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CRIMEA STATE MEDICAL UNIVERSITY CHAPTER



# HANDBOOK OF SURGICAL SUTURES AND KNOTS

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## **FOREWORD**

Although surgery bears upon all sciences, yet, surgery itself can be seen as an art. What differentiates the best surgeon from the better one, is the ability of not just being able to manage the immediate and critical situations dynamically and to analyze the diseases interdisciplinarily, but his ability to perform perfect, aimful and economical coordination of operational movements. The refined technique of the handling and uniting the tissues –in the case of manual skills– is attainable by many practices, and the good surgeon works on the perfection of this technique in his daily operating activities. Dexterity and speed in tying knots correctly constitute an art which only practice can make perfect.

This handbook explains and demonstrates the principle maneuvers of knot tying along with step by step descriptions of each maneuver. The most commonly used suture patterns and knots are described and illustrated, along with Information on suture materials and surgical needles used for sutures and knots

It is our hope that this handbook will be useful to medical students and residents as a quick guide to basic suture patterns and methods of knot tying.

Special thanks to the members of the EMSA-CSMU academic team for putting in their best and time into writing this manual

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## INTRODUCTION TO SUTURING

### WHAT IS A SUTURE?

The word "suture" describes any strand of material used to ligate (tie) blood vessels or approximate (bring close together) tissues. *Sutures* are used to close wounds

### SUTURE COMPONENTS

- A) THREAD
- B) NEEDLE

### TYPES OF THREAD

Surgical suture material can be classified on the basis of the characteristics absorbability, origin of material and thread structure.

They can be absorbable or non-absorbable; synthetic or natural; mono- or multi- filamentous.

### ABSORPTION

Absorption can occur enzymatically, as with catgut, or hydrolytically, as with the absorbable synthetic polymers. An important measure of absorbability is the absorption time or half-life, which is defined as the time required for the tensile strength of a material to be reduced to half its original value. Dissolution time is the time that elapses before a thread is completely dissolved. These times are influenced by a large number of factors including thread thickness, type of tissue, and, not least, the general condition of the patient.

The most important absorption and dissolution times are shown in the following table:

### Approximate absorption times of synthetic suture materials

Material	Half-life (days)	Dissolution time (days)
Serapid®	6 - 8	30 - 42
Serafit®	15 - 20	60 - 90
Serasynth®	28 - 42	180 - 210

### ORIGIN OF MATERIAL

Suture materials can be classified as being of natural or synthetic origin. The former include silk and catgut. The other main groups of suture materials are those produced from synthetic polymers such as polyamide, polyolefines and polyesters. This group also includes absorbable polymers derived from polyglycolic acid.

### STRUCTURE OF THREAD

Monofilament and multifilament thread structures are distinguished.

### Monofilament threads

Synthetic monofilament threads are produced by a special extrusion process in which molten plastic is extruded under high pressure through fine spinnerets. The monofilament structure is used mostly for thinner threads. With thicker threads the wiriness that is a characteristic of all monofilament threads impairs handling and in particular renders knot-tying more difficult. Because of their smooth, closed surface and completely closed interior, monofilament threads have no capillarity. On the other hand, the ease with which they pass through tissue is unsurpassed.

### Multifilament threads

Multifilament threads are composed of many fine individual threads either twisted or braided together. The direction of the twist is generally right-handed. Twisted multifilament threads include e.g. silk threads. All twisted threads show considerable variation in diameter. Their surface is mostly rough. The longitudinal orientation of the individual filaments within the thread results in relatively high capillarity. In braided threads the individual filaments lie more or less obliquely to the longitudinal axis of the thread. This tends to impede the passage of fluid. The capillarity of braided threads is therefore less than that of twisted threads. Multifilament threads have a rough surface that impairs passage through tissue but results in considerably better knot holding security. Multifilament threads are generally coated. The coating smoothes out the irregular surface and thus facilitates passage through tissue without impairing knot-holding security. Coated multifilament threads are less stiff and wiry than monofilament threads. The coating also reduces capillarity.



