Suturing Techniques

Overview

Inserting each suture correctly is the key to good wound closure. Here you will learn how to place a suture and how to avoid damage to the wound edges.

You should be familiar with how to use the needle holder and suture needle to insert a suture with minimal tissue damage.

This module covers:

- simple interrupted
- continuous
- subcuticular
- mattress and pulley sutures

and has plenty of tips on how to overcome common problems.

1 General Principles

Suture material is a foreign body implanted into human tissues and it elicits a foreign body tissue reaction. There are key principles to follow in order to minimise trauma when suturing:

Always handle tissues gently. Rough handling causes microscopic damage to the wound edges. This leads to ischaemia, poor healing and an unsightly scar. Avoid touching the wound edge whenever possible.

1.1 Choosing your suture

Your choice of suture will depend on the area of the body, the patient's age and health and the type of closure.

In general, monofilament sutures elicit less tissue reaction than braided (multifilament) sutures, and non-absorbable sutures elicit less tissue reaction than absorbable sutures.

For more detailed information on sutures and their properties, go to the Needles and Sutures module.

1.2 Mounting the needle in the needle holder

Mounting the needle correctly in the needle holder is essential to good suturing technique. Grasp the needle on the central flat section, about two thirds of the way from the point, with the tip of the needle holder's jaws. If the needle is too near the hinge, the jaws will get in the way.

Angle the needle slightly forward in the instrument's jaws. This conforms to the natural direction of

your hand when inserting a suture and is more comfortable.

Squeeze the handles together to engage the ratchet and lock the needle in position. To release, squeeze the handles again and then separate fractionally.

1.3 Inserting the suture

Always insert and remove a curved needle along the path of its curvature to ensure minimal trauma. Consider the needle's path as a circle that begins before the needle touches the skin and continues after leaving it.

The needle should follow this curved path as it enters and passes through tissue. Continue the circular path as you remove the needle.

Ensure that the needle takes an adequate bite on each side of the wound, passing through all layers of the skin and bringing the edges together without tension.

It is usually best to pass the needle through each edge of the wound separately, repositioning the needle in the needle holder before taking the second bite.

An experienced surgeon using an adequate needle in a small wound can take both sides in a single bite.

1.4 Eversion

When suturing the edges of a wound together, it is important to evert the skin edges - i.e. to get the underlying dermis from both sides of the wound to touch. For the wound to heal, the dermal elements must meet and heal together.

If the edges are inverted - i.e. the epidermis turns in and touches the epidermis of the other side - the wound will not heal as quickly as you would like and a depressed and ugly scar may form.

Avoid inverting the edges by ensuring that your needle tip is directed slightly away from the wound as it enters the skin and subcutaneous tissue.

Aim to evert the wound edges slightly by taking a larger bite of the deeper part of the tissue. As the needle emerges, support the skin next to it with dissecting forceps. Allow for postoperative swelling of the wound edge and do not tie the sutures tightly.

2 Things to avoid

2.1 Failure to evert

Failure to evert the wound may lead to an ugly depressed scar.

2.2 Mounting the needle incorrectly

Holding the needle too near its tip prevents you from taking a satisfactory bite because the needle holder's jaws will get in the way.

Holding it too near the swaged end may cause the needle to buckle or snap.

2.3 Superficial bites

Avoid taking small, superficial bites - this leads to dead space within the wound. Dead space permits the accumulation of blood or serum which can act as a focus for infection and result in delayed healing.

2.4 Incorrect needle path

A curved needle being forced along a straight path can cause a lot of harm. A strong needle will cause tissue damage, while a weak needle will buckle.

Consider the needle's path as a circle that begins before the needle touches the skin and continues after leaving it.

3 Simple interrupted sutures

Simple interrupted sutures are suitable for most wound closures. A series of independent sutures brings the wound edges gently together. The needle takes an adequate bite on each side of the wound, passing through all layers of the skin.

Sutures should be placed at regular intervals and should not be tied too tightly.

3.1 Principles

An instrument tied knot is generally recommended for simple interrupted sutures. For optimum security, we also recommend that you always use a surgeon's knot, rather than a standard reef knot. This variant to the reef knot involves taking the suture twice around the needle holder for the first throw only.

