Basic Suturing Techniques

The approximation of human tissues in an effort to improve healing is an ancient practice, with written references to its use dating back to 2000 B.C. A multitude of materials have been used, from the mandibles of biting insects (the first skin clips?) to filaments of animal hair and sinew, to strands of precious metals. The array of materials available today is no less broad or bewildering !

The ideal suture, like the holy grail, has not been found but some of its characteristics would be as follows :

- Non-electrolytic, non-ferromagnetic, non-allergenic, and non-carcinogenic
- Sterile
- Easy to handle and knot without fraying or cutting
- Minimally reactive in tissue and not predisposed to bacterial growth
- Secure throughout the critical wound healing period
- Resistant to shrinking in tissues
- Absorbed completely with minimal tissue reaction after serving its purpose
- …and in managed healthcare situations I would add cost-effective

Since such as suture is not available, our suture choices must be a compromise on the above, hence the wide array of choices. Each surgeon will develop a preference or "suture routine" based on the basic principles and modified by patient factors, previous clinical experience and technical competence (such preferences used to be noted on cue-cards kept in suture trolley. Sadly, this practice has all but disappeared). It is important to note that no single surgeon's routine is correct, and that slavish adherence to that routine is certainly incorrect ; clinical experience aids in good suture selection.

An important concept is that of *Knot tensile strength,* which is measured by the force (in *lb*) which the suture can withstand before it breaks when knotted. The accepted rule is that the tensile strength of the suture need never exceed the tensile strength of the tissue in which it is placed. However, sutures should be at least as strong as normal tissue through which they are being placed and if the suture strength reduces over time, the relative rates at which the suture loses strength and the wound gains strength are important. If the suture biologically alters the healing process, these changes must also be understood. The accepted surgical practice is to use the smallest diameter suture that will adequately hold the wounded tissue. This practice minimizes trauma as the suture is passed through the tissue to effect closure. It also ensures that the minimum mass of foreign material is left in the body.

As sutures consist of a needle and a filament, both of which will influence the surgeon's choice, we will look at these two issues separately.

The Needle

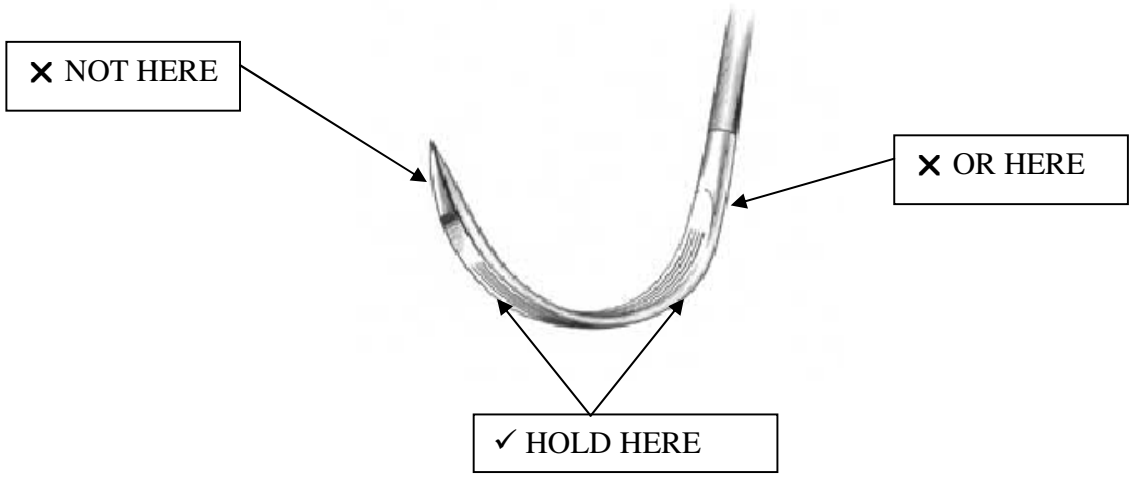
As the needle path determines the suture placement, the performance of a suture is critically related to the needle performance. There are four important criteria that determine needle performance: strength, ductility, sharpness and stability (in the instrument).

Strength is determined by how it resists deformation during repeated passes through tissue. Tissue trauma (both to the surgeon's fingers and the patient's tissues) can be induced if a needle bends during penetration. Maximum strength is determined in the laboratory by bending the needle to 90^{o}, this is referred to as the needle's "ultimate moment". Clinically more useful is "surgical yield point", which indicates the amount of angular deformation the needle can withstand before becoming permanently deformed. This point is usually 10^{o} to 30^{o} and once deformed beyond this point you should **never** reshape such a needle.

