 2.5 mm (near normal); and 90% of patients are satisfied with the result.[22] The one area in which conservative management seems less optimal compared with more meticulous surgical repair is when the nail bed is involved and repair is indicated. Unrepaired nail matrices tend to lead more frequently to deformed nails.[21]

Guidelines for the management of avulsion injuries are offered as follows:

- If the defect is <1 cm in diameter and no bone is exposed, spontaneous healing is the treatment of choice.
- For losses >1 cm, but with an intact nail apparatus and no bone exposure, conservative management can be considered as an alternative to grafting. Children do well with conservative treatment. Local practice, which may necessitate consultation, often dictates the management of these injuries.
- For avulsions with nail apparatus involvement, repair or revision of the matrix is necessary. Consultation may be required.

Figure 13-27. Avulsion injury of the fingertip.

- For injuries with exposed bone, consultation is recommended to assist in the decision regarding the treatment choice.
- Proper dressings for fingertip avulsions include a nonadherent base, such as Xeroform or Adaptic, with a sponge covering and gauze wrapping as described in Chapter 20. As discussed later, antibiotics are suggested for injuries with exposed bone.

Tendon Lacerations

All lacerations of flexor tendons (in the upper or lower extremity) are referred to specialists for care. An emergency wound care setting is not the place to repair flexor tendon injuries. Besides requiring a controlled surgical environment, these tendons are managed most effectively by trained surgeons using the proper instruments and magnification. Under the best of circumstances, flexor tendon injuries present considerable technical challenges, and repair can be fraught with complications. Injuries in zone II, known as *no man's land*, present the greatest challenge to the caregiver (Fig. 13-28).

In many cases, flexor tendon lacerations can be repaired primarily 3 weeks postinjury.[23] Anastomoses done within 7 to 10 days may have a better outcome.[24] After 3 weeks, reconstructive procedures must be used. With agreement from the consultant, the skin can be closed and arrangements can be made for follow-up evaluation and a decision regarding formal tendon repair. The skin closure is done after standard skin cleansing and irrigation. A splint is placed. An intravenous dose of a first-generation cephalosporin is administered in the emergency department, followed by oral cephalosporin or dicloxacillin. Clindamycin can be given to the allergic patient. Immediate

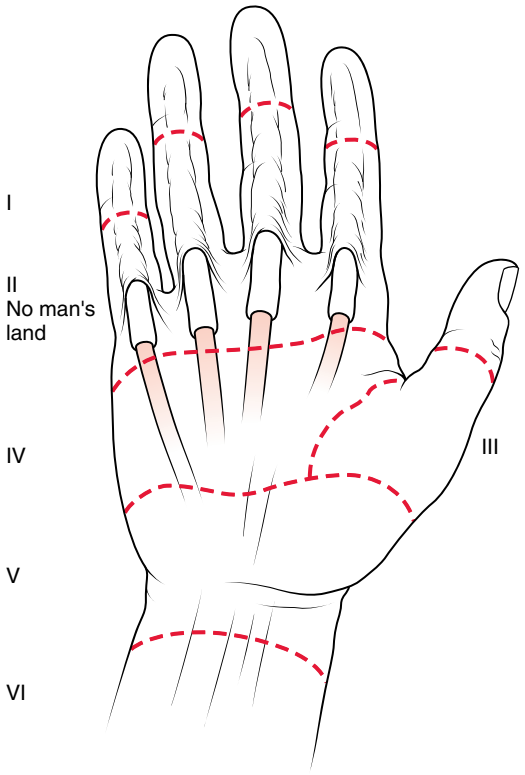

Figure 13-28. Zones of tendon repair. The hand can be divided into zones that have different implications when considering tendon repair strategy and technique. Injuries in zone II, also referred to as *no man's land,* are difficult to repair because of the complex and close relationship of the tendons and surrounding structures.

operative intervention may be necessary for injuries with excessive contamination, skin loss, unstable bony skeleton, or missing tissue.

