

# Basics of Knot-Tying, Suturing and Applications

**Ms Michelle Griffin**

**July 2013**

**Volume 3**

**Issue 1**

**Doctors Academy Publications**

The World Journal of Medical Education and Research (WJMER) is the online publication of the Doctors Academy Group of Educational Establishments. Published on a quarterly basis, it's aim is to promote academia and research amongst all members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from all parts of the world. The principal objective of this journal is to encourage the aforementioned from developing countries in particular to publish their work. The journal intends to promote the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting edge technology and those who need to innovate within their resource constraints. It is our hope that this will help to develop medical knowledge and to provide optimal clinical care in different settings all over the world. We envisage an incessant stream of information will flow along the channels that WJMER will create and that a surfeit of ideas will be gleaned from this process. We look forward to sharing these experiences with our readers in our subsequent editions. We are honoured to welcome you to WJMER.



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World Journal of Medical Education and Research  
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ISSN 2052-1715



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Electronic version published at	:	Doctors Academy, PO Box 4283, Cardiff, CF14 8GN, United Kingdom
Print version printed published at	:	Abbey Bookbinding and Print Co., Unit 3, Gabalfa Workshops, Clos, Menter, Cardiff CF14 3AY
ISBN	:	978-93-80573-31-1
Designing and Setting	:	Doctors Academy, DA House, Judges Paradise, Kaimanam, Trivandrum, 695018, Kerala, India
Cover page design and graphics	:	Sreekanth S.S
Type Setting	:	Viji Shaji
Contact	:	wjmer@doctorsacademy.org.uk

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## Basics of Knot-Tying, Suturing and Applications

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### Keywords:

*Surgical Skills, Knot Tying, Suturing, Tendon Repair, Techniques*

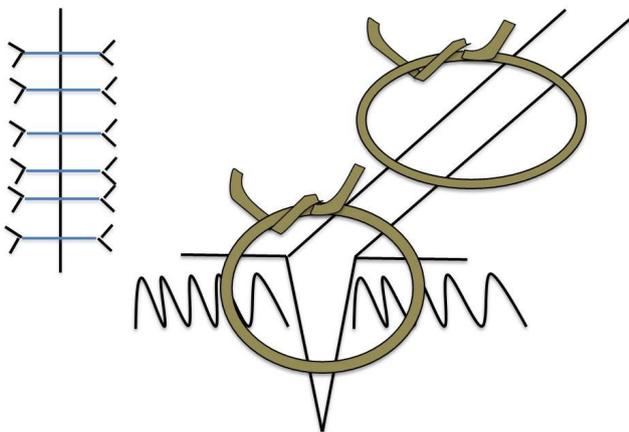
### Introduction

Suturing and knot-tying are essential skills for all doctors, not just those considering surgical specialties. The skills are also useful when lines and tubes require fixation to the skin – for example fixation of central lines and chest drains.

This article discusses the basics of suturing, knot tying and their applications including fixation of a surgical drain, repair of tendons and closure of laparotomy wounds.

### Suturing Techniques

#### Simple Interrupted Suturing



**Figure 1:** Simple Interrupted Suturing Technique – separate individual sutures are placed to bring the opposing wound edges together.

#### Indications

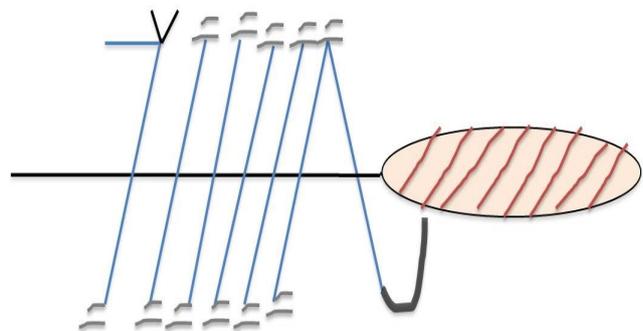
Simple interrupted suturing is the most commonly used surgical suture technique and is commonly used for closure of skin wounds. Interrupted sutures provides greater tensile strength and is particularly useful in areas where there are shear forces due to constant movement of surrounding tissues, for example, in the limbs. This suturing technique is also more forgiving as it allows the surgeon to make constant adjustments to properly align the wound edges. When a poorly placed stitch is made, it can easily be removed without having to redo suturing of the whole wound. However, simple sutures can cause a

greater risk of cross-hatching (train tracks along the suture line).