### *Absorbable Suture Materials*

Material	Structure	Tis. rxn	Strength	T ½	Uses
Gut	Natural	++++	++	5-7d	Mucosal closure, rare
Chromic Gut	Natural	++++	++	10-14d	Mucosa, perineal
Dexon	Braided	++	+++	25d	Sub Q closures
Vicryl	Braided	++	++++	28d	Mucosal closures
Maxon	Monofil	+	+++++	28-36d	Sub Q closures

### *Non-absorbable Suture Materials*

Material	Structure	Tis. Rxn	Strength	Knot sec.	Uses
Silk	Braided	++++	++	++++	Easy to handle
Nylon	Monofil	++	+++	++	Common for skin cl.
Prolene	Monofil	+	++++	+	High memory, sub Q pull
Dacron	Braided	+++	++	++++	Good knot security

### **SUTURE SELECTION**

- Do not use dyed sutures on the skin
- Use monofilament on the skin as multifilament harbor BACTERIA
- Non-absorbable cause less scarring but must be removed
- Plus sutures (monocryl for E. coli, Klebsiella)
- Location and layer, patient factors, strength, healing, site and availability
- Absorbable for GI, urinary or biliary
- Non-absorbable or extended for up to 6 mos for skin, tendons, fascia
- Cosmetics = monofilament or subcuticular
- Ligatures usually absorbable

### *Suture sizing by indication*

Location	superficial non-absorb	deep absorbable
Scalp, torso (chest, back, abdomen), extremities	3-0 to 5-0	3-0 or 4-0
Face, eyebrow, nose, lip	6-0	5-0
Ear, eyelid	6-0	n/a
Hand*	4-0 or 5-0	5-0
Foot or sole*	3-0 or 4-0	4-0
Penis	5-0 or 6-0	n/a

\* deep sutures are to be avoided in the hands and feet unless being used to repair a tendon – they may increase the risk of wound infection.

## NEEDLES

Necessary for the placement of sutures in tissue, surgical needles must be designed to carry suture material through tissue with minimal trauma. They must be sharp enough to penetrate tissue with minimal resistance. They should be rigid enough to resist bending, yet flexible enough to bend before breaking. They must be sterile and corrosion-resistant to prevent introduction of microorganisms or foreign bodies into the wound.

The best surgical needles are:

- Made of high quality stainless steel.
- As slim as possible without compromising strength.
- Stable in the grasp of a needleholder.
- Able to carry suture material through tissue with minimal trauma.
- Sharp enough to penetrate tissue with minimal resistance.
- Rigid enough to resist bending, yet ductile enough to resist breaking during surgery.
- Sterile and corrosion-resistant to prevent introduction of microorganisms or foreign materials into the wound.

**Note:**

The penetration force of a needle depends in the first line on its shape and the polished and etched microsection of the tip, and less on the quality of the steel

- Ductility: how often a needle can be bent back and forth before it breaks
- Austenite: microstructure of steel. Austenitic microstructure is face-centred cubic, forms at high temperatures above approx. 1300°C and only remains stable at these temperatures. The addition of alloy components such as nickel and manganese, however, maintains this structure at room temperature.
- Martensite: microstructure of steel. Martensitic microstructure forms at high temperatures. It is extremely hard and the structure can be maintained by rapid cooling (“quenching”).



## TYPES OF NEEDLES

### **ATRAUMATIC NEEDLES**

Atraumatic sutures are defined as needle-suture combinations, where the needle is firmly attached to the suture in order to reduce tissue trauma.



### **SPRING-EYED NEEDLES**

Spring eye surgical needles are made of 300-series stainless steel. This generation of needles is characterised by optimum resistance to bending, the best possible ductility and outstanding tissue penetration. This guarantees safe and simple working conditions.