Simple, single lacerations of an extensor tendon on the dorsum of the hand, between the distal wrist and the metacarpophalangeal joints (zone VI), can be repaired in the emergency wound care area by appropriately trained wound care personnel.[25] It is recommended that training for extensor tendon repair include several supervised repairs under the guidance of a specialist. It is important to master appropriate techniques and to understand proper splinting and the necessary follow-up care. The specialist should agree with the plan of care because he or she will take over the aftercare treatment.

Single extensor tendons can be repaired in the emergency department under the following circumstances: (1) if the injury is between the distal wrist and the metacarpophalangeal joints (zone VI), (2) if the skin and tendon wounds are sharp and not heavily macerated or contaminated, (3) if the injury is <8 hours old, (4) if the two ends of the tendon are easily visualized, (5) if appropriate instruments are available to minimize trauma to the tissues, and (6) if the patient is cooperative and will comply with follow-up care. The technique for repairing an extensor tendon is shown in Figure 13-29. A 4-0 nonabsorbable suture, such as nylon or polypropylene, on a straight needle is passed through the tendon in the figure-eight pattern until it is secure. The skin is closed with 5-0 nonabsorbable suture material. A plaster splint is placed on the palmar surfaces of the forearm-wrist-hand-digit, over the appropriate nonadherent base and the gauze sponge/wrap surface dressing. The wrist is placed at a 30-degree angle of extension, and the metacarpophalangeal joints are placed at a 20-degree angle of flexion. The fingers are only slightly flexed. The splint remains in place for 3 weeks; however, the patient is referred much sooner to the consultant for follow-up care.

On careful exploration of a laceration of the hand, it is common to discover partially lacerated extensor or flexor tendons. The management of these injuries is controversial. Unrepaired, these injuries have been reported to rupture, cause "triggering," or become entrapped.[26] Successful treatment of these injuries has been reported with skin closure alone followed by splinting.[26,27] Treatment can be guided by cross-sectional size of the laceration. As a general rule, if the tendon is more than 50% transected, it should be repaired as if fully severed. Lesser injuries can be trimmed to prevent triggering or entrapment. Appropriate splinting, rehabilitation, and follow-up care are carried out under the direction of the specialist.

Nerve Injuries

Lacerations associated with sensory or motor deficits of one of the major nerves of the upper extremity require immediate referral to a consultant. Injuries to the digital nerves can be handled differently, however. Surgical repair is indicated if two-point discrimination exceeds 10 mm.[28] For uncomplicated severed nerves, delayed repair can have significant advantages over early repair.[29,30] The repair setting and time are better controlled, the cut nerve ends and epineurium are better delineated, and early skin closure is an effective barrier against infection. The delayed repair is done through a sterile field and incision. In the emergency department, with consultative support, simple skin suturing is done, a dressing is placed, and the patient is referred to the specialist within 1 to 2 days. Nerve repair can be performed on an elective basis 10 days after the injury. When the injury is complicated by contamination, tissue devitalization, or associated injuries, early consultation is recommended. A recent study of volar digital nerve injuries by using ultrasound can accurately predict transection of the nerve.[31] A 12- to 14-MHz linear array hockey-stick transducer is used. Sonographic exam is performed several days after injury to lessen the effect of distortion from edema.