If the wound is short and the sides of equal length, start suturing at one end and go to the other.
If the wound is long or the sides are unequal, use 'progressive halving'. Find the midpoint of each side of the wound and insert your first suture. Then insert sutures at the midpoint of each of the two resulting halves. Repeat this process along the whole wound. The extra length of the longer side is distributed equally along the wound. Even fairly large discrepancies become unnoticeable.
Aim to make the distance between sutures about the same as the distance between the wound edge and the point at which the needle enters or leaves the skin. This is usually between 3 and 5 mm.
Allow for postoperative swelling of the wound edge and do not tie the sutures tightly. The skin edges

should come together without bunching up and the sutures should be tied so that there is room for closed forceps to get under them.

The finished result should look neat and symmetrical. Suture ends should be cut about 0.5cm long to allow enough length for grasping when removing.

Although we recommend you generally tie your interrupted sutures with an instrument, there will be occasions when you will want to tie by hand. This is more wasteful of suture material, but it does allow you to hold both suture strands under tension and to control slippage. If you are tying by hand it also makes more sense to use a larger hand-held needle to avoid having to put down your needle holder at the end of every suture.

To demonstrate the hand held technique here, our surgeon is using a 90mm curved hand-held cutting needle and a 2/0 silk suture. This is the type of suture you would use when fastening a drain. Note, however, that silk should generally be avoided when closing skin because the synthetic alternatives produce much better results.

3.1.1 Instrument tie on skin pad model

The needle takes an adequate bite on each side of the wound, passing through all layers of skin and emerging precisely opposite the entry point.

After looping the suture around the needle holder, the needle holder's jaws pick up the free suture end and the throw is pulled flat. The suture is then looped around the needle holder in the opposite direction and the direction of pull is also reversed to ensure that the whole knot lies flat when tightened.

For a secure suture, up to 3 more throws are fashioned, each time reversing the direction of loop and pull. The suture ends are then cut about 0.5cm long to allow enough length for grasping when removing.

3.2 Practise

When first learning to tie interrupted sutures, we recommend you pass the needle through each edge of the wound separately, repositioning the needle in the needle holder after the first bite before taking the second one. This will help you to ensure that the entrance and exit point of the needle are precisely opposite and that your finished suture is at right angles to the incision. To practise this method, go to the Beginner topic in this section.

A more experienced surgeon suturing a straightforward incision will usually take both sides in a single bite. To practise this method, go to the Advanced topic in this section.

3.2.1 Setting up the skin pad jig

- To ensure a secure fix, make sure the work surface is smooth. Rough surfaces will not work with the sucker feet.
- Make sure that the jig will be properly oriented and comfortably positioned in front of you before you secure it in place.
- Moisten both sucker feet with a little water, place the jig on the work surface and push down along the centre of it.
- Make sure the feet have stuck securely by trying to move the jig.
- Insert the skin pad. You are now ready to start practising.
- To easily remove the jig, completely slide the white part off to one side, leaving the sucker feet in place. Peel the sucker feet off individually. Slide the sucker feet back into the groove under the jig.

3.2.2 Beginner

Using an atraumatic curved needle, grasp the needle on its flat section, about two thirds of the way from the point, with the tip of your needle holder's jaws. Angle the needle slightly forward in the instrument's jaws and take a bite on the first side of the wound ensuring that the needle follows the line of its curvature.

Remove the needle and reposition in the needle holder before taking a corresponding bite on the other side of the wound.

Pull the suture through so that only a short free end remains, then loop the end with the needle attached to it around the needle holder. If your suture material is very springy, we recommend that for this initial throw only you loop it twice around the needle holder as shown here. This will help the throw lie flat and form a more secure surgeon's knot. Now grasp the free end of the suture with the needle holder's jaws and pull it towards you to tighten.

Make a second throw by looping the suture once around the needle holder in the opposite direction to the first throw. Now grasp the free end of the suture with the needle holder's jaws and tighten, this time pulling it away from you. By changing the direction in which you loop and tighten each throw you are ensuring that a reef knot is formed.

Then make three further throws, changing both the direction of throw and pull at each stage.

Cut the suture ends with scissors, leaving the ends about 0.5 cm long.

3.2.3 Advanced

Using an atraumatic curved needle, grasp the needle on its flat section, about two thirds of the way from the point, with the tip of your needle holder's jaws. Angle the needle slightly forward in the instrument's jaws and penetrate the skin at a 90 degree angle, taking an adequate bite and passing

through all layers of the skin. Steady the exit side with dissecting forceps and watch the needle beginning to tent up the skin. Follow the curvature of the needle and emerge on the other side of the wound, precisely opposite the point at which you entered and at the same distance from the wound edge.

Pull the suture through so that only a short free end remains, then loop the end with the needle attached to it around the needle holder. If your suture material is very springy, we recommend that for this initial throw only you loop it twice around the needle holder, as shown here. This will help the throw lie flat and form a more secure surgeon's knot.

