INTRODUCTION

This chapter describes how to handle correctly some of the core skin surgery instruments, and then goes on to describe the key skills required to perform a straightforward ellipse excision and close the wound with sutures or other skin closures. Levels of difficulty are indicated by scalpel ratings. The more scalpel blades, the more difficult the procedure and the more practical experience will be required to become competent at the technique.

The techniques of shave excision, curettage, and cautery are described in Chapter 19, and excision of cysts and lipomas in Chapter 20. Details of the frequently used and appropriate surgical instruments for skin surgery are included in Chapter 1 along with important information about sterilisation. Operating with the correct instruments, of good quality, makes performing surgery safer and more enjoyable.

HANDLING COMMON SURGICAL INSTRUMENTS

Scalpel

Hold the scalpel (usually a No. 15 blade with size 3 Bard–Parker handle, or a round Beaver handle) like a pen, perpendicular to the skin (Figure 17.1a). This is different from the traditional surgeon’s grip (Figure 17.1b), which is useful for large incisions, but not so useful for most skin surgery incisions.

Attaching the blade to the handle

When operating with a reusable scalpel handle, you will need to attach the disposable blade carefully. This is best achieved by holding the blade at the base of the cutting edge in a pair of curved mosquito forceps (see Video Clip 17.1—http://goo.gl/0UUqf). Do not risk damaging suture forceps for this procedure. To remove the blade, you reverse the procedure, holding the blade at the base, to lever it off the handle. Alternatively use a disposable Swann–Morton blade remover.

Figure 17.1 (a) Correct and (b) incorrect way to hold a scalpel.
Basic surgical techniques

Positioning the needle in the suture holder

The needle should be held at the tip (or very close to the tip) of the suture holder, at 90° to it and two-thirds of the way down around the needle, to avoid it bending when used. Suture/needle holders with tungsten carbide jaws (see page 11) have narrow jaws that do not flatten the curved needle, while at the same time ensuring a firm grip on the needle. Figure 17.3a shows the needle held correctly at the tip of the needle holder and at 90° to it, with the needle held no more than two-thirds along its length. Any further and the needle holder would be grasping the hollow, crushable, and bendable section of the needle.

Suture holder (needle holder)

Suture holders can be held in a number of ways depending upon the type of suture being undertaken. The traditional surgeon’s grip (Figure 17.2a) is less used in skin surgery as it is better suited to inserting sutures into cavities. Instead the ‘palm grip’ (Figure 17.2b) is often used. The key is that the surgeon should feel comfortable with whichever grip is used.

The advantage of the skin surgeon’s palm grip is the ease with which it allows the instrument to rotate through 180° as the curved suture needle is inserted, passed through, and then removed from the skin. Using the palm grip, the needle is easily inserted at 90° to the skin, rotated in through, and then rotated out through the skin at 90°; the importance of this will become clear later in the chapter, when the insertion of sutures is discussed.

Figure 17.2 (a) The conventional surgeon’s grip and (b) the palm grip for holding a suture holder.

Figure 17.3 Position of the needle in the holder:
(a) correct; (b) incorrect—needle holder liable to flatten the needle; (c) incorrect—needle held by the bendable hollow section; (d) incorrect—needle at an angle.
Scissors

The technique for improved handling of scissors involves using the thumb and middle fingers to operate the scissors and using the index finger to stabilise the scissors over the hinge joint (Figure 17.5a). In addition, it is possible to rotate and hold the scissors 'in reverse' to reduce the risk of injury when not actually cutting. It is then a simple procedure to rotate the scissors back to the cutting position. Figure 17.5b shows the wrong way to hold the scissors.

Forceps

Tissue forceps should be held like the scalpel, in a pen grip, and not in the ‘screwdriver’ grip used with the needle holder (Figure 17.4). Using them in a screwdriver grip gives rise to excess tissue forces and can result in rotational damage to the fine ends of the forceps.
OPERATING ON THE SKIN: IMPORTANT PRINCIPLES