#### Technique

As with all wound closures, it is imperative to ensure haemostasis and that the wound has been adequately cleaned and if necessary, debrided. In simple interrupted suturing, the needle is angled at 90 degrees to the skin within a few millimeters of the wound edge. The needle is passed through the superficial layer, through the middle of the wound, and in a separate bite, passed directly opposite through the opposing wound edge to exit equidistance to the wound edge as the initial entry point. A surgeon's knot is used either using a hand-tie or and instrument tie, followed by alternate throws to ensure a secure knot. The ends of the suture are then cut, leaving about 0.5cm of length at both ends. It is important to ensure the wound edges are everted and that the correct tension is applied, i.e. enough tension to approximate the wound edges but not so tight that the tissues become ischaemic. Further interrupted sutures are performed in accordance to Jenkin's rule until the wound is fully closed.

#### Simple continuous suturing



**Figure 2:** Continuous suturing technique – initial suture placed as per simple interrupted technique but instead of cutting the suture, sequential bites are placed through the tissue and is only tied off and cut once the entire wound is closed.

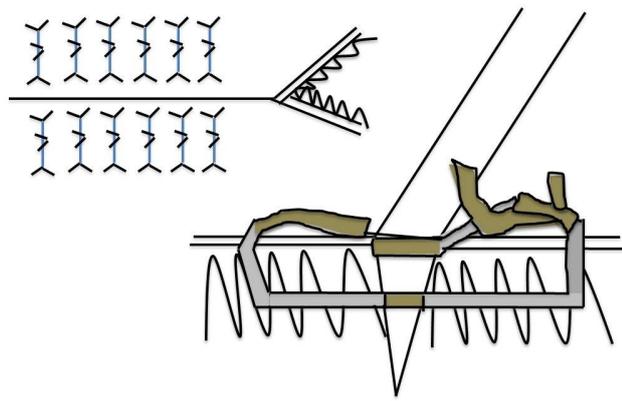
#### Indications

Continuous or running sutures are used in long wounds where deep sutures have already been placed allowing

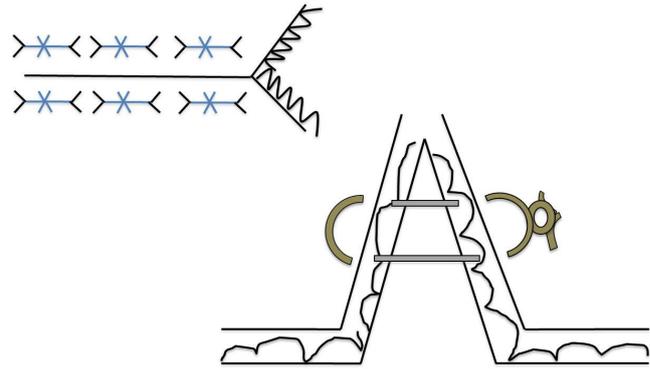
good approximation of the wound edges. This type of suture may also be used to secure a split- or full-thickness skin graft. There should be less scarring with this technique because fewer knots are placed than with simple interrupted sutures. However, the number of needle insertions remains the same. Some of the advantages of the simple running suture, when compared to the simple interrupted suture, are the faster placement of sutures and the rapid re-approximation of the wound edges. The disadvantages include the inability to make fine adjustments along the suture line, puckering of the suture line if used on thin skin, possible cross-hatching, and the risk of dehiscence if the suture material ruptures.