Now grasp the free end of the suture with the needle holder's jaws and pull it towards you to tighten. Make a second throw by looping the suture once around the needle holder in the opposite direction to the first throw. Now grasp the free end of the suture with the needle holder's jaws and tighten, this time pulling it away from you. By changing the direction in which you loop and tighten each throw you are ensuring that a reef knot is formed.

Then make up to three further throws, changing both the direction of throw and pull at each stage.

Cut the suture ends with scissors, leaving the ends about 0.5 cm long.

3.2.4 Hand tied interrupted suture

Take the first bite exactly as you would for an instrument tied suture. Pull the suture through with your left hand and grasp the shorter end with your right. Make the first throw with your right index finger, pulling the short end towards you and pushing the long end away. Snug the knot down with your right index finger.

Form the second throw with your right middle finger and tighten in the opposite direction, i.e. pulling the short end away from you. Again, snug the knot down with your right index finger.

Continue to form alternate index and middle finger throws, each time tightening in the opposite direction and snugging down with your index finger. Cut the suture ends at a length of approximately 0.5cm.

3.3 Things to avoid

Many people experience difficulties when they are learning to close wounds. This section provides examples of common problems with interrupted suturing, together with advice on how to solve them.

3.3.1 Knot fails to bed down

Monofilament sutures have inherent memory, which makes them springy and resistant to being straightened after being coiled up in their packet. This may mean you have trouble getting your first throw to bed down and lie flat. A way to remedy this is to use a surgeon's knot for your first throw, ie.

loop the suture twice around the needle holder, rather than once. This adds friction which will give extra grip and prevent the knot from coming undone.

An alternative to using the surgeon's knot is to ‘tweak’ the first throw. Pull firmly on the suture end in your non-dominant hand while giving a sharp tug towards it with the needle holder in your dominant hand. This secures the knot temporarily while you make the second throw.

3.3.2 Incorrect suture spacing

Irregular intervals between sutures look untidy and unplanned.

Avoid placing sutures too close together. Crowded sutures produce too much tension and interfere with healing.

Excessively wide spacing allows subcutaneous fat to bulge through. It also puts undue tension on the few sutures present.

A useful rule of thumb is to make the distance between the sutures the same as the distance between each edge and the position of the suture bite. This is usually between 3 and 5 mm. If the wound is long, or the sides are unequal, use “progressive halving”. Find the midpoint of each side of the wound and insert your first suture. Then insert sutures at the midpoint of each of the two resulting halves. Repeat this process along the whole wound.

3.3.3 Uneven or inadequate suture bites

Uneven bites on each side of the wound produce an asymmetrical closure. This is caused by misjudging the entry and exit points when suturing.

Ensure that entry and exit points are at the same distance from the wound. Steady the exit side with dissecting forceps and watch the needle beginning to tent up the skin. Adjust it if necessary before it emerges.

Too superficial a bite will bring the skin edges together but will leave dead space beneath. Dead space permits the accumulation of blood or serum which can act as a focus for infection and result in delayed healing.

Tiny bites increase wound edge tension without improving closure, while a very superficial bite may allow the suture to tear out. Ensure that you take an adequate bite of tissue on each side of the wound, passing through all layers of the skin and bringing the edges together without tension.

3.3.4 Slanting sutures

Sutures which are not at right angles to the long axis of the wound exert a shearing force on the wound edges. Irregular slanting sutures also look untidy.

Slanting sutures are caused by failing to ensure that the entrance and exit point of the needle are precisely opposite.

Ensure that sutures are placed at right angles to the long axis of the wound. A useful rule of thumb is to make the distance between sutures the same as the distance between each edge and the position of the suture bite.

3.3.5 Wound edge inversion

As the wound heals, its edges sink down slightly. If the edges are inverted (i.e. the epidermis turns in and touches the epidermis of the other side), a depressed and ugly scar will form.

Ensure that the wound edges are everted by taking a larger bite of the deeper part of the tissue.

3.3.6 Suture too tight/ too loose

All wounds swell after suturing. Tight sutures will become even tighter after 24 hours, causing pressure on the crucial wound edges. This leads to ischaemia, poor healing and bad results.

Allow for swelling by deliberately tying sutures so that closed forceps can get under them. The skin edges should come together without bunching up. This allows for postoperative swelling. If a suture is too tight, cut it out and reinsert it.

If the suture is too loose it will not appose the wound edges at all. This often happens if the knot comes loose after your initial throw.