The aim of any surgical procedure involving the skin is to achieve a scar that is as small and as neat as possible. This should be possible in most cases by observing a few simple rules:
- Skin is a living tissue and must be treated gently and with respect. Good healing will only occur if the cut edges are held during healing in their exact position and under minimal or no tension.
- Skin should be cut with a sharp scalpel rather than scissors, which have a shearing action.
- Tissues should be handled as little as possible, and particularly not with any crushing forceps. Skin hooks should be used to hold or retract skin flaps.
- Deeply placed absorbable sutures should be used to allow closure in layers whenever possible, and their knots tied in the deeper plane.
- With deep and absorbable sutures, the least bulk of suture material should be left in the wound to be absorbed.
- Skin sutures, when used, should be of the minimum calibre required to hold the wound together, and should be removed as soon as wound integrity allows.
- Numerous fine skin sutures that distribute tension evenly are preferable to a few widely spaced large stitches that concentrate skin tension.
- Haemostasis should be achieved with care and, when required, with the avoidance of excessive cautery to the wound. In most minor surgical procedures, haemostasis should not be a problem.
- The surgeon who inserts the sutures should ideally be the person who removes them, or at least supervises their removal. Only by personally examining each wound postoperatively can improvements in technique be achieved.

CUTTING AN ELLIPSE

Marking the ellipse

Mark the lesion with a pen designed for skin marking, especially if the lesion is deep, before infiltrating with local anaesthetic or you may be unable to find it after infiltrating around it (see Chapter 7 for information on local anaesthesia). Always mark out the proposed incision on the skin before cutting anything. Any adjustments can easily be made at this stage before committing yourself to a scar by incising the skin. Bear in mind that if you cover the patient with sterile towels, you will find it more difficult to get your bearings. A sterile or non-sterile skin marker pen can be used according to personal preference.

It is important to ensure the markings do not wash off immediately when the skin is cleaned with antiseptic solution. An aqueous solution is less likely to cause this than an alcohol-based one.

Even if your incision is elliptical, the result will be a linear wound. Consider first in what orientation you want this line, and either mark each end of it on the skin with a dot or draw a line along which the intended scar will run. The apex of each end of the ellipse will lie along this line.

Next mark each side of the lesion with a dot. These two dots will represent the side of the ellipse at the narrowest margin to the lesion. This margin should be no less than 2 mm (dependent upon the lesion). Then draw the ellipse, making sure it encompasses the lesion adequately, taking account of the skin creases.

The ratio of the ellipse will usually be such that the length is three times the width in order to close the wound easily (Figure 17.6a). It is very easy to draw the ellipse too short, resulting in a more spherical or ovoid excision that will tend to stretch during healing (Figure 17.6b). When learning these measurements, it is worth using the scale on the marker pen, or on a ruler to check the 3:1 ratio. Remember that a 10 mm diameter lesion will need an ellipse 14 mm wide, and this in turn means an ellipse 42 mm long.

Once the area has been marked up, infiltrate with local anaesthetic and wait for this to take effect (see Chapter 15).

Figure 17.6  (a) Correct proportions—3:1 ratio, and (b) incorrect proportions for an ellipse.
Making the incision

Using the scalpel

Hold the scalpel in a ‘pen grip’ and not a ‘knife grip’, perpendicular to the skin, and at a cutting angle of about 45° (Figure 17.7). It is important to remember that your hand will tend to hold the scalpel at an angle to the perpendicular. Check that you resist this tendency (unless following the orientation of hair follicles on hair-bearing skin) (Figure 17.8).

Incise the skin boldly and avoid tentative scratching. The scalpel blade should produce clean, linear incisions (Video Clip 17.2a—http://goo.gl/wZJcs). It must not be used like an artist’s pencil to produce a ‘feathered’ edge (Video Clip 17.2b—http://goo.gl/6xvJ7). By always cutting perpendicular to the skin, you will ensure that the cut edge of the wound remains at the very least perpendicular, and at best slightly undermined (see Figure 17.7c).

Following the skin markings

When cutting into skin, the purpose of skin marking will become apparent. It is for good reason that carpenters state ‘Mark twice, cut once.’ With the cut lines already marked out, the surgeon is left with the relatively easy task of ensuring that the blade follows the line (Figure 17.9). There is a natural tendency to cut inside the marked lines. This tendency should be resisted, as the distance between the lesion and the margin will be reduced and an incomplete excision may result. The blade should follow either the centre or the outside edge of the skin marker. Keep to the marks you have made and do not modify the incision when you start to cut.

Figure 17.7 Correct incision technique: (a) ‘pen’ grip; (b) 45° cutting angle; (c) perpendicular wound edge.

Figure 17.8 Incorrect incision technique: scalpel held at an angle to the perpendicular.