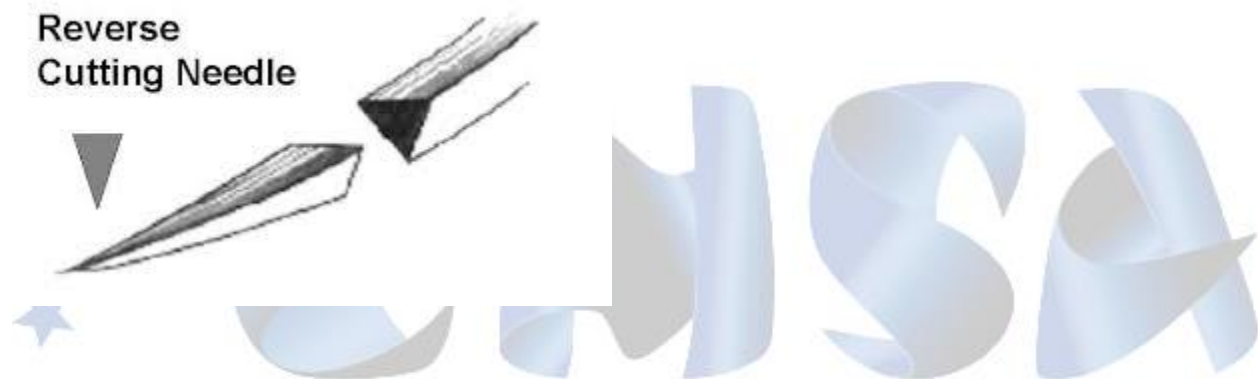


## REVERSE CUTTING NEEDLE

These needles were created specifically for tough, difficult to penetrate tissue such as skin, tendon sheath, or oral mucosa. Reverse cutting needles are used in ophthalmic and cosmetic surgery where minimal trauma, early regeneration of tissue, and little scar formation are primary concerns.

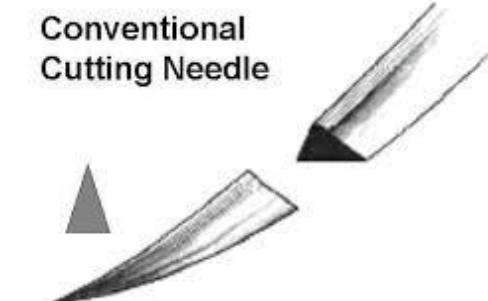
### ADVANTAGES

- Reverse cutting needles have more strength than similar-sized conventional cutting needles.
- The danger of tissue cutout is greatly reduced.
- The hole left by the needle leaves a wide wall of tissue against which the suture is to be tied.



## CONVENTIONAL CUTTING NEEDLES

In addition to the two cutting edges, 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 on both straight and curved needles. This needle type may be prone to cutout of tissue because the inside cutting edge cuts toward the edges of the incision or wound.