Gently tighten the knot if possible. If this does not work, cut out the suture and reinsert it. Aim to appose the wound edges neatly with the minimum of tension.

3.3.7 'Dog ear'

Sometimes one side of the wound is longer than the other. Inserting sutures progressively from one end will create an excess of tissue at the other. This is a 'dog ear'.

Progressive halving minimizes the effect of a discrepancy in length. Find the midpoint of each side of the wound and insert your first suture. Then insert sutures at the midpoint of each of the two resulting halves. Continue this process along the whole wound.

The extra length of the longer side is distributed equally along the wound. Even fairly large discrepancies become unnoticeable.

3.3.8 Wrong suture thickness

Too fine an interrupted suture will cause a cheese-wire effect on the skin edge by cutting in.

Too coarse an interrupted suture will be difficult to tie neatly and will cause unnecessary tension on the

wound.

You will generally use sizes in the middle range: 3-0 to 5-0. On areas where cosmetic concerns are not of the utmost importance, 3-0 or 4-0 sutures are best, because the larger size makes the technique easier and the thicker sutures are stronger.

It is best to use 5-0 or 6-0 sutures on the face in order to minimise scarring. The tendency is also to use smaller sutures on children because of their more delicate skin.

3.3.9 Too long a loop of suture

Leaving too long a free end wastes suture material. This can also lead to the formation of a troublesome loop when tying.

Pull the suture through until only a short length protrudes, then tie the knot.

Cut suture ends about 0.5cm long to allow enough length for grasping when removing.

3.3.10 Wound edge tension

You must avoid suturing under excessive tension as this will lead to ischaemia and poor healing. The skin edges should come together without bunching up.

Progressive halving can help to distribute tension evenly over the length of the wound. Find the midpoint of each side of the wound and insert your first suture. Then insert sutures at the midpoint of each of the two resulting halves. Repeat this process along the whole wound. The extra length of the longer side is distributed equally along the wound. Even fairly large discrepancies become unnoticeable. A temporary suture at the midpoint of the wound can be useful. At the end of the procedure, remove this initial suture and replace it.

Judicious undermining of the wound edge with a scalpel blade held flat may sometimes be needed to relieve tension. This technique is covered in detail in the chapter on Undermining which you'll find later in this Suturing Techniques module.

In extreme cases, a pulley stitch may be useful. A pulley suture starts like a mattress suture with a deep bite on each side and a more superficial one nearer the wound edge. Then the needle is passed back through a loop of suture and tied on the other side. This acts like a pulley, distributing wound tension evenly and bringing the wound edges together while further sutures are inserted. This technique is covered in detail in the chapter on Mattress and Pulley sutures which you'll find later in this Suturing Techniques module.

4 Continuous sutures

Continuous (also known as running) sutures are made by passing the needle from side to side (across

the wound) multiple times before finally tying the suture.

Although it will not always be possible, it is advisable to have an assistant to help you if you are using this method of suturing, in order to maintain the tension on the suture.

4.1 Principles

The first suture is inserted in exactly the same way as an interrupted suture, at right angles to the skin edge, and tied using a standard reef knot. Then the short end is cut. If you have an assistant, the long end of the suture is passed to them at this point. Their role is to follow, keeping the tension even and holding the trailing suture out of the way.

The distance between sutures should be exactly as for interrupted sutures (between 3 and 5mm). Work along the wound, making sure to maintain equal distance and tension between sutures, but varying the width of each stitch to prevent the fascia tearing along the line of the fibres.

After the final suture has been inserted, one loop is left long and tied off using a hand tied Aberdeen knot. The index finger and thumb of one hand display the loop, then grasp and pull through the free suture end. This forms a new loop and the old one is tightened and eliminated. Once the knot has been tied, the suture material can be cut.

Continuous sutures are appropriate for long wounds where wound tension has been minimized with properly placed deep sutures and where approximation of the wound edges is good.

Continuous sutures are also indicated to quickly control bleeding in the absence of other bleeding control measures, for example with a profusely bleeding scalp wound.

Theoretically, less scarring occurs with continuous sutures compared with interrupted because the sutures are placed again and again without tying each individual one. However, although there are less knots, the number of needle insertions remains the same. Continuous closure is quicker to perform than interrupted and can lead to more rapid re-alignment of wound edges. Disadvantages include possible cross-hatched scarring if the sutures are pulled too tight, difficulty in making fine adjustments along the suture line, and puckering of the suture line when the stitches are placed in thin skin.

For continuous sutures, your suture length should be a minimum of four times that of the incision so that you are able to complete the closure without using excessive tension.