Figure 17.9 Following the skin markings (a) correctly and (b) incorrectly.
Follow the skin markings with a smooth action from one apex of the ellipse, maintaining skin tension with your other hand, but avoiding cutting toward your own or your assistant's fingers. Stop a millimetre or two from the second apex (Figure 17.10 and Video Clip 17.3a,b,c). Then do the same on the other side of the ellipse, again stopping just short of the end. Then, with the blade rotated through 180° in your hand, and with the sharp edge toward the cut side, starting from the second apex, finish off the ellipse on both sides. By doing this you reduce the chance of creating a 'fishtail'-shaped incision (Figure 17.11a and Video Clip 17.4). You can also avoid the fishtail effect by taking the first cut from each point toward the centre and then joining each edge up in the middle; this technique is also acceptable.

Figure 17.10 Ellipse excision: (a–c) from one apex, and (d–f) from the other apex. See Video Clips 17.3a—http://goo.gl/7B55P; 17.3b—http://goo.gl/OjCQE; 17.3c—http://goo.gl/MUpB0.
Depth of the incision
The depth of the incision should be the full thickness of the dermis and almost always to the fat layer (exceptions include the back of the hand and the pretibial area, where fat is absent). If the incision does not reach this depth, closure will be under tension and healing will be affected. Your incision should ideally cut through these layers and down to the fatty layer in one clean cut. This is, however, rarely possible except with very delicate skin, and it is often safer to repeat the incisions, gradually cutting down to the fat layer, rather than to risk cutting too deeply with the first incision. Figure 17.12 illustrates an ellipse excision, down to the fat but avoiding blood vessels.

Removing the lesion
Use a skin hook or fine dissecting forceps to hold up the apex of the specimen at one end, and dissect the lesion out along the fat plane (Figure 17.13 and Video Clip 17.5). Take care to avoid structures running superficially in the fat layer (nerves and blood vessels). With the right level of tension on a skin hook, it is almost possible to lift the specimen off the fat layer, just using the scalpel to lightly facilitate this. This level of tension will also help maintain haemostasis.

Some surgeons advocate cutting the specimen from the fat layer with scissors, others with the scalpel. Either will do. If the margins have been cut down to, but not through, the fat layer, it should be easy to divide the lesion from the fat with the aid of gentle traction on the specimen. The more friable the specimen, the gentler the traction should be to avoid tearing it. Ideally, hold the specimen (using either a skin hook or forceps) by the apex. This will avoid any crush artefact of the lesion.

While cutting through the fat layer, use the skin hook or forceps to reflect the specimen back to enable visualisation of the underlying area. In this way, any important structures can be seen and accidental damage avoided. Where such structures are expected, the technique of hydrodissection may be used (see Chapter 7).

As the specimen is removed, pressure should be applied to the wound to reduce bleeding. Place the specimen in a histology pot clearly labelled with the patient’s details, the site of the lesion, and the date. Where multiple specimens are to be removed, use in addition a simple ‘a’, ‘b’, ‘c’ method of labelling, and record this in the patient’s records.
Undermining

Undermining is the technique whereby the surrounding skin is lifted free of the underlying layer prior to wound closure (Figure 17.14 and Video Clip 17.6). This technique may be necessary to reduce the tension caused when the cut edges are brought together for suturing, by allowing the skin edges to move together without compressing deeper planes and the skin to stretch more easily. Undermining is not always required, especially if the existing skin tension is slight, and may be best avoided in areas of anatomical concern (where important structures are located close to the surface). The technique should be undertaken carefully, gently, and usually with blunt dissection, as there is commonly a lack of direct visualisation.

An instrument (ideally blunt-ended, curved iris scissors) is inserted under the edge of the wound, between the dermis and subcutaneous fat. The instrument is inserted closed and parallel to the skin (the aim is not to go deeper, but to follow the existing resection depth) and then opened to bluntly dissect the edges free of the fat.

This process should be undertaken methodically and progressively around the wound edge. In this way, significant structures will be avoided and problems with haemostasis are less likely to arise. The process is facilitated by the use of a skin hook to raise and stabilise the area of skin being undermined. As undermining is more likely to reach the anaesthetised margin, it is advisable to ensure that the patient is asked to report any pain or discomfort while undermining takes place. Undermining should involve the circumference of the wound. Areas of resistance will occasionally need to be cut with the scissors. Ensure, however, you know exactly what you are cutting, and never cut blind.

Once undermining is complete, there should be reduced skin tension when the wound edges are brought together. The wound now requires closure.

Figure 17.14 (a) Diagrammatic representation of undermining technique. Undermining with scissors (b) closed and (c) open. See Video Clip 17.6—http://goo.gl/b3Rv7z.
SKIN CLOSURE

Whatever suture you use to close the wound, you must be able to tie surgical knots, so the next section considers this. This is then followed by a section on different suturing techniques and finally other types of skin closure.