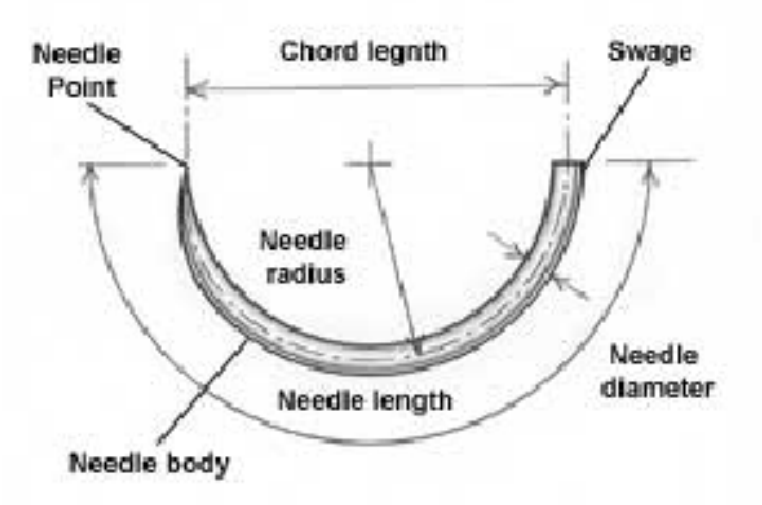
Ductility refers to the needle's resistance to breaking under a given amount of bending. Searching for part of a broken needle can cause added tissue trauma, anesthetic time and litigation! Needle bending and breakage can be minimized by passing needles through tissue in the direction of the curve of the needle body (this will be addressed in the suture workshop). Needles are not designed to be used as retractors to lift tissue.

Sharpness is especially important in delicate or cosmetic surgery. The sharper the needle, the less the trauma and the less scarring that will result. However, the right balance must be found. If a needle is too sharp, a surgeon may not have adequate control of needle passage through tissue. Sharpness is related to the angle of the point as well as the taper ratio of the needle.

Stability of the needle in the grasp of a needleholder is essential for accurate suturing. Needles are flattened as well as ribbed in the grasping area (the middle third) to enhance control by providing a crosslocking action in the needleholder to prevent rocking, twisting, and turning. This action can only occur in the jaws of a **needleholder** and does not occur if an artery forceps is used. Needles should only be grasped in the designated area and never at the tip or the eye (see picture below).



Anatomy of a needle
All needles consist of three basic areas: the tip or point, the body and the eye. In addition, there are several measurements to determine size (the picture below will help…)



The chord length is the straight line distance from the point of a curved needle to the swage. The needle length is the distance measured along the needle itself from point to eye. The radius is the distance from the center of the circle to the body of the needle if the curvature of the needle were continued to make a full circle. The diameter or the gauge is the thickness of the needle wire ranging from very fine gauge for microsurgery to large, heavy gauge needles used to penetrate the sternum.

The eye of the needle
The eye is where the filament is attached to the needle. The eye falls into one of three categories: Mayo (or closed) eye, French (split or spring) eye, or swaged (eyeless). See the picture below.

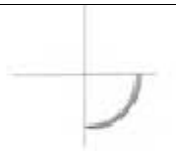
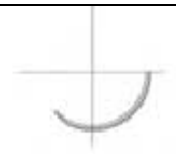
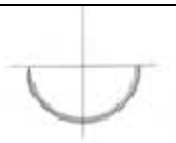
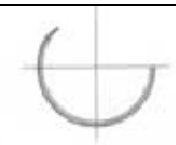
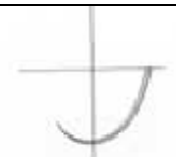
The closed eye is similar to a household sewing needle and may be round, oblong, or square. French eye needles have a slit from inside the eye to the end of the needle body with ridges that catch and hold the suture. Eyed needles have three big disadvantages: firstly they must be threaded, a time-consuming and potentially hazardous procedure for the scrub nurse. Secondly, having to pull a double strand of suture or a knot of material through the tissue creates a larger hole with additional tissue trauma. In addition, the suture may still become unthreaded while the surgeon is using it. Finally, repeated use of

these needles with more than one suture strand causes the needle to become dull, thereby making suturing more difficult. Eyed needles have been relegated to historical texts as all modern needles are swaged.

Swaging is a metal forming technique in which the metal is plastically deformed to its final shape using high pressures, either by pressing, hammering, or by forcing through a die. Swaging differs from forging (heated in a furnace and worked hot – like Japanese swords!) in that the swaged metal is cold worked, and the output of the swaging operation is usually the finished shape. As it relates to sutures, this configuration joins the needle and suture together as a continuous unit that is convenient to use and minimizes trauma, hence such needles are referred to as “atraumatic”. The method of attaching the suture to the needle varies with the needle diameter. In larger diameter needles, a hole is drilled in the needle end. In smaller diameter needles, a channel is made by forming a "U" at the swage end or a hole is drilled in the wire with a laser. Each hole or channel is specifically engineered for the type and size of suture material it will hold, and crimped or closed around the suture to hold it securely. Some needles are designed to be released from the swage with a sharp tug when the surgeon has finished placing the suture line. These needles are called “CONTROL RELEASE” needles (or “Pops” if you live in America…).

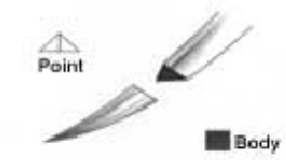
The Needle Body

Needles come in a variety of shapes, designed to assist the surgeon by making the passage of the needle through the tissues as ergonomic and atraumatic as possible. Here is a montage of the most common needle shapes and applications.