If you are using monofilament sutures, which can be springy due to their inherent memory, there is a risk that you will experience slippage when tying the loop and suture end together to complete the suture line - even when using an Aberdeen knot. A more secure technique when using monofilament sutures is to start a continuous suture at each end of the wound and then tie the two ends together in the middle with a standard knot. An example of when you might use this technique would be closure of the abdominal wall musculature.

4.2 Practise

Begin by inserting a standard interrupted suture. Tie off using a standard reef knot, but trim off the short end only. Pick up the long end with your needle holder ready to insert the next suture.

Insert a second suture in exactly the same way as the first and pull the thread through. Continue to work along the wound edge in this way, maintaining a distance of 3-5mm between sutures and keeping moderate tension at all times to prevent weak areas in the closure. Vary the width of each stitch to minimise the risk of the fascia tearing along the line of the fibres. When you insert the last suture, don't pull the thread all the way through but leave a loop ready to tie an Aberdeen knot.

Display the loop between your right index finger and thumb and hold the free end of the suture with your left index finger and thumb.

Use your right index finger and thumb to grasp the free end through the loop. Pull it through and form a new loop, keeping the free end in your left hand so that the old loop is flattened and eliminated.

Repeat this process until you have completed four throws. Finally pass the free end through the loop, tighten down and then cut the suture thread to complete your Aberdeen knot.

4.2.1 Alternative technique for springy monofilament

This technique will minimise the risk of slippage if you are using monofilament sutures which can be very springy.

Place your first suture at one end of the wound, tying with a surgeon's knot but trimming off the short end only. Continue with equally spaced continuous sutures, varying the width of each stitch to minimise the risk of the fascia tearing along the line of the fibres. Stop when you reach the midpoint of the wound.

Now take another suture and repeat this process starting at the other end of the wound. Place equally spaced continuous until you reach the midpoint again. Cut one of the suture ends leaving enough length to form the short end of your tie. Now tie the two sutures together using a surgeon's knot.

4.3 Things to avoid

In this section we will show examples of common problems with continuous closure, together with suggestions for solving them.

4.3.1 Too much tension

Pulling the suture and tying too tightly, as shown here, will produce excessive tension and a "purse-string" effect. Tissues may swell in the first few hours after surgery, tightening the suture line even further.

You should aim to approximate the wound edges comfortably, and no more.

With a wider wound where there is significant tension pulling the wound edges apart, you may find it difficult to close the wound using continuous sutures, as shown here. Even with a double throw on the first knot, the knot fails to bed down and a triple throw is necessary to achieve this. This is an early indication that the closure may fail. As the closure progresses, it becomes more evident that the edges can only be approximated if the suture is pulled through too tightly. The finished result is an ugly, purse string effect with a gap in the closure.

In cases like this where tension is too great, use interrupted sutures instead to close the wound and progressive halving to help distribute the tension equally across the wound.

4.3.2 Too little suture material

Make sure your suture length is adequate. Using too short a suture can be the reason why you have too much tension and will result in gathering or puckering of the wound.

The suture length should be a minimum of four times that of the incision.

4.3.3 Slippage with monofilament sutures

When completing a continuous suture line, you finish with a loop and an end to tie together. When using springy monofilament sutures, there is a danger of slippage, even when using an Aberdeen knot. A more secure technique is to start a continuous suture at each end of the wound and then tie the two ends together in the middle with a standard knot.

4.3.4 Too fine a suture

Too fine a suture will provide inadequate friction to hold the wound together and the edges will gape.

You will generally use sizes in the middle range: 3-0 to 5-0. On areas where cosmetic concerns are not of the utmost importance, 3-0 or 4-0 sutures are best, because the larger size makes the technique easier and the thicker sutures are stronger.

5 Subcuticular sutures

A single unbroken suture snakes to and fro in the subcuticular plane, parallel to the skin surface. This closure relies on suture friction and can only be used on straight or slightly curved wounds where there is minimal wound tension.

It is not suitable for wounds where the skin edges are irregular, unequal lengths, or ragged and traumatised.

Absorbable braided (multifilament) sutures are usually used for subcuticular closure because they do

not need to be removed and are gradually absorbed. They also have more friction than monofilament sutures and so do not gape easily.

5.1 Principles

Before you can practise this technique, you must be able to identify the subcuticular plane. This glistening layer lies between the skin and the subcutaneous fat. The needle is guided in through the skin, a short distance from the end of the wound, and emerges in the subcuticular plane.

The free end of the suture is grasped with artery forceps to stop it pulling through.