Knot-tying

Knot-tying is an art form in itself. General surgeons perfect the single-handed knot-tying technique, which is essential within body cavities. But although this is impressive to watch, it is unnecessary and usually inappropriate for skin surgery as the use of suture material will be excessive. More appropriate is the instrument-tied knot. This method of tying conserves the suture and also allows very precise knot tension.

The instrument-tied knot consists of using the needle holder to produce the turns or throws of the knot, and to pull the ends through to tie the knot. The act of rotating one end of the suture upon the other is termed a throw. The more throws in one direction, the more the knot will tend to hold, but also the greater the resistance there will be to its being tightened. Rotating a second throw in the opposite direction may be sufficient to tie the knot, but for smooth monofilament material several alternating throws may be required.

The first golden rule of knot-tying is to pull most of the suture material through the skin to the side with the needle attached (avoiding the obvious mistake of pulling the end too far). This should make it easier to grab the end of the suture with the needle holder. If the majority of the length of the suture is not pulled through, the likely result is either a large amount of wasted material or the complication of a loop of suture being pulled through as the knot is tied.

During surgery, knot-tying involves two distinct steps. The purpose of the first step is to secure precise approximation of the wound edges by tying either a two-throw or a three-throw knot. The second step is to lock the suture to prevent slippage. In the description that follows, it is assumed that the surgeon is right-handed.

With the needle holder held in the traditional surgeon’s grip in the right hand and the needle end (but not the needle) of the suture held in the left hand, a number of loops or throws around the needle holder can be made (three throws for monofilament, two throws for braided sutures). This action can take place at a distance from the patient. With plenty of suture material between the left hand and the patient, there is no need to struggle to complete these throws close to the wound. This is best achieved with a combination of the left hand looping the suture around the needle holder with the right hand moving the tip of the needle holder around the left hand.

Next, the jaws of the needle holder (with the throws of suture material around the arms of the needle holder) are directed down by the right wrist to grasp the free end of the suture, close to the skin (Figure 17.15a). This free end is drawn through the throws of the knot by withdrawing the suture holder in the right hand away from the wound (Figure 17.15b).

The resulting knot now needs to be drawn down to the skin. The trick here is to pull the knot tight by pulling the left hand (the needle end of the suture) away from the patient while at the same time advancing the right hand with the needle holder tip toward the skin. This minimizes wastage of the suture material. The aim is to end up with plenty of suture material in your hand and very little wasted at the needle holder tip. If both left and right hands are pulled to form the knot, a large amount of suture material will be wasted. By pulling in the ends in the same orientation as the knot (and perpendicular to the wound), the skin edges can be brought together gently.

When using interrupted sutures, the suturing process should do no more than allow the skin edges to touch; any more tension and postoperative wound swelling (while healing) will cause the sutures to dig into the skin, causing pain and inflammation, and at worst causing the suture to pull through the wound edges.

Once the first throws have been tightened down in contact with the wound, the surgeon will be able to confirm the accuracy of the apposition of the wound edges. If there is excess separation of the wound edges, the two-throw or three-throw knot can be gradually tightened to bring the wound edges closer together. The knotted suture loop should bring together the wound edges without devitalising the tissue encircled by the suture loop.
If the knot slips at this stage, it can be ‘locked’ by bringing one suture end across the wound, under tension so that both suture ends are together (Figure 17.16). The end that has been pulled over in this procedure is now ‘locked’ and will remain so unless it is pulled in the opposite direction to which it was locked.

A second throw, performed counter to the first (Figure 17.17), provides a reasonably stable suture, but with monofilament the knot is not complete.

At least one extra throw, in the same direction of rotation as the first, should be performed. This final throw is the one that allows the knot to be pulled tight without fear of tightening the suture loop and crushing skin. The ends of the suture should then be cut to leave sufficient for any slight knot loosening. Deep-buried sutures will be trimmed very close to the knot, but longer cut ends are necessary for interrupted skin sutures to facilitate both suture location and suture removal in hair-bearing skin.

What precisely do we mean by a throw, and what are the knots?

A single-wrap throw is formed by wrapping the two strands around each other so that the angle of the wrap equals 360° (see Figure 17.15). In a double-wrap throw, the free end of a strand is passed twice, instead of once, around the other strand; the angle of this double-wrap throw is 720° (Figure 17.18). The tying of one or more additional throws completes the knot.
Skin closure

Suturing techniques

This section describes the common suturing techniques. These include interrupted sutures, buried interrupted sutures, mattress sutures, and the continuous subcuticular suture. Whatever the suture type, safe, accurate suturing requires deft handling of the suture holder, delicate handling of the skin, and attention to detail in respect of the knot-tying described above.