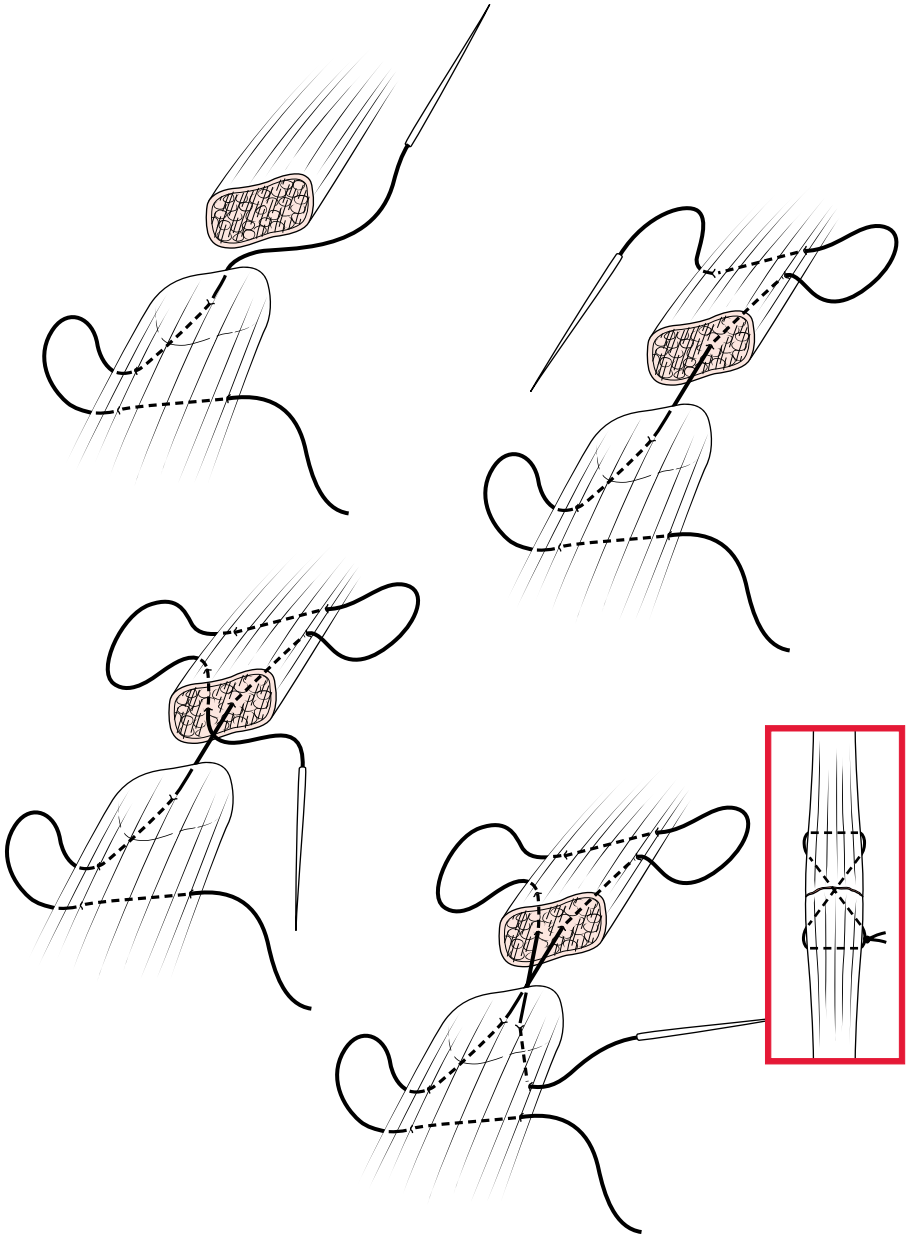

Figure 13-29. The figure-eight technique to reappose sharply divided lacerated extensor tendons. See text for further explanation.

Amputated Parts

Emergency physicians often are involved in the early management of patients with amputated parts. Although the injury is not within the realm of emergency wound care personnel to manage, proper handling of the injured extremity and severed part is important, especially if there is a chance of reimplantation by a specialist.

The injured extremity is gently cleansed and wrapped in lightly saline-moistened gauze sponges followed by gauze wrapping. A tourniquet rarely is needed to stop hemorrhage because natural vasospasm and platelet plugging of the severed vessels occur rapidly after injury. It is common to administer a dose of intravenous first-generation cephalosporins to the patient as prophylaxis.

The severed part is placed in a dry, sterile sponge wrapping. Saline soaking causes unnecessary and unwanted edema and makes reimplantation much more difficult. The wrapped severed part is placed in a small plastic covered cup or bag. The cup and its contents can be put in a container with ice to cool the tissue. Great care has to be taken to ensure that ice does not come into direct contact with the severed part so as not to cause necrosis from freezing. When these steps have been taken, the patient can wait for the specialist or can be transported to an appropriate care facility.