#### Technique

The initial step of the continuous suturing technique is the same way as a simple interrupted suture, but once the needle is threaded through the tissues and tied, instead of cutting the suture, a series of simple sutures are placed evenly spaced in succession allowing tissue to gradually oppose without tying or cutting the suture material. At the end of the wound, a knot is tied between the tail end of the suture material where it exits the wound and the loop of the last suture placed.



**Figure 3:** Vertical Mattress Suture - initial suture placed as per simple interrupted technique, but instead of tying the suture, the needle is reversed, re-entered closer to the wound edge on the same side of the wound, and exited on the opposite side equidistance as the re-entry point to the wound edge. The suture is then tied using either hand or instrument.



**Figure 4:** Horizontal Mattress Suture - initial suture placed as per simple interrupted technique, but instead of tying the suture, the needle is reversed, re-entered approximately 0.5cm along the wound edge on the same side of the wound, and the exit point is directly opposite the re-entry point. The suture is then tied using either hand or instrument.

#### Mattress Horizontal and Vertical Suturing

##### Indications

A vertical mattress suture is useful when maximum wound eversion and minimal tension across the wound is required. This technique can also be used for attachments to a layer of fascia. Some of the disadvantages of this suture are a high risk of cross-hatching due to increased tension across the wound and the four entry and exit points of the stitch in the skin. The horizontal mattress suture is similar, but is particularly used for fragile skin under tension where tension can be spread along the wound edge, reducing the risk of the suture cutting through the skin. Precise placement of each stitch and symmetrical bites are especially important with both these suturing techniques.

##### Technique

The initial bite of a vertical mattress suture begins as one would with a simple interrupted suture by penetrating the skin surface with the needle at 90 degrees and can be placed into deeper layers i.e. either through the dermal or sub-dermal layer. The needle then exits the opposite wound edge at the same distance from the wound. It is then reversed and the skin is re-penetrated by the needle on the same side but closer to the wound edge. The final

exit is through the opposing skin edge equidistance to the wound edge as the third bite, and the knot is then tied either by hand or using an instrument using the appropriate tension so as not to cause tissue ischaemia (see Figure 3). The horizontal mattress suturing technique is very similar but rather than reversing the needle closer to the wound edge, it is advanced approximately 0.5cm along the wound edge on the same side of the wound, and the exit point is directly opposite the re-entry point (see Figure 4).

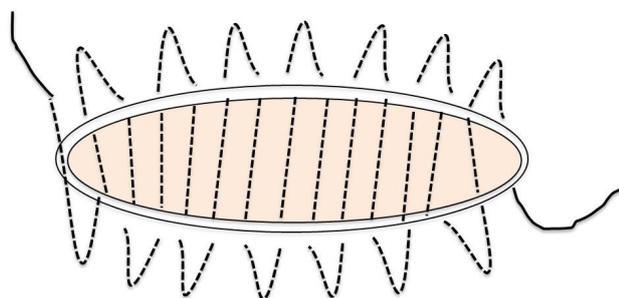
**Dermal-Subdermal Suturing**

**Indications**

The subdermal technique buries the knot within the tissue and is particularly useful in deep gaping wounds where extra stitches can close the tissue dead-space and to reduce tension in skin stitches. The skin closure can then be completed by a beautiful tension-free subcuticular closure.

**Technique**

The dermal-subdermal suture technique is essentially a reversed simple interrupted suture, starting by taking a bite of the deep tissues with the needle curving upwards and exiting on the same side in the layer just beneath the epidermis. The needle is then reinserted directly opposite side just under the skin and exiting in the deep



**Figure 5:** Subcuticular suturing technique - The suture is secured at the apex of the wound, then horizontal sutures through the papillary dermis are placed on alternate sides of the wound in a sequential manner. Once the wound has been closed, the suture is again secured either in the form of a buried knot, with steri-strips or beads.

tissues (similar depth to the first bite). The suture is then tied, resulting in a buried knot.

