

Suture patterns

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There are many types of suture patterns available to close the incisions and wounds encountered daily in veterinary practice. Selecting the appropriate type of pattern is important to achieve not only uncomplicated wound healing, but also good cosmetic appearance. However, the important factors that assist in the selection of the appropriate pattern are not always clear. This review article provides some helpful hints and suggestions.

Suture patterns are typically categorised as:

1. continuous or interrupted
2. inverting, appositional, or everting
3. the effect the suture pattern has on wound tension.

The choice of using interrupted versus continuous suture patterns still remains controversial (Table 1). Perhaps the biggest advantage of continuous suture patterns is their speed, allowing faster wound closure, thereby saving anaesthetic and surgical time in

irregular wound edges. How these wound edges look once they are apposed and the suture pattern is applied can be described as either inverting, appositional, or everting. For most tissue closure, appositional suture patterns are preferable, as they allow the best anatomical approximation of the disrupted tissue planes. Inverting suture patterns have been traditionally described for the closure of hollow viscera. However, studies have shown no added benefit of using inverting suture patterns on routine closure of hollow viscera, and have even documented a delay in healing when compared to appositional suture patterns (Radasch 1990). An inverting pattern can sometimes be quite useful, for example to invaginate a section of stomach wall when managing a patient with gastric dilatation and volvulus whose gastric mucosal viability is questionable. Otherwise, due to concerns regarding possible stricture formation and delayed healing, inverting patterns for gastrointestinal surgery have largely fallen into disfavour. Everting suture patterns are used primarily in areas that require dispersal of tension forces along the wound closure line. Many of the tension relieving suture patterns commonly in use will produce slight eversion. The benefit of having slight eversion on skin closure becomes evident after removal of sutures (or staples), as the scar has a tendency to flatten rather than widen. More commonly, most skin closures are accomplished using a more traditional interrupted or continuous appositional type pattern.

TABLE 1: Advantages and disadvantages of interrupted versus continuous suture patterns

INTERRUPTED SUTURE PATTERNS

Advantages

- Allows adjustment of tension throughout the suture line
- Failure of one knot is often inconsequential

Disadvantages

- More time needed to tie individual knots
- Poor suture economy
- Increased amount of foreign material in the wound

CONTINUOUS SUTURE PATTERNS

Advantages

- Faster
- Less foreign material in wound
- Potentially better airtight or watertight seal

Disadvantages

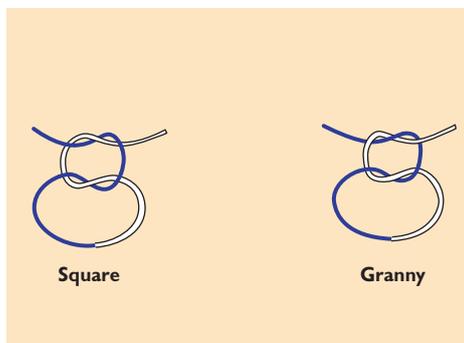
- Failure of knot may lead to disruption of suture line
- Less precise control of wound approximation and tension

critically ill patients. However, interrupted patterns allow the tension along the wound line to be more precisely controlled, adjusting tension according to the variable spreading forces along the margin. These types of forces are usually more of a problem with

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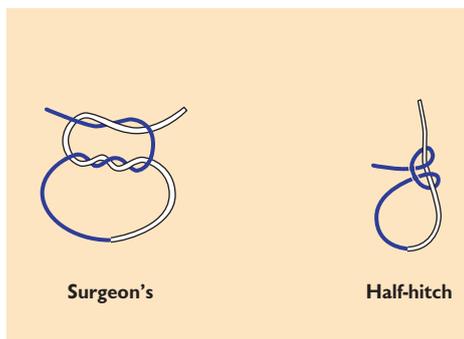
KNOTS

All suture patterns start with one basic component – the **square knot** (Fig. 1a). Also known as the ‘reef’ knot, this knot is primarily used to start and finish all suture patterns, whether continuous or interrupted. Each square knot consists of two ‘throws’, and by reversing directions after each throw and applying even pressure as the knot is tightened, the resulting knot leaves the ‘tags’ of the knot coming out on the same side of the loops. Extra throws are placed over the square knot to produce the final knot, with the number of throws depending on the type of suture material. As a general rule, all square knots should have a minimum of three total throws (Rosin 1989). Extra throws beyond those necessary to produce a secure knot will result in unnecessary extra bulk. Failing to reverse directions while tying the knot produces a **‘granny’ knot** (Fig. 1b), thus producing ‘tags’ that exit on opposing sides of the suture loops. This knot is inferior to the square knot because of its tendency to slip (Rosin 1989).