The needle is held parallel to the surface of the skin and stays in this plane throughout the closure. The needle follows the path of its curvature and care must be taken not to traumatise the wound edge. Each new bite starts at a point exactly opposite the place where the previous bite emerged, so that the closure is regular and symmetrical.

The suture should be left loose as the closure progresses, with the wound edges separated. This makes it easier to see what you are doing and to make adjustments as you go.

When the end of the wound is reached, the needle is brought out through the skin at a little distance from the wound.

Gently pulling both ends of the suture will draw the wound edges snugly together. A steri-strip can be used to secure each suture end.

Most subcuticular closures are now performed using absorbable sutures that are not removed, and a buried knot technique rather than steri-strips to secure each end. When starting the suture line, the first bite goes deep into the subcutaneous tissue and then a second bite is taken back to the starting position. A standard surgeon's knot is tied and the short end is cut as close as possible to the knot.

To secure the other end of the suture line, a short loop is left when pulling through the last suture and a surgeon's knot is tied using the loop as a substitute for the free end. The looped end is then cut as close as possible to the knot and the long end is taken down through the subcutaneous tissue and emerges beyond the end of the wound. Now this long end is cut flush with the skin. The finished result is a wound with no visible knots.

Some surgeons prefer to use a hand held straight needle and an absorbable suture for subcuticular closure, since it is quicker and therefore more suited to larger incisions. However, this technique requires great care because of the higher risk of needlestick injury.

In this demonstration the surgeon is using a 60mm reverse cutting hand held straight needle with a 3/0 undyed vicryl suture. The needle is inserted a long way from the wound edge in the subcuticular plane and emerges right in the corner of the wound. The closure then proceeds with a series of

horizontal, looping bites in the subcuticular plane. Tension is adjusted as required and then the needle is taken out along the subcuticular plane, emerging through the skin at some distance from the end of the incision. Both suture ends are then cut flush with the skin.

5.2 Practise

Guide the needle in through the skin a little way from the start of the incision and emerge in the subcuticular plane. Grasp the free end of the suture with the artery forceps to stop it inadvertently pulling through, then reposition the needle in the needle holder.

Hold the needle parallel to the surface of the skin. Take a curved bite in the subcuticular plane, allowing the needle to follow its own curve. Readjust the needle. Start the second bite exactly opposite the place where the needle emerged from the first bite on the other side.

Repeat this process with a series of looping bites along the wound length, all in the subcuticular layer. Always insert and remove the needle along the line of its curvature.

When you reach the end of the wound, bring the needle out through the skin at a little distance from the wound. Gently pull the ends of the suture. The wound should close neatly and remain closed when you let go.

A steri-strip can be used to secure each suture end.

5.2.1 Buried knot technique

Starting at one end of the wound, insert your first bite deep in the subcutaneous tissue. Reverse your needle and take a second bite back to your starting position. Tie a standard surgeon's knot then cut the short end as close as possible to the knot.

Now pick up the long end and take a deep bite in the subcutaneous tissue, emerging in the skin at the beginning of the incision. The closure now proceeds with a series of horizontal, looping bites along the wound length, all in the subcuticular layer.

When you reach the end, adjust tension as required before taking a deep bite in the subcutaneous tissue. Pull through leaving a short loop which will act as a substitute for the short end of the suture. Tie a standard surgeon's knot and cut the short looped end only, as close as possible to the knot. Don't cut the long end of the suture at this stage.

Now pick up the long end and take a final bite emerging in the skin a short distance beyond the end of the incision. Cut your suture flush with the skin.

The finished result should be a wound with even tension and no visible knots.

5.3 Things to avoid

In this section we will show examples of common problems with subcuticular closure, together with suggestions for solving them.

5.3.1 Buttonholing

If you do not keep the needle parallel to the skin surface while suturing, the needle may come out of the skin and go back in again. This ugly effect is called 'buttonholing'.

5.3.2 Incorrect spacing of bites

Taking a needle bite which starts nearer to the insertion point of the suture than where the previous bite emerged will make the closure bunch up, causing ugly wrinkles.

Taking a needle bite which is not exactly opposite from where the previous suture emerged will leave a gap in the suture line, with too much room between the bites. Ensure that each bite starts exactly opposite the point where the previous bite came out.

If you make the bites that run parallel to the skin too long, this will result in too few bites for the overall wound length and will cause gaps when the wound is drawn together.

5.3.3 Bite pulling out

Too shallow a bite in the subcuticular layer will give inadequate purchase. The needle will pull out of the subcuticular tissue.