The configuration of the knot can be classified into two general types by the relationship between the knot ends and the loop. When the loop and the end of the two throws exit on the same side of the knot or parallel to each other, the type of knot is judged to be square or reef knot (Figure 17.19). The knot is considered to be a granny knot if the loop and end exit or cross different sides of the knot (Figure 17.20).

A simple code has been devised to describe a knot's configuration. The number of wraps for each throw is indicated by the appropriate number. The relationship between each throw being either crossed (granny) or parallel (reef) is signified by the symbols × and =, respectively. In accordance with this code, a square (reef) knot is designated 1 = 1 and a granny knot, 1 × 1. From this it should be clear what is meant by a 2 × 2 × 2 knot without giving the knot a name. All surgical knots can be defined by this international language. For most monofilament sutures, the knot will be 3 = 1 = 1.

Figure 17.19  (a) Tying a reef knot. (b) A reef knot.

Figure 17.20  (a) Tying a granny knot. (b) A granny knot.

Suturing techniques

Always close in layers. Wherever possible, skin wounds should be closed in layers using buried interrupted sutures, followed by either interrupted or subcuticular sutures. This will reduce skin tension and the chance of the wound stretching, or dehiscence.
Interrupted skin sutures

Needle position in suture holder

As described earlier in the chapter, the needle should be held at the tip of the needle holder and at 90° to it, with the needle no more than two-thirds along its length to avoid grasping the hollow, crushable, and bendable section of the needle (see Figure 17.3a).

Passing the needle and suture through the skin

When suturing through skin, it is important that the needle is inserted at 90° to the skin and subsequently emerges at 90° to the skin. This ensures that any tension is borne by the full thickness of the skin and there is less chance of the suture cutting through the skin.

For all but the smallest of wounds, it is best to undertake each suture in two ‘bites’ (Figure 17.21 and Video Clip 17.8a,b) as follows:

- Insert the needle through one side of the wound, rotating the suture holder as it passes through the skin, the rotation mirroring the curve of the needle.
- Grab the inserted needle with either the suture holder or your forceps.
- Reposition the needle on the suture holder and then match the size of ‘bite’ on the other side of the wound with the needle emerging at 90° to the skin (Figure 17.21b,c).

As the needle point emerges through the skin, it will again need to be held by the needle holder or forceps. At all times, avoid holding the needle by the very tip as the tip of the needle is very easily bent or broken. This is why it is often better to insert the suture in two small ‘bites’ one side at a time than one big ‘bite’. The needle needs to be drawn or rotated through the skin in an arc, mirroring its curved profile (Figure 17.21e).

At all costs, avoid pulling the needle straight through the skin surface. At the very least, the needle will bend; at worst, it will break or tear the skin. As the needle exits the skin and the suture material begins to appear, the needle point should almost be touching the insertion point. In this way, the needle has executed an almost perfect circle. Sutures inserted and withdrawn in this method require very little effort to complete. The knot is then thrown (see above), and sufficient tension is applied across the wound to achieve wound edge apposition.

Suture placement

The surgeon repeats the suture process described above along the length of the wound (Figure 17.22). Suture placement should be sufficiently spaced to bring the edges together without the wound gaping in between. Ideally, all the knots should be located to one side of the wound. This ensures that the line of the wound is free from knots, the wound is more easily cleaned, and the sutures are more easily removed. The suture placements shown in Figure 17.23 are incorrect.

Figure 17.21 (a) Passing the needle through the first skin edge. (b,c) Bringing the needle through the second side of the wound. (d) Showing the whole path of the needle and the suture. (e) The circular arc of the needle. See Video Clips 17.8a—http://goo.gl/Kqfrv and 17.8b—http://goo.gl/6Cebr.
**Progressive halving**

Some surgeons advocate placing the first suture in the centre of the wound and then inserting subsequent sutures equidistant on each side, so-called 'progressive halving' (Figure 17.24 and Video Clip 17.9), the rationale being to ensure that the wound closes symmetrically. The drawbacks are that this places the first suture under the greatest of tension, it can make the first knot difficult to tie, and it is more likely to cause the suture to tear through the skin. A skilled skin surgeon should be able to judge suture placement to avoid unequal closure. Progressive halving is of most use in very small procedures, but in larger wounds, it is usually better to start suturing at one end and work along the wound, placing sutures equally to avoid excessive skin tension.
**Dog ears**

A ‘dog ear’ occurs either when the sutured edges are of different lengths or when the surgeon closes an ellipse of significantly less than 3:1 length-to-width ratio. Minor differences in wound edge length can usually be accommodated without causing a dog ear (see Chapter 25 for more information on crescentic excisions). The skill of closing such a wound is to space out the sutures so that a dog ear does not occur.