Paronychia

The most common hand infection is a paronychia.[32] A paronychia is an infection of the eponychium, and it usually is associated with a collection of pus between the eponychium and the nail root. The infection is localized most often to one side of the eponychium, in the lateral nail fold. It can include the eponychium in the midline, however, or can proceed in "horseshoe" fashion to involve the entire eponychium. Pus also can invade the space under the nail plate. The most common bacteria found in a paronychia are gram-positive cocci, either *Streptococcus pyogenes* or penicillin-resistant *Staphylococcus aureus*.[32,33]

One of the most serious events in soft tissue infections is the appearance of community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA).[34] This organism has been cultured from hand infections including paronychia.

The simplest and most effective manner to drain a paronychia is to insert a no. 11 blade between the eponychium and the nail plate and gently to sweep the blade to elevate the eponychium (Fig. 13-30). With deft technique in a calm patient, this procedure can be done without anesthesia. Otherwise, a digital block is performed before drainage. After drainage, a simple adhesive bandage (Band-Aid) dressing is applied. The patient is instructed to remove the Band-Aid and to soak the finger in warm, soapy water twice a day. Band-Aids can be reapplied between soakings. Some authorities recommend placing drains under the eponychium. Uncomplicated paronychia in patients, who do not have risk factors such as diabetes, does not necessitate these measures. Antibiotics often are prescribed but are unnecessary if the pus is completely drained and there is no surrounding digital cellulitis. If there is cellulitis, a first-generation cephalosporin or clindamycin (for allergic patients) can be prescribed for 7 days. If CA-MSRA is suspected, recommended antibiotics are trimethoprim-sulfamethosoxazole, clindamycin, or doxycycline.

Occasionally a paronychia extends below the nail plate between the nail and matrix. Pus can be seen through the semitranslucent nail. If pus is suspected to be in this space, partial or complete nail removal is recommended. Merely sweeping a no. 11 blade under

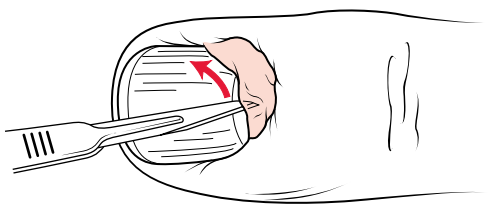

Figure 13-30. Technique for draining a simple paronychia. The no. 11 blade is brought between the nail and the eponychium parallel to the nail plate. This simple maneuver drains most paronychias.

the eponychium does not suffice. Figure 13-31 shows a method of partial nail removal to accomplish the drainage of the paronychia and the pus under the nail plate. A paronychia that involves the entire eponychium and nail root area can be managed as illustrated in Figure 13-32. An incision of the eponychium is made to free the nail root for removal. Occasionally the entire nail must be removed to effect complete drainage.

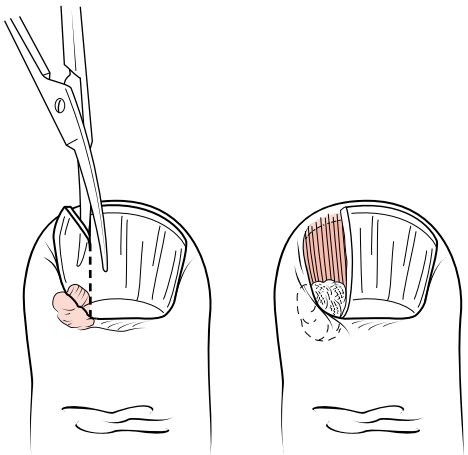

Figure 13-31. When a paronychia extends below the nail and insinuates between the nail bed and the nail plate, partial nail removal must take place. When nail removal is accomplished, a small packing or drain is left in place for 5 to 7 days.