Ensure that each bite is deep enough to get a firm purchase in the subcuticular layer.

Take a substantial bite along the curvature of the needle, remaining at the same depth throughout.

5.3.4 Suture in wrong layer

A suture in the subcutaneous fat is very likely not to hold. It may pull through the fat and come out.

Ensure that you have correctly identified the subcuticular layer. Ensure that your suture bite remains within the subcuticular plane.

5.3.5 Suture end pulling through

The free end of the suture can pull out as you are inserting the continuous subcuticular suture. To avoid this problem, secure the free end of the suture with artery forceps after entering the subcuticular plane.

When grasping a fine suture with artery forceps, hold the suture so that it runs at right angles to the grooves in the artery forceps' jaws. Failure to do this will allow the suture to slip out.

5.3.6 Too fine a suture

Too fine a suture will provide inadequate friction to hold the wound together and the edges will gape.

3-0 (2 metric) is suitable for most subcuticular closures.

5.3.7 Wound edge tension

The wound edges are held together by friction on the suture in the subcuticular layer. The closure will only succeed if there is no significant tension pulling the wound edges apart.

Judicious undermining with a scalpel may be needed in some cases.

Sometimes you may need to insert absorbable sutures in the subcutaneous layer to bring the wound edges together before you attempt the subcuticular closure. Even with two or three throws, you may experience problems with slippage using an instrument tied knot. Tying your knot by hand will allow you to hold both strands under tension and snug the knot down to alleviate this problem. The ends of the knot should be cut as short as possible.

If tension is still too great, use interrupted sutures to close the wound instead, and the technique of progressive halving to distribute the tension equally across the wound.

6 Mattress and pulley sutures

Mattress sutures represent an alternative form of interrupted suturing. They may be either vertical or horizontal. Typically they are used for closing larger surgical wounds and traumatic lacerations. They can be useful for ensuring either eversion or inversion of a wound edge and for situations where more tension is needed to approximate irregular skin edges.

This type of suture can lead to an unsightly scar and is not often needed.

6.1 Vertical mattress sutures

A vertical mattress suture starts some distance from the wound edge, passes deeply under the wound and emerges on the opposite side at the same distance from the edge. It then returns by taking a more superficial bite (just a few mm) from each wound edge. The suture draws the edges together and the knot is tied on one side.

Compared with a simple interrupted suture, this suture pattern allows better closure of dead space and better apposition of wound edges. However, the disadvantage is that there is more risk of injury to wound edges, so it should be used with caution.

6.1.1 Principles

A vertical mattress stitch consists of “far-far” and “near-near” components. It starts with the “far-far”

component which is exactly like a simple interrupted suture. A bite is taken approximately 4mm from the wound edge, passing deeply under the wound and emerging on the opposite side at the same distance from the edge.

For the "near-near" component, the needle is reversed in the needle holder and returns by taking a more superficial bite (just a few mm) from each wound edge. The curved path of the needle is followed at all times.

The suture is pulled through, taking great care to follow the line of curvature and the edges are drawn together. The knot is tied on the side of the wound where the needle emerges.

This pattern is repeated until the wound is closed, with intervals of approximately 4mm between stitches. The resulting suture pattern shows stitches that do not appear to cross the wound and knots tied all on one side.

6.1.2 Practise

Insert the suture approximately 4-5mm from the wound edge, passing deeply under the wound and emerging on the opposite side at the same distance from the edge.

Reverse the needle in the needle holder and pull the suture through. Now go back, this time taking a more superficial bite of just a few millimetres. Be sure to keep following the line of curvature of the needle when pulling the suture through to avoid tearing.

Tie the suture on this side of the wound. Use a surgeon's knot for extra security, or a standard reef knot. Cut the suture ends leaving a length of approximately 0.5cm.

6.1.3 Things to avoid

If the return superficial bite is not handled with extreme care, there is a danger that it may pull through and tear the skin edge. The best way to avoid this is to make certain not only that your bite follows the circular path of the needle but that as you pull the suture thread through you continue to follow the line of the curvature.

6.2 Pulley sutures

A pulley suture is a modified mattress suture and can be useful where there is unexpected tension on the wound edges. One end of the suture is passed through the loop at the apex of the suture. This provides a mechanical advantage in apposing the edges and distributes tension more evenly.

6.2.1 Practise

Start your pulley suture like a vertical mattress suture, passing deeply under the wound and emerging on the opposite side of the wound at the same distance from the edge.

Reverse the needle in the needle holder and go back, this time taking a more superficial bite of just a few millimetres.