Some surgeons advocate cutting a lesion out with a circular excision, then judging where the least skin tension exists (by looking at the shape of the wound) and then closing the centre of the wound to follow that orientation, followed by cutting out the two dog ears that are created. Dog ears may therefore occur by design, as a result of different tensions between the sides of the wound or as a consequence of suture placement. It is easier to remove a dog ear that forms at the end of a wound than one that forms in the middle (a good reason for closing a wound by suturing from one apex to the other, and not from both apices to the middle).

The technique used to remove the defect is simple: the incision is extended to remove the raised dog ear of skin. In order to do this, a fine skin hook should be used to pull the raised ‘tented’ section of skin across and down to one side, against the normal skin. A cut is then made along the base of the ‘tent’. The cut material is then lifted up and the whole of the flap of skin pulled across to the other side; the remaining ‘base of the tent’ is cut off in a similar way, leaving a small straight incision to suture (Figure 17.25).

When removing the dog ear, care needs to be taken to avoid either cutting outward beyond the new apex (creating a ‘fishtail’ scar) or cutting inward and through a suture (see Video Clip 17.10—http://goo.gl/HYYsC).

---

**Buried sutures**

Buried sutures should be the mainstay of skilled skin surgery for all but the smallest of wounds, or for certain anatomical locations (such as the dorsum of the hand, the pre-tibial area, and some head and neck locations). To date, there has been little published evidence to support their superiority over simple skin sutures (Al-Abdullah et al., 2007), but there is a wealth of personal experience, especially with the newer monofilament absorbable sutures. The aim of buried sutures is not only to eliminate dead spaces under the skin (spaces that facilitate postoperative bleeding and potential wound infection), but to also provide support to the skin as it goes through the wound healing phases.

The aide-memoire for inserting buried sutures is: ‘deep to superficial; superficial to deep’. The needle is first inserted into the deep aspect of the dermis and exits superficially at the level of the epidermis on one side of the wound (Figure 17.26 a,d). From here, the needle is inserted superficially into the epidermis on the opposite side of the wound, at the same depth as the first side, and exits the deep aspect of the dermis, again at the same depth as the other side (Figure 17.26e).

The knot is thereby tied deep to the dermis, i.e., it is a buried knot. With a buried knot the ends need to be pulled tight along the line of the wound (and not across the wound as with interrupted skin sutures; Figure 17.26g).

With skill and practice, it is possible to close nearly all wounds (except for those mentioned before) with buried sutures, thereby reducing the need for skin sutures. It is important that the knot ends are cut short to minimise the bulk of suture material left to be absorbed.

---

![Diagrammatic representation of correcting a dog ear.](http://www.surgical-techniques.com/loose strategie)
**Skin closure**

Figure 17.26  Buried sutures: (a) the first suture is inserted from deep to superficial and (b) is then continued from superficial to deep; (c) the knot is tied; (d) the second suture is inserted from deep to superficial and (e) is then continued from superficial to deep; (f) the second suture before knot-tying; (g) tightening a buried knot.
**Mattress sutures**

This form of suture utilises a ‘loop’ of skin on each side of the wound to achieve greater tensile strength and also to help eliminate dead spaces (Figure 17.27). Mattress sutures may be horizontal or, more commonly, vertical. Although this is a useful suture technique to be able to perform, the cosmetic outcome is not usually as good as for other types of sutures, so these sutures are less widely used than the others described in this text.

**Horizontal mattress sutures**

The horizontal mattress suture is effectively two linked interrupted skin sutures (Figure 17.28). The first part is exactly as an interrupted suture, but instead of throwing a knot, the needle is reinserted at a suitable distance from the first exit point and exits at an equal distance on the other side of the wound. The strength is gained from spreading the tension across the skin between the two sutures. This can be useful where there is little dermal thickness (e.g., the shin).

**Vertical mattress sutures**

The initial ‘bite’ taken by the needle through the skin is larger than that used for a simple interrupted skin suture. The needle is inserted further from the incision edge, and the depth of the insertion is greater. The needle is withdrawn from the depth of the wound before an identical, large ‘bite’ is taken into the opposite side. After this, the direction of needle travel is reversed, and a traditional interrupted skin suture is inserted with smaller ‘bites,’ but in line with the deeper ‘bites.’ The ends are then tied under tension to bring the wound edges together (Figure 17.29 and Video Clip 17.11).