## SURGICAL SUTURES

### Classification of suture types

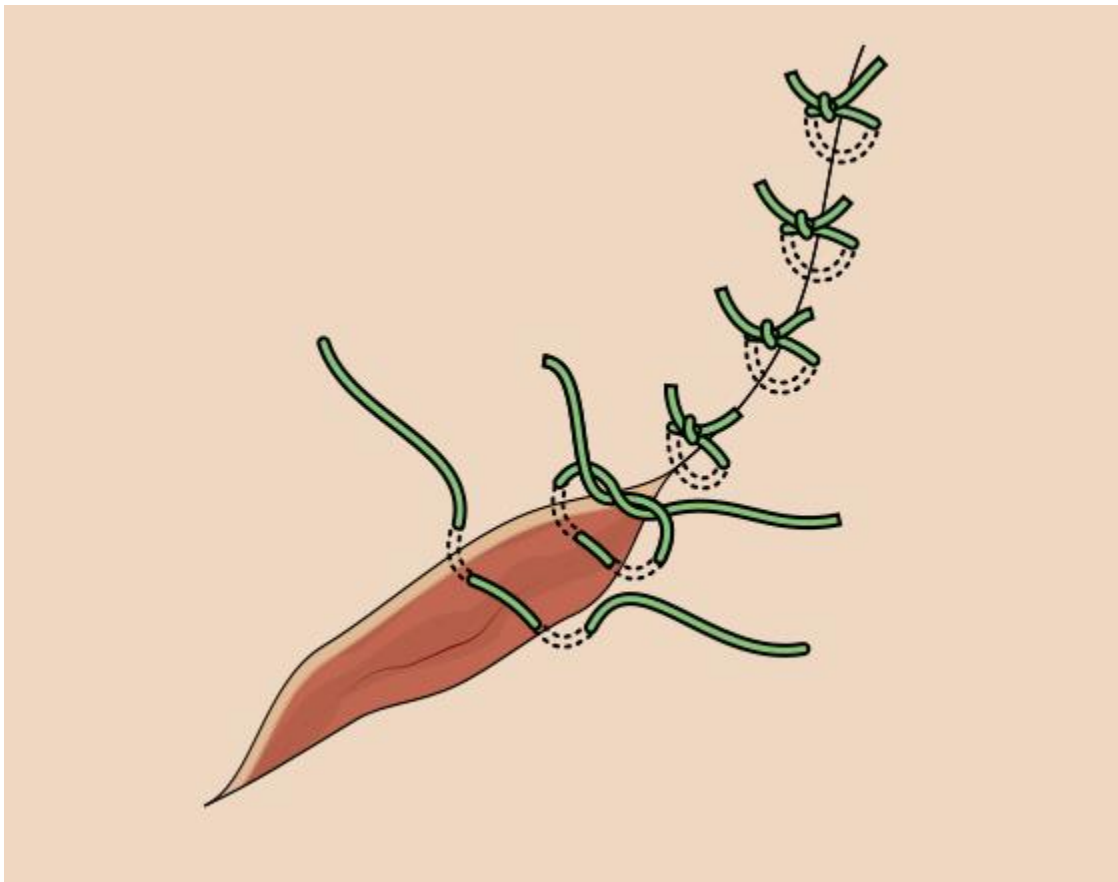
- According to layer: One layer (if we approximate only one layer of tissues), two or more layers
- According to depth: one or two lines (rarely more lines)
- According to length: interrupted or continuous suture line

### General rules of the stitches:

- Not too close to the margin of the wound
- Stitches should be placed in the same distance
- Knots should be placed out of the wound line
- No wrinkles or gaps
- Avoid the overturn of the edges of the wound (exception purse-string ligature)

### Simple interrupted sutures

The most commonly used and versatile suture in cutaneous surgery is the simple interrupted suture. This suture is placed by inserting the needle perpendicular to the epidermis, traversing the epidermis and the full thickness of the dermis, and exiting perpendicular to the epidermis on the opposite side of the wound. The 2 sides of the stitch should be symmetrically placed in terms of depth and width. In general, the suture should have a flask-shaped configuration, that is, the stitch should be wider at its base (dermal side) than at its superficial portion (epidermal side). If the stitch encompasses a greater volume of tissue at the base than at its apex, the resulting compression at the base forces the tissue upward and promotes eversion of the wound edges. This maneuver decreases the likelihood of creating a depressed scar as the wound retracts during healing (see image below). Simple interrupted suture placement.

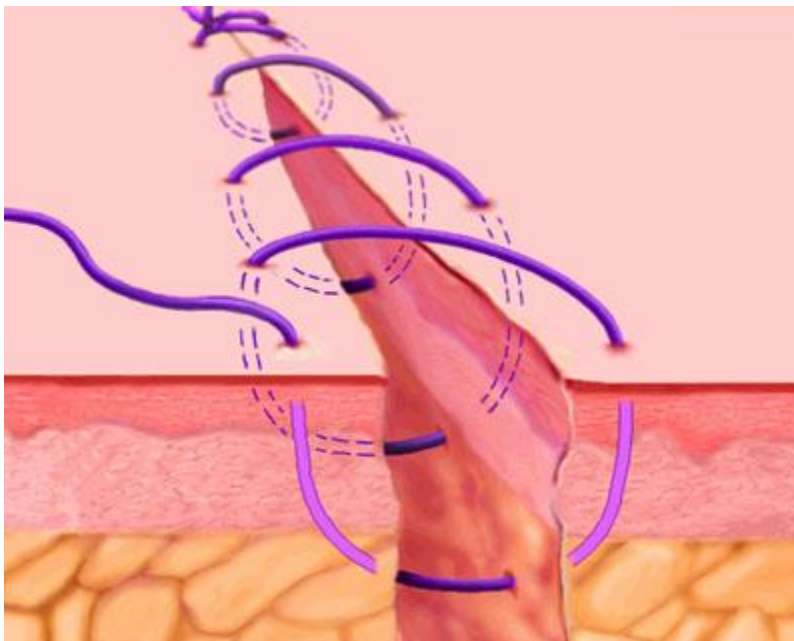


Simple interrupted suture placement. Image shows a flask-shaped stitch, which maximizes eversion.