Now pass the needle back through the external loop of suture on the other side of the incision and pull it across. Tie using standard reef knot technique.

Your new loop functions as a pulley, directing tension away from other strands.

6.3 Horizontal mattress sutures

A horizontal mattress suture passes deeply under the wound like a simple interrupted suture, but a horizontal bite is then taken before returning to the other side.

The finished suture should be approximately square.

6.3.1 Principles

With a horizontal mattress suture, the first suture should be inserted approximately 5mm from the wound edge, pass deeply under the wound and emerge on the opposite side of the wound at the same distance from the edge. The needle is reversed in the needle holder but this time, before going back to the other side of the incision, it is moved horizontally approximately 5mm. A reef knot or surgeon's knot is then tied in the same way as for an interrupted suture and the suture material cut.

The finished suture should be approximately square.

6.3.2 Practise

Begin as if you were inserting a standard interrupted suture. Take a bite on the first side of the wound ensuring that the needle follows the line of its curvature. Remove the needle and reposition in your needle holder before taking a corresponding bite on the other side of the wound. Hold the needle with the forceps and rotate it in the needle holder to prepare for the backhand part of the mattress suture.

Now take a bite on the same side of the skin, staying parallel to the incision or wound. The bite should be the same size as the width of the suture you have just placed. Now take a return bite to the opposite side of the wound. Pull the suture through and then tie a standard knot without excess tension. The finished suture should be approximately square. Trim the ends. Continue with equally spaced horizontal mattress sutures until the wound is closed.

6.4 Continuous mattress sutures

This type of suture is useful when dealing with a large skin incision that needs to be closed quickly. It tends to stop bleeding from the edges more successfully than an interrupted suture and there is no time taken up in cutting of individual knots.

One side of the wound follows the horizontal mattress methodology, whilst the other follows the vertical mattress methodology. The finished result is asymmetrical, with vertical bites on one side of the wound and horizontal bites on the other.

6.4.1 Principles

This closure begins in the same way as an interrupted vertical mattress suture, with a deep bite under the wound followed by a more superficial return bite. However, the long suture strand is not cut.

The needle is then reversed in the needle holder and a horizontal bite is taken on the same side before taking a deeper bite under the wound back to the other side. The needle is reversed in the needle holder again and returns to the other side of the wound with a superficial bite, emerging just beyond the point at which the horizontal bite finished.

The closure continues in a similar fashion - horizontal bite, deep bite to the other side, superficial return bite. Ideally, an assistant should follow you during this procedure, ensuring that the long suture is kept out of the way whilst you are working, but our video shows you how to practise this technique alone.

6.4.2 Practise

Insert the first suture approximately 5mm from the wound edge, passing deeply under the wound and emerging on the opposite side of the wound at the same distance from the edge. Reverse the needle in the needle holder and pull the suture through. Now go back, this time taking a more superficial bite of just a few millimetres. Tie the suture on this side of the wound. Use a surgeon's knot for extra security, or a standard reef knot. Cut the short free suture end leaving a length of approximately 0.5cm, but leave the long suture strand uncut.

Reposition the needle in the needle holder and take a horizontal bite of approximately 5mm on the same side of the wound, before returning to the other side of the wound with a deep bite. Reverse the needle in the needle holder and go back to the other side of the wound with a more superficial bite, emerging just beyond the point at which your horizontal stitch finished. Reverse your needle in the needle holder and take another horizontal bite before going deep under the wound to the other side. Continue the closure in this same pattern – superficial, horizontal, deep, superficial, horizontal, deep.

To complete the closure, leave a loop of suture when you pull through the last suture bite, and tie off using an Aberdeen knot. Cut the suture strands, leaving a length of approximately 0.5cm.

7 Undermining

Excessive tension can lead to ischaemia and poor healing. Judicious undermining with a scalpel may be needed in some cases to relieve tension on a wound edge.

Lift the skin edge with a skin hook or forceps, and with your scalpel cut into the deep subcutaneous tissue along the length of the wound until the skin has the required mobility. Try to stay at the same depth as you cut.

Be careful not to devitalise the wound edges by undermining excessively. A few small scalpel cuts is usually all that is needed.

7.1 Practise

Lift the skin edge with your forceps, and with your scalpel, make a series of cuts into the subcutaneous tissue along the length of the wound until the skin has the required mobility. Try to stay at the same depth as you cut.

Now, using the other side of the wound, practise mobilising the deeper fatty tissue. Make your incisions at a depth of approximately 1 cm, and cut back approximately 1cm under the wound.