Figs. 1a and 1b.

A **surgeon’s knot** (Fig. 1c), produced by passing one strand through the loop twice on the first throw of a square knot, is occasionally used for closure of tissues where tension on the tissues makes it difficult to apply a regular square knot. The increase in frictional forces obtained from passing the strand through the



Figs. 1c and 1d.

loop twice will allow a second throw to be placed without loss of significant tightening. However, this does produce an asymmetrical knot, and subsequent regular square knot throws must be utilised to prevent the knot from slipping or coming undone. The increased bulk and asymmetry of the knot

makes it less suitable for general ligation than the square knot. There should never be a need to routinely use a surgeon’s knot other than in areas where the tension is too great to facilitate tying a square knot. In addition, surgeon’s knots should not be utilised with catgut as the increased friction has a tendency to make the material fray.

An alternative to the surgeon’s knot for utilisation in areas of wound tension is to tie a **‘half-hitch’ knot** (Fig. 1d), slide it down the suture line towards the pedicle, and by judiciously pulling the correct tag, turning the half-hitch into a true square knot. This is termed a ‘sliding knot’. This technique requires some patience and practice, but can be a very useful addition to the surgeon’s armamentarium, particularly when ligating structures within deep cavities. It leaves a square knot rather than the more bulky and asymmetrical surgeon’s knot. However, it must be tightened correctly in order to avoid the suture material slipping off the pedicle.

Surgeons will often utilise a ‘buried’ knot for subcuticular or intradermal patterns. This knot is tied using the same knotting technique as a square knot, but the suture is passed on the near side from deep to superficial and then across to the far side from superficial to deep. In effect, this produces an ‘upside down’ version of the simple interrupted suture, with the knot buried in the deeper layers of the tissues.

GENERAL PRINCIPLES OF TYING KNOTS

There are three basic methods for tying knots:

1. instrument
2. one-handed
3. two-handed tying techniques

Numerous methods have been described for each technique, and detailed descriptions can be found in the recommended reading list at the end of this article. Instrument tying is the most widely used tying technique, and has the advantage of producing consistent and reliable square knots. This technique can be difficult to apply in deep cavities, where the one-handed tie may be more useful. The two-handed tie produces reliably more consistent square knots than the one-handed method, but can be slower and unwieldy in small areas. All three techniques have their distinct advantages and disadvantages, and mastery of these three methods allows the surgeon to secure ligatures in a wide variety of situations.

There are several important principles to consider when tying suture material (Toombs and Clarke 2003):

- Knot security is inversely proportional to diameter of the suture material. As a general rule, use sutures no larger than 3-0 (2M) on individual vessels and 0 (3.5M) on tissue pedicles)
- Ensure that adequate and equal tension is applied to each strand during knot tightening to produce a secure square knot

- Completed knots are left with 3 mm long tags for synthetic material and 6 mm long tags for surgical gut. Gut must be cut long due to its tendency to swell and potentially loosen when exposed to tissue fluids.
 - Do not include frayed or damaged suture material within a knot, and only use instruments
- on the end of the suture material. This tag end will be removed at the completion of the knot anyway.
 - Extra knots produce more bulk and potentially more tissue reaction. Only use the recommended number of throws for your particular suture material.