Any skin tension is taken up between the deeper and superficial ‘bites’ rather than between the superficial ones and the wound edges. This reduces the likelihood of the suture tearing through the skin, increases the amount of tension that can be used to bring edges together (for difficult to close wounds), and helps eliminate dead space.

So why isn’t this closure used for all skin wounds? First, it doubles the number of skin penetrations by the suture material, thereby potentially doubling the number of puncture scars and entry points for infection. Second, as the edges come together and the knot is tensioned, the wound takes on a marked ‘everted’ appearance, with a noticeable ridge (which may take a little while to subside after the sutures have been removed; Figure 17.28h). Although experience shows that this everted wound produces a wound of great strength, it can also appear quite disfiguring to the patient. Patients need to be reassured that the wound will flatten as it heals.

Third, mattress sutures need to be removed, and when they are removed both superficial and deep wound support is removed. As buried sutures can take the place of a mattress skin suture in many locations, and provide continued wound support after any skin sutures have been removed, they are usually the favoured skin closure.

For all these reasons, mattress sutures are often best reserved for those areas where their cosmetic appearance is less visible, or where buried sutures can be difficult to insert (e.g., the scalp).

*Figure 17.27* Diagrammatic representation of mattress sutures: (a) horizontal; (b) vertical; (c) cross-section of a vertical mattress suture.

*Figure 17.28* Horizontal mattress sutures (arrowed) with alternate skin sutures.

*Figure 17.29* Vertical mattress sutures.
Figure 17.29  Vertical mattress suture: (a) inserting large 1st 'bite' on one side of the wound; (b) taking the needle from the large 1st bite; (c) inserting equally large bite on the other side of the wound; (d) taking the needle from other-side large bite; (e) inserted needle for smaller second bite; (f) tying the knot; (g) three completed mattress sutures; (h) everted edge of mattress suture wound. See Video Clip 17.11—http://goo.gl/3XAN0.
Continuous subcuticular sutures

This form of skin closure will be familiar to many hospital doctors: large incisions can be closed with a running, subcuticular suture of nylon utilising a straight needle. Although the principle is the same for skin surgery, the smaller incisions require the use of curved rather than straight needles. This form of closure is only suitable where there is little skin tension, otherwise the suture risks being exposed by wound edge separation.

In its simplest form, the suture needle is inserted through skin just distant to one of the apices of the wound. The needle exits, within the epidermis of the wound, close to the apex. From here, it is inserted horizontally into the opposite wound edge and then out again (Figure 17.30 and Video Clip 17.12a,b).

The exit point on one side corresponds to the next insertion point on the other side. The wound is thus closed with a number of S-shaped loops from side to side. When the second apex is reached, the suture needle exits the skin at a distance similar to the distance of the entry point from the first apex. The ends of the suture can then be tied together. An alternative to tied ends is the use of small crimped metal clips to hold the suture ends.

Once the wound has gained strength (7–10 days), the suture can be cut and withdrawn, although on longer wounds this can be problematic, due to friction. The tip here is to allow one S-shaped suture loop through the skin half way, enabling the resultant suture to be cut in two and withdrawn from each side when it is time for removal.
Additional tapes (such as Steri-Strips™) can be applied across the wound. A variation on this subcuticular suture is to use absorbable material, which allows the suture to remain in situ. If the ends are brought out through the skin and tied, they will need to be trimmed under tension (after the same time interval that the non-absorbable equivalent is pulled out and removed).

A final variation on this theme is to use an entirely buried absorbable suture in two layers. The first layer closes the wound with buried, interrupted, absorbable sutures. As the final suture (at one apex of the wound) is tied, only the loose end is cut. The still attached suture needle is then inserted from the knot in the deep layer up to the epidermis close to the apex. From here, a running subcuticular suture is completed as normal. The final end of the suture can then be trimmed, under tension, so that the whole suture remains buried.

If there is concern that the wound might open slightly, thereby exposing the suture material, the needle can be taken out through the skin and then reversed and reinserted back on itself (effectively producing a loop under the skin) prior to exiting the skin one last time. After trimming the suture, it will be able to provide some extra tensile support to the wound through this doubled-back path. This double-layered closure with absorbable sutures is particularly useful where the wound is likely to stretch and the dermis is sufficiently thick, for example on the back.