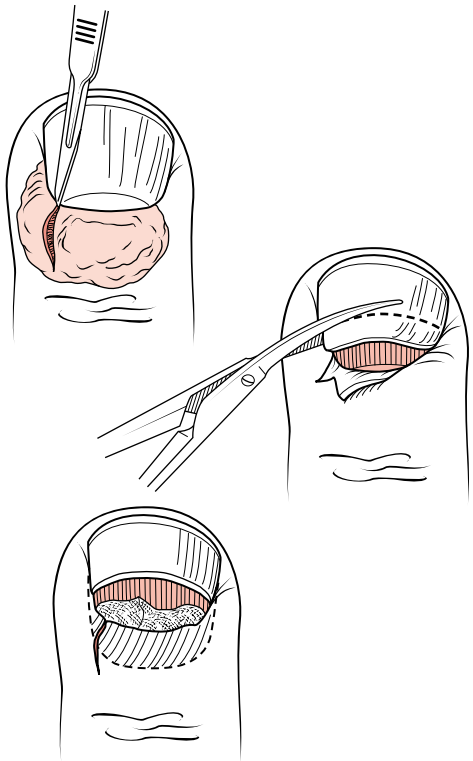

Figure 13-32. A complex "horseshoe" paronychia usually needs to be drained by incising the paronychia directly and removing either a portion or all of the nail. Packing is left in place for 5 to 7 days to prevent adherence of the eponychium to the germinal matrix.

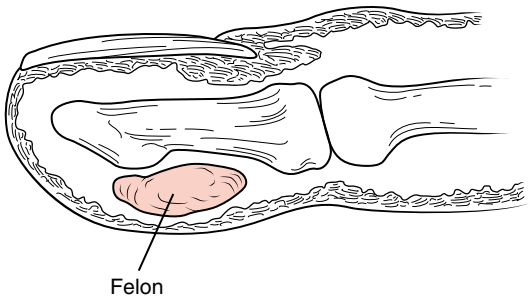

Figure 13-33. Felon in the pulp of the finger space.

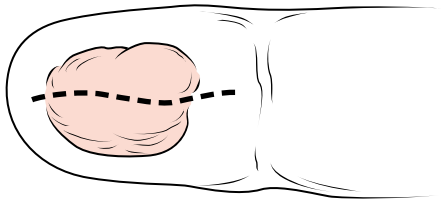

Figure 13-34. Technique for draining a felon. The incision is made directly over the area of maximal tenderness and fluctuance.

Antibiotics often are recommended for complex paronychia. Antibiotics for hand wounds are discussed in the text that follows.

Felon

A felon is an infection with a collection of pus in the pulp space of the fingertip (Fig. 13-33). The finger pad is quite swollen and is exceedingly tender. The most common bacteria found in these infections are *S. pyogenes* and penicillin-resistant *S. aureus*.[32,33] The previous discussion regarding CA-MRSA applies to felons as well. Whenever paronychia and felons are present, the patient needs to be assessed for extension of the infection to the tendon. Suspicion for tenosynovitis is raised if the patient has the four signs of Kanavel[35]:

- Uniform symmetric swelling of the digit
- At rest, digit is held in partial flexion
- Excessive tenderness the whole length of the flexor tendon sheath
- Pain of the tendon sheath and finger with passive extension

Several methods to drain felons have been recommended through the years. The so-called fish-mouth and lateral incisions that cut through the supporting fibrous septa of the finger pad are thought to increase the occurrence of unnecessary sequelae.[36]

The simplest technique to drain a felon is to make a longitudinal incision directly through the finger pad on the volar surface of the digit into the pulp space and pus collection (Fig. 13-34).[36] The incision is kept open with a small, loose-fitting wick made of a nonadherent dressing material or by a small sliver of rubber, such as part of a Penrose drain or a rubber band. The drain is removed at follow-up at 48 hours, after which a soaking routine similar to the one used for paronychia is encouraged. Patients are then started on antibiotics. The treatment protocol should include the possibility of CA-MRSA infection.