Needle Shape	Typical Applications
Strait Needle	Designed to be held in the fingers, much like a darning needle. The Keith needle is still used for tendon repairs and the Sims needle for subcuticular closure. The Bunnell needle was used for tendon repairs. A transchamber needle was used for intraocular lens placement. The above strait needles are now uncommon and can be considered a surgical curiosity.
 Half-curved / ski needle	The low profile (point-on view) allows easy passage down laparoscopic trocars, and this is where it finds its best application. Its use in skin closure is limited because, while the curved portion passes through tissue, the strait portion is unable to follow with ease.
 ¼ Circle Needle	Used for ophthalmic and microsurgical applications because of the limited amount of pronation and supernation required to pass the needle through delicate tissues.
 3/8 Circle Needle	Curved needles allow predictable needle turnout from tissue and require less space for maneuvering than a straight needle. The 3/8 circle is most commonly used for skin closure. The surgeon can easily manipulate this curvature with moderate wrist action in a relatively large and superficial wound. It is very difficult to use this needle in a deep body cavity or restricted area because a larger arc of manipulation is required.
 ½ Circle Needle	The 1/2 circle needle was designed for use in a confined space, although it requires more pronation and supination of the wrist to pass it through the tissues. Commonly used for gastrointestinal tract sugery, nasal and oral cavity and pharynx surgery as well as pelvic and urogential surgery. It is difficult to use for skin closure.
 5/8 Circle Needle	A 5/8 circle needle may be more useful than the 1/2 circle where space for manipulation is extremely limited, especially in some anal, urogenital, intraoral, and cardiovascular procedures. Skin closure with such a needle is impossible.
 Compound Curved	Developed for anterior segment ophthalmic surgery. The tight 80^{o} curvature of the tip follows into a 45^{o} curvature throughout the remainder of the body. The initial curve allows short, deep bites into the tissue. The curvature of the remaining portion of the body forces the needle out of the tissue, everting the wound edges and permitting a view into the wound. Equal suture bites on both sides of the corneal-scleral junction minimizes the possibility of astigmatism .

The Needle Point

The point extends from the extreme tip of the needle to the maximum cross-section of the body. Each needle point is designed and produced to the required degree of sharpness to smoothly penetrate specific types of tissue.

Needle Shape	Typical Applications
Conventional Cutting 	Cutting needles have at least two opposing cutting edges. They are sharpened to cut through tough, difficult-to-penetrate tissue. Cutting needles are useful for skin sutures that must pass through dense, irregular, and relatively thick connective dermal tissue. Because of the sharpness of the cutting edge, care must be taken in some tissue such as tendon to avoid cutting through more tissue than desired. Conventional cutting needles have a third cutting edge on the *inside* concave curvature of the needle. The shape changes from a triangular cutting blade to that of a flattened body. This needle type may be prone to cutout of tissue because the inside cutting edge cuts toward the edges of the incision or wound. Sternotomy needles are typically conventional cutting.
Reverse Cutting 	These needles were created specifically for tough, difficult-to-penetrate tissue such as skin and tendon. Reverse cutting needles are used in ophthalmic and cosmetic surgery where minimal trauma, early regeneration of tissue, and little scar formation are primary concerns. The reverse cutting needle is as sharp as the conventional cutting needle, but its design is distinctively different. The third cutting edge is located on the *outer* convex curvature of the needle. This offers several advantages: They have more strength than similar-sized conventional cutting Needles and the danger of tissue cutout is greatly reduced since the hole left by the needle leaves a wide wall of tissue against which the suture is to be tied.
Side-Cutting Spatula 	Also referred to as *spatula needles*, they feature a unique design, which is flat on both the top and bottom, eliminating the undesirable tissue cutout of other cutting needles. The side-cutting edges are designed for ophthalmic procedures. They permit the needle to separate or split through the thin layers of scleral or corneal tissue and travel within the plane between them. The optimal width, shape, and precision sharpness of this needle ensure maximum ease of penetration, and gives the surgeon greater control of the needle as it passes between or through tissue layers. The position of the point varies with the design of each specific type of spatulated needle. Another useful application is the suturing of nailbed lacerations for the same reasons as above.
Taper 	Also referred to as *round needles,* taper point needles pierce and spread tissue without cutting it. The needle point tapers to a sharp tip and the needle body then flattens to an oval or rectangular shape. This increases the width of the body to help prevent twisting or turning in the needleholder. Taper point needles are usually used in easily penetrated tissue such as the peritoneum, abdominal viscera, myocardium, dura, and muscle. They are preferred when the smallest possible hole in the tissue and minimum tissue cutting are desired. They are also used in internal anastomoses to prevent leakage which can subsequently lead to contamination of the abdominal cavity. In muscle & fascia, taper point needles minimize the potential for tearing the thin connective tissue lying between parallel and interlacing bands of denser tissue.
Blunt 	Blunt point (BP) needles also called *dolphin-nose needles* can literally dissect friable tissue rather than cutting it. They have a taper body with a rounded, blunt point that will not cut through tissue. They may be used for suturing the liver and kidney. Due to safety considerations, surgeons also use blunt point needles in obstetric and gynecological procedures when working in deep cavities which are prone to space and visibility limitations.