The main drawback with a continuous subcuticular suture wound closure is that it effectively seals the wound edges together. Whereas blood or serous fluid can leak out between interrupted sutures, this is not possible with a continuous subcuticular suture. Therefore avoid using this closure when bleeding may be more likely to occur, or ensure that adequate pressure bandaging is used postoperatively.

**Other skin closures**

**Skin adhesives**

Several adhesives have been developed for wound closure. One substance, cyanoacrylate, has been used for over 25 years. Although it can be useful for allowing wound edges to be held together, the material will not hold wound edges that are under tension. It is therefore best for incisions, lacerations, or where buried sutures have been used (Figure 17.31).

Subcutaneous (buried) sutures should be used to take the tension off the skin edges prior to applying the cyanoacrylate. Subcutaneous suture placement will aid in evertting the skin edges and minimise the chances of deposition of cyanoacrylate into the subcutaneous tissues. Some cyanoacrylate glues can induce a substantial inflammatory reaction if applied subcutaneously. If used superficially on the epidermal surface, little problem with inflammation occurs. Indeed, cyanoacrylate used to be used as a barrier

![Figure 17.31](image_url)

(a) Adhesive applied to the wound surface. (b) Closing a wound on the scalp with finger pressure. (c) The same wound as in (b) immediately after closure. (d) A 4-year-old child with a laceration beneath the chin. (e) The same child as in (d) 3 months later. (Images (d, e) provided courtesy of Dr David Watson, Lewisham Hospital.)
against common bacteria, including certain staphylococci, pseudomonads, and *Escherichia coli*.

Fibrin-based tissue adhesives can be created from autologous sources or pooled blood. They are typically used for haemostasis and can seal tissues. Although they do not have adequate tensile strength to close the skin, fibrin tissue adhesives can be used to fix skin grafts or seal cerebrospinal fluid leaks.

**Staples**

Staples provide a quick method of wound closure (Figure 17.32), and studies have shown decreased wound infection rates with them. Staples are composed of stainless steel, which is less reactive than some traditional suture materials. The act of stapling requires minimal skin penetration so potentially fewer microorganisms are carried through the skin. Staples are more expensive than traditional sutures and also require great care in placement, especially in ensuring the eversion of wound edges. With proper placement, the resultant scar is cosmetically equivalent to that of other closure techniques.

However, the removal of staples, like skin sutures, leads to a loss of all wound support, and because of their bulk they are less suitable for those areas where buried sutures and closure by layers is difficult (the scalp, pretibial region, and some facial areas). In addition, they cannot be used to bring together wound edges in the same way that a tightened skin suture can. For these reasons, their use is almost entirely limited to closing surgical incisions rather than excisions.

**Tape**

Closure using adhesive tapes was first described in France in the 1500s, when Pare devised strips of sticking plaster that were sewn together for facial wounds. This method allowed the wound edges to be joined and splinted together. The porous self-adhesive sterile paper tapes (e.g., Steri-Strips™; Figure 17.33) used today are reminiscent of these earlier splints. They can be used to ensure proper wound apposition and to provide additional wound reinforcement. These tapes can be used in addition to skin sutures or with deep sutures, and instead of skin sutures or even alone where skin tension is minimal (e.g., incisions and lacerations).

Skin adhesives (e.g., OpSite® spray or tincture of Benzoin; Figure 17.34) aid tape adherence.

### REFERENCES

LINKS TO VIDEO CLIPS

VC 17.1: Attaching the scalpel blade
http://goo.gl/0UUqJ

VC 17.2a,b: Using the scalpel
http://goo.gl/wZJcs
http://goo.gl/6xvJ7

VC 17.3a,b,c: Ellipse excision
http://goo.gl/7B55P
http://goo.gl/OjCQE
http://goo.gl/MUpB0

VC 17.4: Fishtail incision
http://goo.gl/VUEeA

VC 17.5: Excision down to fat
http://goo.gl/pTZLy

VC 17.6: Undermining
http://goo.gl/b3Rx7z

VC 17.7: Knot-tying
http://goo.gl/glkNr

VC 17.8a,b: Interrupted sutures
http://goo.gl/Kqfrv
http://goo.gl/6Cebr

VC 17.9: Progressive halving
http://goo.gl/ZDzp5

VC 17.10: Dog ears
http://goo.gl/HYYsC

VC 17.11: Vertical mattress suture
http://goo.gl/3XAN0

VC 17.12a,b: Subcuticular suture
http://goo.gl/ku2TD
17.12b—http://goo.gl/UkmJ