**Subcuticular Suturing**

**Indications**

Subcuticular suturing technique when done well provides an excellent cosmetic result, but should only be used when the tension and dead space are minimal. The epidermis is not penetrated, effectively eliminating the risk of cross-hatching.

**Technique**

The subcuticular stitch is anchored in the wound by a variety of methods, the most common being a deep dermal stitch near the apex of the wound. Beginning

from the apex of the wound, horizontal bites through the papillary dermis are then taken on alternating sides of the wound. It is important that the needle penetrates the other side of the wound directly opposite the previous exit point to prevent travelling and creating a cosmetically inferior scar.

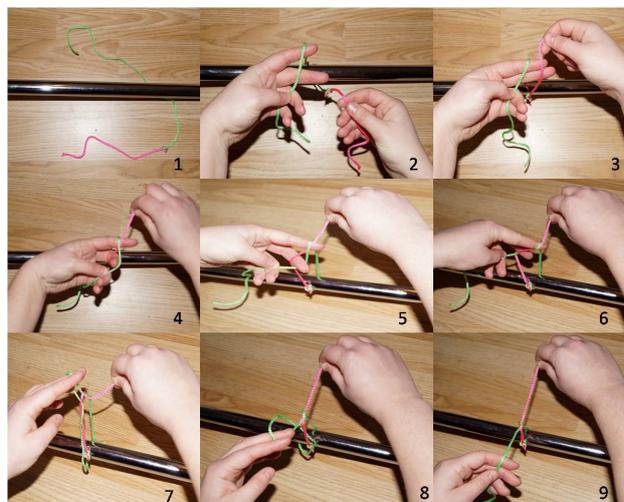
**Knot Tying**

Knot tying is a fundamental technique, used in every aspect of surgery from skin suturing to ligation of blood vessels to complex repairs of various tissues. The secret of tying a good knot is to ensure that it is secure and does not cause excess tension or cut through the structures it is trying to ligate. Whilst knot tying, it is important to avoid grasping the suture material with instruments (apart from the free end whilst performing an instrument tie) as this weakens the suture. In addition, monofilament suture material will require more throws, usually a minimum of five, depending on the operation.

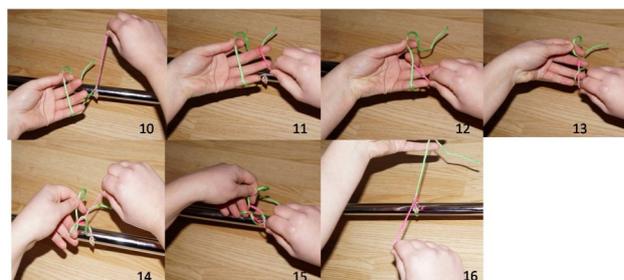
**Single handed reef Knot**

A single-handed reef knot is the most frequently utilized knot in surgery. It should be practiced using the non-dominant hand, as the dominant hand may be holding the needle holder.

The figure above illustrates a step-by-step breakdown of performing a single-handed reef knot. The short end



**Figure 6a:** Single handed reef knot technique (first throw).



**Figure 6b:** Single handed reef knot technique (second throw).

(green) of the suture is held between the thumb and ring finger of the non-dominant hand with the palm facing upwards and the remaining length of suture draped over

the index finger. The long end (pink) should then be placed parallel to the short end over the index finger of the non-dominant hand, resulting in the formation of a loop in the suture. The index finger is then flexed in order for short end to be pulled through the loop, creating the first throw. In order for the knot to be secure, it is important to cross hands in order to ensure the knot is laid flat.

The second throw follows on from the first without releasing the previous suture ends, hence the non-dominant hand should still be grasping the short end (green). The non-dominant is supinated with the palmar aspect facing upwards, and as a result, the little finger of the non-dominant hand should be placed on top of the suture. The long end (pink) is draped parallel to the short end over the middle, fourth and fifth fingers. The middle finger is flexed and the short end is then pulled through the loop creating a second throw. A minimum of three throws is required in order for the knot to be secure.