The Filament

The thread that is used to approximate tissues is often given primary importance, as this is what is left in the patient. The choices are bewildering and you must remember that not every surgeon will use all the possible types. As in pharmacology, sutures often come with two names, one is the raw material (generic name) and the other is the brand name (trade name). In this manual I will use both generic and the brand name of ETHICON (a Johnson & Johnson Company) as they are the most widely used suture supplier and you will most likely use their products more than any other brand. They are also my first choice for their unparalleled quality (I don't get any financial incentive for this!)

There are three ways of classifying suture material:

a. Natural Vs. Synthetic (Neither obvious nor terribly helpful)
b. Monofilament Vs. Braided (Marginal clinical significance)
c. Absorbable Vs. Non-Absorbable (Clearly the most important)

A useful overview table is included on the last two pages.

Sizes

The length of suture in the packet is usually printed on the package, but the size usually refers to the diameter of the filament. There are two sizing standards : Metric and U.S.P. (which stands for United States Pharmacopoeia – a Federally governed formulary which sets standards for drugs and other medical devices like sutures. Similarly the letters B.P. on medications like calamine lotion stand for British Pharmacopoeia). The diameter is given a size designation based on the ability of the thread to hold a certain force without snapping. Sizes are a range of diameters and are different for absorbable and non-absorbable (for which there are three sub-classes). That is to say, 5/0 steel is different in diameter to 5/0 chromic, but all 5/0 steel from any manufacturer must be of equivalent size and strength as specified in the U.S.P. guideline. The U.S.P. sizes vary from 5 (elephant suture) to 13/0 (super-microsurgery). The scale below gives an idea of the range. The designation /0 is used for convenience and means smaller as 0 is smaller than 1 and 00 (or 1/0) is smaller and 000000 or (5/0) is even smaller. The standard available range is size 2 to size 11/0. 7/0 and smaller are for use with special instruments.

BIGGEST SMALLEST

5 4 3 2 1 0 1/0 2/0 3/0 4/0 5/0 6/0 7/0 8/0 9/0 10/0 11/0 12/0 13/0

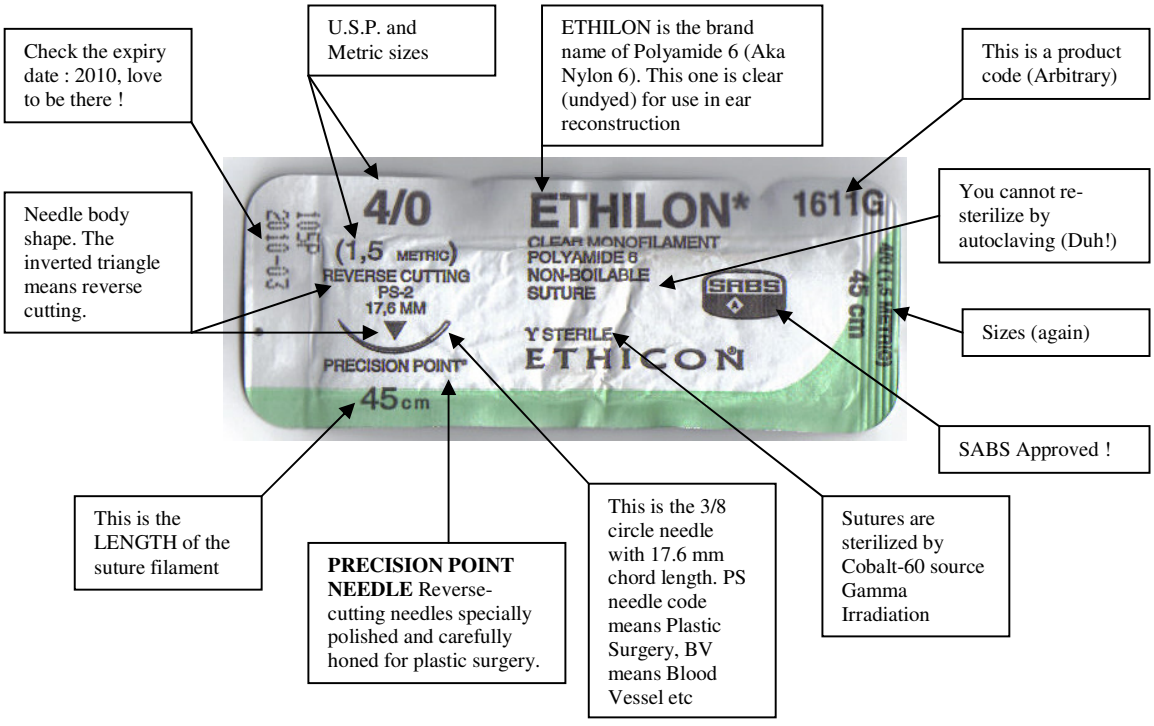
| Clinical Use with standard tools | Microsurgical Use

The Metric size (one has to love the French) is the suture diameter in tenths of a mm and can be related (more or less – depends on suture type) to the U.S.P. size by the following table : Remember that metric refers to an exact size (measurable) whereas U.S.P. refers to some arb American guideline – check it out for yourself : 4/0 chromic and 4/0 silk are of different metric sizes !