TABLE 2: Appositional patterns

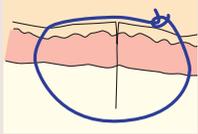
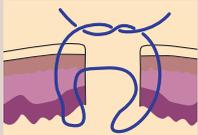
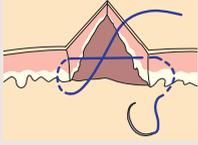
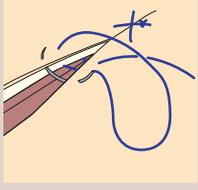
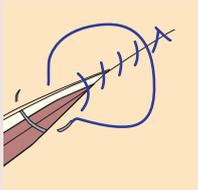
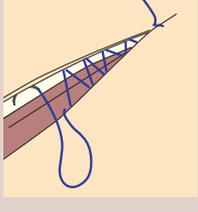
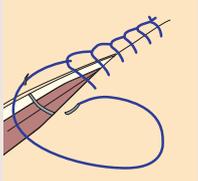
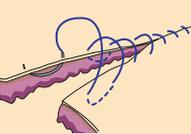
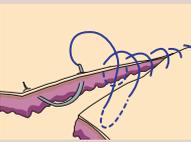
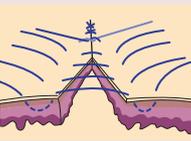
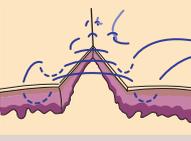
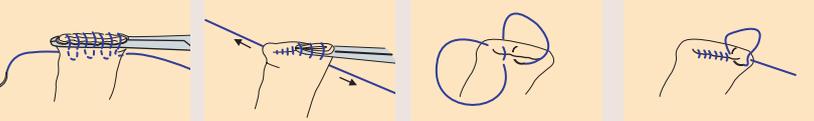
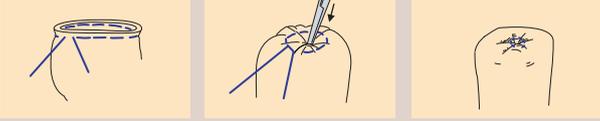
Name of pattern	Features	Usages
 <p>Simple interrupted (Fig. 2a)</p>	<ul style="list-style-type: none"> • Easy to apply • Secure anatomical closure • Allows adjustment of suture tension 	<p>Skin, subcutaneous tissue, fascia, vessels, nerves, gastrointestinal and urinary tract</p>
 <p>Gambee (Fig. 2b)</p>	<ul style="list-style-type: none"> • A modified simple interrupted, but more difficult to apply • Helps control mucosal eversion • Less susceptible to bacterial 'wicking' 	<p>Intestinal anastomosis</p>
 <p>Simple interrupted intradermal (Fig. 2c)</p>	<ul style="list-style-type: none"> • Upside down simple interrupted to 'bury the knot' 	<p>Intradermal or subcuticular closure</p>
 <p>Interrupted cruciate (Fig. 2d)</p>	<ul style="list-style-type: none"> • Faster closure than simple interrupted • Resists tension and prevents eversion • Stronger closure than simple interrupted 	<p>Skin</p>
 <p>Simple continuous (Fig. 2e)</p>	<ul style="list-style-type: none"> • Faster than interrupted suture patterns • Promotes suture economy • Provides a more airtight or fluid tight seal • More difficult to adjust tension • Can fail completely if knot is weak or inadequate 	<p>Skin, subcutaneous tissue, fascia, gastrointestinal and urinary tract</p>
 <p>Continuous intradermal (Fig. 2f)</p>	<ul style="list-style-type: none"> • A type of modified horizontal mattress suture • Promotes suture economy • Provides good skin apposition • Weaker than skin sutures • No sutures to remove 	<p>Intradermal or subcutaneous closure</p>
 <p>Ford interlocking (Blanket stitch) (Fig. 2g)</p>	<ul style="list-style-type: none"> • Similar to simple continuous but more secure if knot fails • More difficult to remove 	<p>Skin</p>

TABLE 3: Inverting patterns

Name of pattern	Features	Usages
 <p>Cushing (Fig. 3a)</p>	<ul style="list-style-type: none"> • A type of variation on continuous horizontal mattress sutures • Engages submucosa but not mucosa 	<p>Closing hollow viscera like bladder, stomach, or uterus</p>
 <p>Connell (Fig. 3b)</p>	<ul style="list-style-type: none"> • Similar to Cushing except complete penetration into lumen of viscera 	<p>First layer of hollow viscera closure (stomach, bladder, or uterus)</p>
 <p>Lembert (Fig. 3c)</p>	<ul style="list-style-type: none"> • A variation of the vertical mattress suture • Penetration of submucosa but not mucosa 	<p>Closing hollow viscera like bladder, stomach, or uterus Fascial imbrication</p>
 <p>Halsted (Fig. 3d)</p>	<ul style="list-style-type: none"> • A variation of the Lembert 	<p>Second layer of closure for hollow viscera</p>
<p>Parker-Kerr (Fig. 3e)</p> <ul style="list-style-type: none"> • A single layer of Cushings sewn over a clamp and tightened as the clamp is removed. Oversewn with Lembert 		
<p>Purse-string (Fig. 3f)</p> <ul style="list-style-type: none"> • Circular variation of Lembert <p>Closure of hollow viscera stumps or securing of tubes and catheters</p> 		