#### The Surgeon's Knot

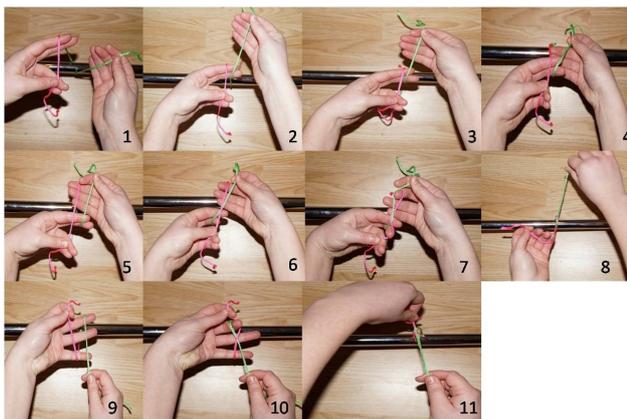


Figure 7: Surgeon's knot technique.

A surgeon's knot is a modified version of the single handed reef knot where two loops of the suture is passed in a single throw in order for the knot to become more secure and less easily unraveled between throws. Figure 8 illustrates a stepwise guide to performing a surgeon's knot. The initial throw begins as one would when performing a single handed reef knot. However once the short end of the suture is passed through the loop, rather than tightening the throw, the loop is held open by middle finger of the dominant hand. The middle finger of the dominant hand is then flexed so a second pass of the suture is placed through the loop. Once this throw is completed and tightened, revert to alternate reef knot throws.

#### Instrument tie

The instrument tie is a favoured by orthopaedic and plastic specialities as it requires less suture length. It is however difficult to perform when tying at depth. Figure 9 illustrates the steps of performing an instrument tie. The suture is looped around the needle holder. The short end of the suture is then grasped by the needle holder

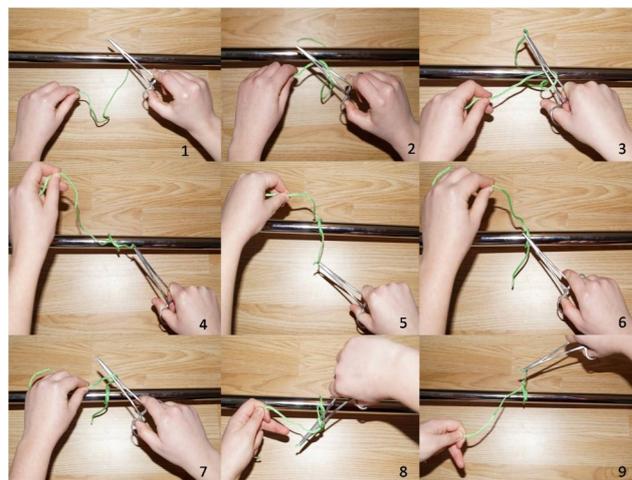


Figure 8: Using an instrument to tie a knot

and pulled through the loop to create the first throw. Alternate throws are performed by ensuring that the needle holder is always held over the suture so the suture material is passed in alternate directions when crossing hands as one would when performing a single handed reef-knot.

#### Securing a surgical drain

Surgical drains including chest drains are usually secured with a heavy silk tie, anchoring it to the skin. The simple interrupted skin stitch is placed near the drain site, then prior to it being cut, the suture material is tied securely with several ties to ensure that the drain does not fall out accidentally. It is particularly important in chest drains as if drains fall out prematurely, may result in re-accumulation of air or fluid in the chest (depending on the initial indication for placing the chest drain) and cause respiratory compromise.

#### Repairing a tendon

Tendon repair involves a combination of core and epitendinous sutures: core sutures to provide the main strength and epitendinous sutures to improve gap resistance and to enhance the strength of the repair<sup>1</sup>.