U.S.P.	Metric
5	7
4	6.5
3	6
2	5
1	4
0	3.5
1/0	3.0
2/0	2.5
3/0	2.0
4/0	1.5
5/0	1.0
6/0	0.7
7/0	0.5
8/0	0.4
9/0	0.3
10/0	0.2
11/0	0.1

How to "read" a suture packet

If you put everything you have learnt previously together, you will now be able to competently "read" the front of a suture pack – ETHICONese is so simple! Below is an actual suture packet.

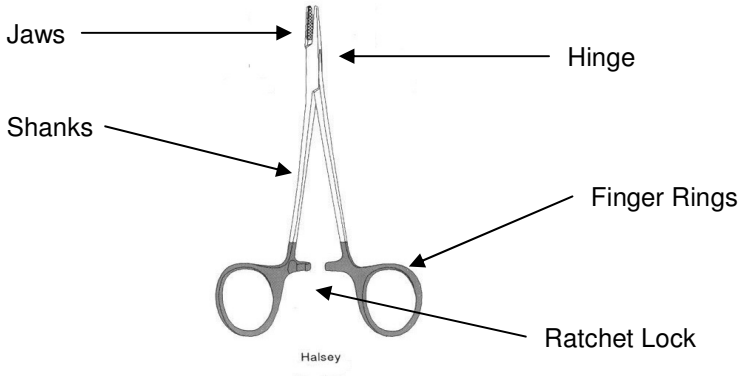


Suture Techniques

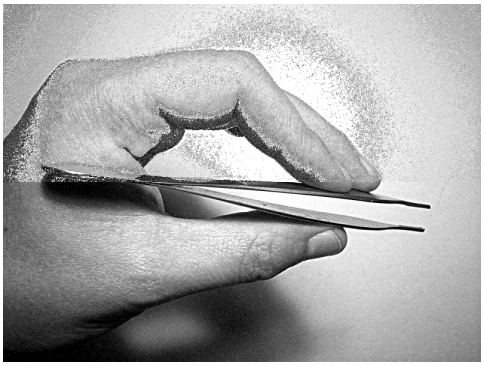
More than any of the above subjects, this area is subject to the greatest degree of personal interpretation. As long as you adhere to the basic principles (highlighted in bold) you can add your own flair (the second of Gillies' 10 commandments of Plastic Surgery is "Thou shalt have style"). This is not to say that your sitchcraft can be haphazard – good suturing is like making risotto – even professionals need to pay meticulous attention every time.

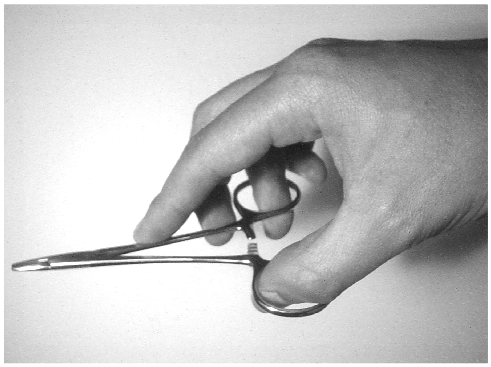
Use of weapons

Knowing how to hold your instruments correctly makes you safer, more proficient and more efficient. The practical side of the workshop will focus on this extensively.



The needleholder is held in the dominant hand, with the thumb and ring fingers in the instrument's rings. The middle finger is placed on top of the ring, and the index finger acts as a stabilizing strut along the finger-side shank of the instrument. The instrument should rest no more proximally than the **distal interphalangeal joints** of the fingers, for finer work the instrument is grasped with the pulps of the fingers as they have the greatest sensitivity. While such as position may initially feel precarious, a small time investment will pay-off handsomely later (see photo below)





To open the needleholder, the instrument is braced on the thumb and flexion of the fingers opens the ratchet lock and frees the jaws. To grasp the needle simply squeeze the instrument's rings together until the ratchet lock "clicks". Ideally only one click should be necessary if the instrument is of good quality (not many are, unfortunately). All

standard needleholders have the ratchet lock set for a right-handed surgeon. If you are left handed, please come and speak to me so that I can show you how to open the lock.

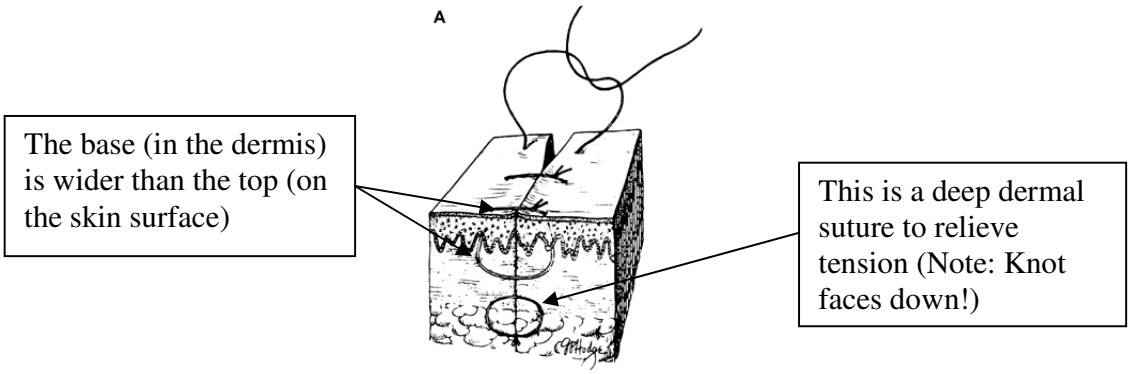
The forceps should be held in the non-dominant hand like a pen (not in the palm like a muppet). The index and middle fingers both grasp the shank opposite the thumb for greater control. NEVER, EVER retrieve a needle from the tissue with your fingers – tears will follow shortly. Try to avoid the (almost) irresistible temptation to reposition the needle with your fingers – this bad habit is VERY difficult to unlearn.