Pressure Injection Injuries

An injury to the hand that is caused by a high-pressure injection device, such as a paint sprayer or grease gun, initially seems benign. Through a pinhole, such a device can create a needle-thin stream that can have a pressure of 15,000 psi. A variety of paints,

petroleums, and other chemicals can easily pierce the skin and, under the pressure created, spread throughout the hand along natural tissue planes and tendon sheaths. Grease and paint are the two most commonly injected substances.[31]

The entry wound is often no more than a small puncture. The most common site of entry is the tip of the index finger, which happens as a result of "testing" to see if the device works. Some of the injectable chemicals, such as the petroleums, do not cause an immediate reaction or pain. The patient often has minimal complaints. The combination of the small wound and relative lack of symptoms is deceptive. These injuries can progress over hours to marked pain, swelling, and inflammation of the entire hand. They require immediate consultation. Some authorities recommend fasciotomies of the hand, before significant swelling develops, to forestall ischemia created by an increase in tissue pressure from the intense reaction, to remove the chemical, and to débride necrotic tissue. The overall incidence of amputation has been reported to be 48%.[37]

ANTIBIOTICS FOR HAND WOUNDS

The use of antibiotics in patients with hand injuries is largely empirical, because there are few definitive, well-designed studies examining their use. Several studies have shown that prophylactic antibiotics are of no value in uncomplicated lacerations of the hand.[4,12,38] In more complicated injuries, such as avulsions of the fingertip, antibiotics often are prescribed, but there are no definitive studies to support this practice. Some studies have shown that antibiotics are of no value.[15,17]

It is common to treat fingertip injuries with prophylactic antibiotics. In a large study of 299 patients treated without antibiotics for injuries ranging from simple lacerations to avulsions, only two infections developed.[39] One group found a decrease in the infection rate with the use of antibiotics when bone was exposed under severe crushing forces.[40] It has not even been shown in the face of a paronychia that antibiotics improve outcome. Despite this controversy, some recommendations that rely more on traditional practice and clinical judgment can be made. Antibiotics should be used in the following situations:

- Wounds >8 hours old
- Wounds caused by a crushing mechanism in which some tissue compromise is suspected
- Contaminated or soiled wounds in which extensive cleansing and débridement have been necessary
- Fingertip avulsions with exposed bone
- Open fractures
- Tendon or joint involvement
- Mammalian bites (see Chapter 15 for further discussion and special circumstances)
- Complex paronychia with pus under the nail
- Felons
- Immunocompromised patients or patients who have diabetes

The choice of antibiotics for hand injuries also generates debate. First-generation cephalosporins, which are effective against most of the common gram-positive and gram-negative organisms that are implicated in wound care, are a good first choice[41]; these include cephalexin (Keflex) or amoxicillin/clavulanate. For penicillin-allergic patients, the azithromycin (Zithromax) and clindamycin (Cleocin) are appropriate. For antibiotics to have any value, they must be administered as soon as possible in the emergency department, preferably within 3 to 4 hours after the time of injury.[42] For maximal effectiveness, the initial dose should be administered intravenously. A recommended intravenous first-generation cephalosporin preparation is cefazolin (Ancef);

clindamycin (Cleocin) can be used for penicillin-allergic patients. For prophylaxis, the duration of administration is 4 to 5 days. As discussed previously, if CA-MRSA is a possible contaminant, antibiotics that cover CA-MRSA need to be considered. Risk factors for CA-MRSA include children, parenteral drug abusers, men who have sex with men, prisoners, military personnel, and members of athletic teams.[40] Antibiotic choices include clindamycin, TMP/SMX, or doxycycline. It is important to consult local sensitivity patterns for CA-MRSA.

DRESSINGS AND AFTERCARE

The basic finger dressing is described in Chapter 20. Xeroform is a popular nonadherent base, as is Adaptic. As a nonadherent dressing, Adaptic is followed by the application of a gauze pad and a wrap overlay. [43] Adaptic has been shown superior to other dressing for avulsion and fingertip repairs. The latter is probably less adherent in wounds in which there is more exudate and crusting. All fingertips are well padded with gauze sponges. A metal protective splint is recommended for patients who are going to return to work or resume manual activities.

Most hand wounds are best followed up within 48 hours with dressing removal for inspection. If a suture line becomes infected, suture removal and wound cleansing with thorough irrigation are performed as soon as possible. Infections of the hand can be disastrous and can often spread rapidly to important structures from a small nidus. Most sutures of the hand are removed in 8 to 10 days.

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