CHOOSING THE APPROPRIATE SUTURE PATTERN

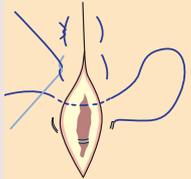
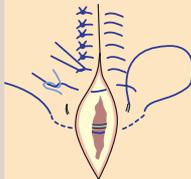
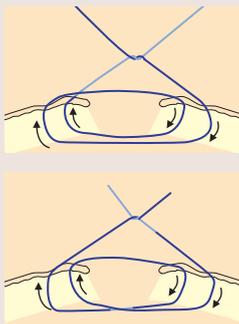
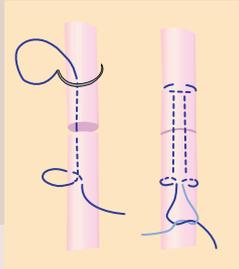
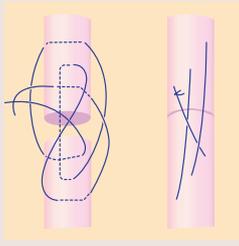
Choosing the appropriate suture pattern may seem daunting to some, but in reality most surgeons utilise a few standard suture patterns that they feel comfortable with and that have worked for them in the past. Tables 2, 3, and 4 contain lists and uses for the most common veterinary suture patterns and refer to illustrations on what these look like. Some types of speciality patterns (e.g. three loop pulley or locking loop) are used in special circumstances, and reference to them can always be made before an operation to refresh the memory. The important factor is not always the pattern type, but that the appropriate suture material type and size has been chosen, the knots are tied securely, and the correct tissues have been engaged. Finally, some golden rules are worth remembering:

- Most materials should have four throws (two

square knots), and some may require more (e.g. polydioxanone).

- It is worth remembering that a continuous line should end with one more throw than it started with.
- Make sure to tighten your knots appropriately
- Use a sliding or surgeon’s knot only when the tissues are under tension, otherwise use a normal square knot
- Appositional patterns will provide the best anatomical reconstruction in most cases, and should be preferable to everting or inverting patterns
- Tension relieving sutures should never need to be applied on a routine basis. Most tissues (especially skin) should be closed without significant tension or need for tension relieving suture patterns

TABLE 4: Tension sutures

Name of pattern	Features	Usages
 <p>Interrupted horizontal mattress (Fig. 4a)</p>	<ul style="list-style-type: none"> • Appositional to everting suture pattern depending on tightness of throws • Can strangulate blood vessels at wound edges 	<p>Closure in areas of high tension or occasionally used in closure of flat tendons or muscle with minimal fascia</p>
 <p>Interrupted vertical mattress (Fig. 4b)</p>	<ul style="list-style-type: none"> • Appositional to everting suture pattern • Stronger in tissues under tension (i.e. some situations of skin closure) than horizontal mattress • Less likely to occlude small vessels at wound edge 	<p>Closure in areas of high tension (i.e. some situations of skin closure)</p>
 <p>(Fig. 4c) Far-far-near-near and far-near-near-far</p>	<ul style="list-style-type: none"> • Variations of vertical mattress • Can provide necessary tension for wound approximation without direct tension to wound edge 	<p>Skin, subcutaneous, and fascial closure under tension</p>
 <p>Interlocking loop (Fig. 4d)</p>	<ul style="list-style-type: none"> • Self tightening suture 'locks' into tissue 	<p>Tendon repair</p>
 <p>Three loop pulley (Fig. 4e)</p>	<ul style="list-style-type: none"> • Resembles a far-near pattern type but revolves around the tendon 360° 	<p>Tendon repair</p>

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