Your First Suture

Placing your first suture is a daunting, exhilarating and often time consuming exercise (I took 60 minutes for my first 5 sutures!). Do NOT be concerned with time, the good surgeon does not watch the clock, since stitchcraft is not a race. **First you must be good, <u>then</u> you can become fast**. The best surgeons are not fast because their individual movements are quick, they are fast because they have mastered economy of motion.

We will start with the simple interrupted suture since this most commonly employed suture. Start by loading the needle in the needle holder, grasping it in the designated area only. In general you should place sutures from the dominant to the non-dominant side, and from further to closest.

To place the suture, **first pronate your wrist so that the needle will enter the skin perpendicularly**, passing into the deep dermis at a point further removed from the entry of the needle. This allows the **width of suture at its base in the dermis to be wider than the epidermal entrance and exit points, giving the suture a somewhat triangular appearance when viewed in cross section**. This aids in eversion the skin edges (see the diagram on the next page).



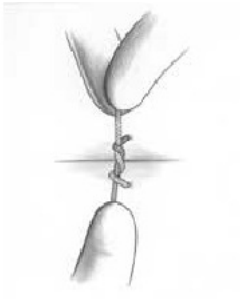
Some surgeons like to remove the thumb from its ring to avoid wrist strain – this is matter of personal style. The edge of the skin may be everted with the forceps to aid in getting the needle perpendicular. **The needle is driven through the tissue by supernation of the hand only and no forward action is required. The arc of the needle determines the arc of supernation required**. Thus larger radius needles require less supernation than smaller needles. Except in the most scarred of tissues, needle passage is smooth and occurs with minimal resistance – if you have to "push" the needle your action is invariably incorrect. If your action is correct then the "bite" you have taken will be even.

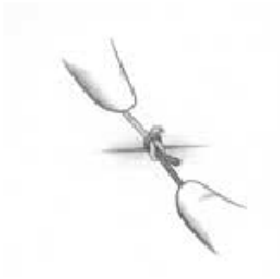
Retrieve the needle with the forceps, avoiding the delicate tip area, and reload the needleholder. Perform an equal bite on the opposing wound edge as before. Care must be taken to ensure that the suture is placed at the same depth on each side of the wound. As you gain confidence and skill you may wish in certain circumstances to take bites of both wound edges in a single movement. This is however more challenging and in inexperienced hands likely to cause unequal bites with poor approximation.

Sutures are usually placed approximately 5 mm to 7 mm apart and 1 mm to 2 mm from the skin edges, although the location and size of the needle and caliber of the suture material make this somewhat variable.

Knot tying

Knots may be tied with an instrument or with the fingers. Generally, when suturing, the knots will be tied with an instrument. Accurate, sturdy knots are critical to successful stichcraft – I have witnessed knots untying while the patient is still on the table. **All knots, no matter where, must be "square" and must be "locked" by the additional throws for adequate security**. These concepts will be emphasized during the workshop. Start by grasping the "long" end of the thread between your index and thumb of your non-dominant hand. Leave an appropriate length between your fingers and the skin edge to tie with ease – too long and the thread becomes unwieldy, too short and you risk pulling the end out of the tract (your preference will be determined by skill and setting – for me this is about 8-13 cm). Loop this length 2 or 3 times over the needleholder end (clockwise, looking down the shanks), grasp the short end in the jaws and complete the first knot by pulling the short end to the opposing edge, while pulling the long end in the opposite direction. Be sure that the knot is "square" as opposed to "granny" as shown in the diagram.





For the next throw, loop the "long" end under (anticlockwise) the needleholder, grasp the short end in the jaws and pull the short end back to the original side while pulling the long end in the opposite direction, this will result in a "square" or "surgeon's" knot as shown above. **The guiding principle is that the throw direction and the short end pull must alternate directions on every throw. The number of throws required is determined by tension and the "slipperiness" of the material, but 4 throws is probably the minimum**, I use 4 for nylon, 5 or 6 for monocryl and vicryl, 7 for PDS II and up to 9 for prolene which has a very low friction co-efficient.

It is probably impossible to give hard and fast rules on how tight to tie each knot as this is the area most subject to clinical intuition, but here is a rough metaphor: the first throw should be pulled until the wound edges just "kiss" (the way you kiss your cousin – lightest contact and nothing more!). The second throw should be pulled until it "locks" the first, as in the diagram above. The third throw should be pulled until "tight" – if the previous throws have been locked properly, they will have "set" the wound edges and tightening the third throw should have no real effect on the wound edges. More throws are added as required.