#### Core sutures

The most common technique for placing core sutures in tendon repair is known as a modified Kessler's technique. The suture material is passed between the damaged tendon to oppose the two ends together, and is then looped outside the tendon at the non-damaged end. The suture is then reversed, passed through the opposing end with equal tension so that a greater number of suture material bridges the injured part of the tendon and hence strengthen the repair. Braided 3-0 or 4-0 non-absorbable sutures are best suited for core tendon repair, and the optimal number of suture strands is between four to six suture strands. In addition, the sutures should ideally be placed dorsally and knots should lie outside the repair site as this increases the biomechanical strength of the repair.

### Epitendinous sutures

Epitendinous sutures were initially designed to improve tendon glide, but have the additional benefits of increasing the tensile strength by up to 50% and reducing the gap resistance of tendon repairs. The most commonly used epitendinous suture is a monofilament polypropylene material used either as a running locked, horizontal mattress, epitendinous or cross-stitched technique.

### Sheath repair for tendon repair

The flexor tendons of the hand are enclosed by specialized digital flexor sheaths, which are often disrupted during the initial injury. Controversy exists as to whether the sheath needs to be primarily repaired as it may provide a barrier to extrinsic adhesion formation and increase the rate of return of synovial nutrition. However, apart from increasing the technical difficulties of tendon repair, there are also increased foreign material at the repair site and may even cause narrowing of the sheath and restrict the glide of the tendon. At present, there are no distinct advantages of sheath repair, and the decision lies with the individual surgeon.

### Closure of a mid-line laparotomy wound

Midline laparotomy closures require careful attention to the underlying abdominal contents to ensure that these are not injured by an inadvertent slippage of the suturing needle. To date, literature suggests several ways of performing abdominal wound closure, including layered closure, mass closure technique, interrupted or continuous suturing, placement of retention sutures and the usage of different suture materials. The mass closure technique which includes all layers of the abdominal wall apart from skin and subcutaneous fat, has been shown to be faster to perform, more cost-effective and have equivalent if not better complication rates (e.g. wound dehiscence, wound infection, incisional hernia formation), hence is now the preferred closure method for most surgeons.

### Technique

The abdominal contents are carefully returned to the abdominal cavity, ensuring that the bowel is in the correct orientation and covered with omentum. A plastic

guard or large swab may be temporarily placed within the abdomen to protect the abdominal contents. Loop 0/0 PDS is often used on either a sharp or blunt-ended curve needle as PDS has a long half-life to allow adequate time for tissues to heal. Starting from the apex of the wound, each bite should include adequate amount of tissue from the linea alba, the rectus sheath, and if necessary rectus muscle to ensure that the suture does not cut through the tissues. Once the first suture has been placed on either side of the wound, the needle is either passed through the loop, or tied to anchor the knot, and a continuous technique under direct vision, following Jenkin's rule (1cm of tissue, 1cm between each bite) is performed. This allows an even spread of tension across the suture to minimize risk of tissue necrosis caused by excessive tension. As laparotomy wounds are often long, a second suture starting from the opposite end is required. The same technique is applied and the two sutures are tied in the middle of the wound using a minimum of seven throws, to minimize the risk of the monofilament suture being unravelled. Prior to completing the abdominal wound closure, a correct swab and instrument count must be achieved to ensure that all instruments are accounted for and that there are no outstanding material left within the abdominal cavity. The skin can then be closed most commonly with staples due to the contaminated nature of abdominal surgery.

### Conclusion

In summary, this article has covered a range of surgical skills and techniques, from simple interrupted suturing and single handed reef knots, to tendon repair and abdominal wound closures. Throughout the surgeon's career, it is important to remember that even the most basic of surgical skills such as a securely placed knot with adequate tension can be the difference between an anastomosis succeeding or failing and, may, ultimately, be the difference between life and death. Although the theoretical aspects of the skills has been described in this article, there is no substitute for practicing these skills outside the operating theatre and, with time, transfer these skills onto real patients and perform successful surgeries.

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