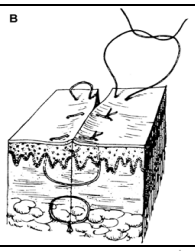
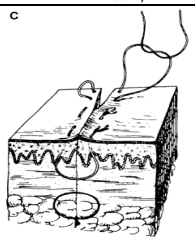
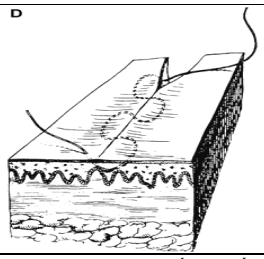
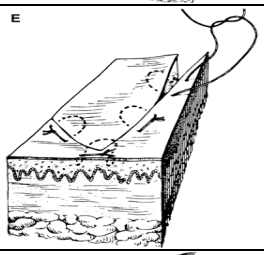
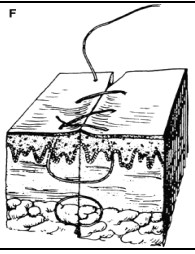
Suture Cutting

Cutting the suture is the final step and is a subtle art, often performed very badly. If the suture is to remain in situ then the ends should be cut as short as possible to minimize foreign material in the wound. Place the one blade on the knot, angle the other at 45^{o} upwards and cut – this will avoid the exasperating experience of cutting through the knot. Cutting sutures that will have to be removed is a more precise exercise, and each surgeon has his or her preference. **The general principle is to cut the length long enough so that it can be easily removed later, but short enough to prevent the ends being caught up in the next suture – an enormously irritating occurrence**. As a rough guide, a length of 6mm is adequate.

The Small Stuff

Dr Phil may not want you the sweat the small stuff, but the finer points of wound closure can be the difference between an unattractive, poorly healed scar and an imperceptible one. **The wound edges must come together precisely or in very slight eversion. Inversion is absolutely verboten!** In simple interrupted sutures where there is minimal tension, the technique described above is sufficient. Where more tension exists, the use of buried absorbable deep dermal sutures is recommended. To ensure that the knot will face the depths of the wound, start the suture in the middle of the wound, taking the bite from

deep to more superficial, and the opposing edge is then taken from superficial to deep. Below are descriptions of other types of sutures, which may be useful in various circumstances.

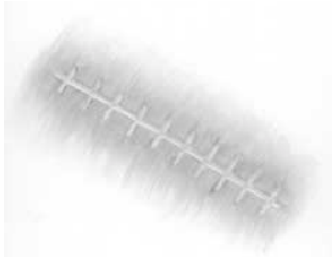
	Vertical Mattress	Vertical mattress sutures are used when eversion of the skin edges is needed and cannot be accomplished with simple sutures alone. Vertical mattress sutures leave obvious cross-hatching and must be removed early.
	Horizontal Mattress	Horizontal mattress sutures also provide approximation of the skin edges with eversion. They are particularly advantageous in thick glabrous skin (feet and hand). However, they produce more ischemia of the wound edges (but are useful for haemostasis!).
	Subcuticular	For subcuticular (intradermal) sutures the needle is passed horizontally through the superficial dermis parallel to the skin surface to provide close approximation of the skin edges. Care must be taken to ensure that the sutures are placed at the same level. Such a technique circumvents the possibility of suture marks in the skin.
	Half-Buried Horizontal Mattress	Half-buried horizontal mattress sutures are used when it is desirable to have the knots on one side of the suture line with no suture marks on the other side. The best use of such a suture is to suture down the tip of a triangular flap of tissue – this is eponymously known as a Barron's Suture.
	Continuous Over-and-Over Suture	Continuous over-and-over sutures can be placed rapidly and provide hemostasis by compression of wound edges. They are especially useful in scalp closures and for closure of oral & vaginal mucosa. They should not be placed on cosmetically important skin as they cause cross-hatching.

Ambroise Paré a famous French surgeon presented this dictum (among others) in 1564 – "Restore to their places things which are displaced". When faced with long jagged laceration, inexperienced surgeons may become dismayed – do something positive (Dr Phil, again), start with two edges that definitely fit and work from there – you will oftentimes be surprised at your ability to close the most daunting of lacerations. Sometimes there may be nothing obvious to guide you. Here the technique of "halving"

the laceration may be valuable to prevent “dog-ears” at the ends due to edge length mismatch.

Removing Sutures

Again, this area generates controversy and confusion but guiding principles are available. The timing depends on the anatomical site, the progress of wound healing, the wound tension and the desired cosmetic result. Epithelialization of the suture tract develops within 10 days, and persists long after suture removal if allowed to develop. This causes comedone-like lesions of heaped up keratin at the entry and exit sites and sometimes along the deeper tract – this results in the railroad scar as shown below. An interesting and widespread (but off-code) use of cholamphenicol eye ointment is application to the suture line prior to dressing – this lubricates the suture, allows it micro-movement in the tract and subsequently decreases epithelialization of the tract.



The face with its excellent blood supply usually heals well and is of prime cosmetic importance. Sutures should be removed on day 5 to 7 (latest). In other areas a strong wound is of greater importance than cosmesis and sutures can be left for 10 days to 2 weeks. In cosmetically important areas such as the breast, intradermal techniques which do not require removal are preferable. Sutures should be removed with the same care that they are inserted with. A fine non-toothed forceps and a sharp pair of iris sissors are the tools of choice, a stitch cutting blade is barbaric, painful and may cause multiple small areas of dehiscence - it cannot be recommended. Always pull the cut end over the wound to remove, never away as this causes force vectors that act to open the wound.

Colour	Suture Name	Raw material	Classification	Absorption	Uses
Yellow	Plain Gut PLAIN	Collagen from sheep and cow submucosa and serosa	**ABSORBABLE**, NATURAL, MONOFILAMENT	Tensile strength = 5-7 days Absorption = 70 days	Moderate tissue reaction must be balanced against rapid absorption and low cost. The only real use is oral and vaginal mucosa approximation commonly with continuous running suture.
Brown (Ugly!)	Chromic Gut CHROMIC	As above, but treated in a bath of chromium salt	**ABSORBABLE**, NATURAL, MONOFILAMENT	Tensile strength = 10-14 days Absorption = 90 days	
Purple	Polyglactin 910 RAPIDE VICRYL	Copolymer of glycolide and lactide coated with polyglactin 370 and calcium stearate.	**ABSORBABLE**, SYNTHETIC, BRAIDED	Tensile strength = 10-14 days Absorption = 42 days	Essentially the same use as gut, has minimal reaction but cost 5 x more. Useful as a skin suture in young children as removal of sutures can be traumatic (in both contexts!).
Red and purple candy stripes (Pretty!)	Polyglactin 910 VICRYL (Coated)	As above	**ABSORBABLE**, SYNTHETIC, BRAIDED	Tensile strength = 21 days Absorption = 56 days	Good general approximation of muscle and subcutaneous tissues. Not for sheath, tendon, ligament or intradermal use.
Coral Pink	Poliglecaprone-25 MONOCRYL	Copolymer of glycolide and epsilon-caprolactone.	**ABSORBABLE**, SYNTHETIC, MONOFILAMENT	Tensile strength = 21days Absorption = 91-119 days	Also good general approximation of above tissues. Mainly used for sub- and intradermal sutures.
Silver	Polydioxanone PDS II	Polyester polymer.	**ABSORBABLE**, SYNTHETIC, MONOFILAMENT	Tensile strength = 6 weeks Absorption = 6 months	Useful for bowel anastomosis, sheath closure and some soft tissue repairs where extra healing time is needed. NOT for dermal suturing.
Plum	PANACRYL No generic name – this is unique to ETHICON	Copolymer of lactide and glycolide coated with a polymer of caprolactone and glycolide.	**ABSORBABLE**, SYNTHETIC, BRAIDED	Tensile strength = > 6 months Absorption = 1.5 – 2 years	Useful where extended healing time is needed. Applications include sheath closure, some tendon and ligament repairs.

Colour	Suture Name	Raw material	Classification	Absorption	Uses
Light Blue	Black Silk PERMA-HAND	Silkworm cocoons. Must be de-gummed and de-waxed and dyed black	**NON-ABSORBABLE**, NATURAL, BRAIDED	Tensile strength = 1 year Absorption = 2 years. Is in reality a slowly absorbing suture	Has the ultimate handling properties, but is highly reactive in the tissues. Useful in eyelid margin suture (because of its softness)
Ochre	Stainless Steel	316 L high grade steel alloy with nickel and chromium. 316 has the lowest carbon of the 3 series.	**NON-ABSORBABLE**, NATURAL, MONOFILAMENT	Tensile strength = many years Absorption = indefinite	A very biocompatible material (but does not osseo-integrate). Useful for sternal closure and some tendon repairs.
Green	Nylon ETHILON	Polyamide polymer of hexamethylene diamine and adipic acid	**NON-ABSORBABLE**, SYNTHETIC, MONOFILAMENT	Tensile strength = 2 years Absorption = indefinite but fragments over time	Minimal reaction with good handling properties. Most useful suture – skin, tendon, ligament are all good applications.
Turquoise	Polyester MERSILENE	Polymer of polyethylene terephthalate, tightly braided into a multifilament strand. Ethibond is identical to mersilene except for a polybutilate coating	**NON-ABSORBABLE**, SYNTHETIC, BRAIDED	Tensile strength = many years Absorption = indefinite	As a braided suture, they have excellent handling properties, no meaningful degradation over time and minimal tissue reaction. Strict asepsis required as the braids may harbour bacteria. Most useful for cardiothoracic (valve) surgery and joint capsule repair and hernia surgery
Orange	Polyester ETHIBOND EXCEL				
Deep Blue	Polypropylene PROLENE	Isostatic, highly unsaturated hydrocarbon polymer	**NON-ABSORBABLE**, SYNTHETIC, MONOFILAMENT	Tensile strength = many years Absorption = indefinite	Very unreactive monofilament, but requires multiple throws to knot. Mainly used in vascular repairs as minimal platlet adherence occurs on its smooth surface
Cranberry (Yup, that's what they call it!)	Poly (hexafluoropropylene-VDF) PRONOVA	Co-Polymer of vinylidene fluoride and cohexafluoropropylene.	**NON-ABSORBABLE**, SYNTHETIC, MONOFILAMENT	Tensile strength = many years Absorption = indefinite	Resists infection and has been successfully employed in contaminated and infected wounds to eliminate or minimize later sinus formation and suture extrusion.