In general, tissue bites should be evenly placed so that the wound edges meet at the same level to minimize the possibility of mismatched wound-edge heights (ie, stepping). However, the size of the bite taken from the 2 sides of the wound can be deliberately varied by modifying the distance of the needle insertion site from the wound edge, the distance of the needle exit site from the wound edge, and the depth of the bite taken. The use of differently sized needle bites on each side of the wound can correct preexisting asymmetry in edge thickness or height. Small bites can be used to precisely close wound edges. Large bites can be used to reduce wound tension. Proper tension is important to ensure precise wound approximation while preventing tissue strangulation.

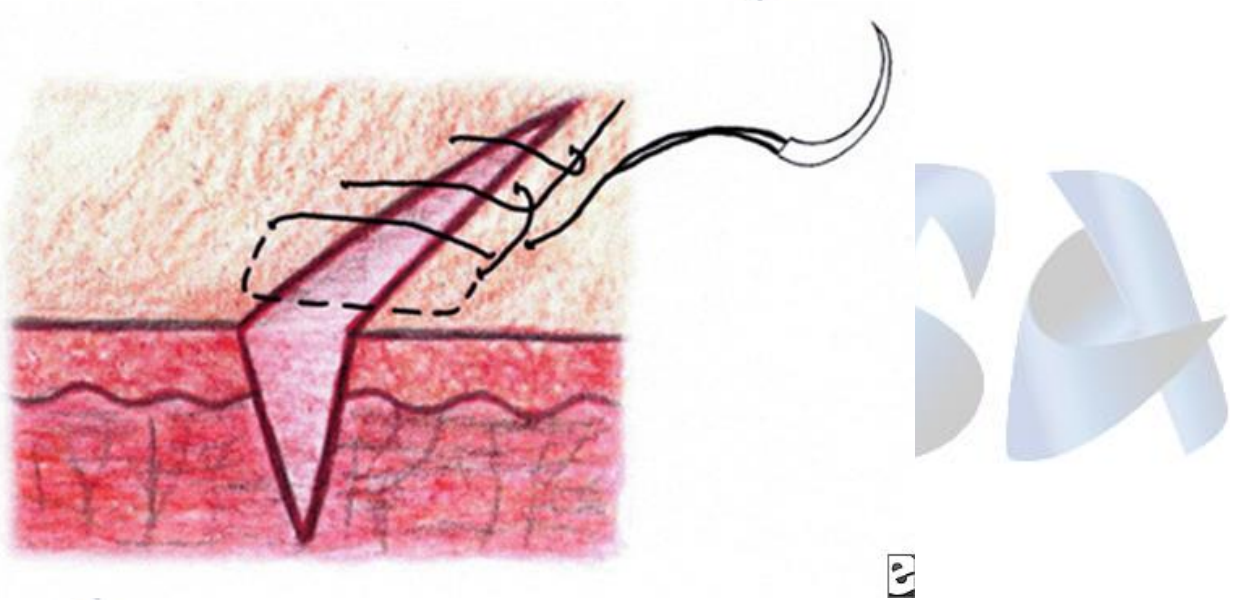
#### Simple running sutures

The simple running suture is an uninterrupted series of simple interrupted sutures. The suture is started by placing a simple interrupted stitch, which is tied but not cut. A series of simple sutures are placed in succession without tying or cutting the suture material after each pass. Sutures should be evenly spaced, and tension should be evenly distributed along the suture line. The line of stitches is completed by tying a knot after the last pass at the end of the suture line. The knot is tied between the tail end of the suture material where it exits the wound and the loop of the last suture placed.



### Running locked sutures

The simple running suture may be locked or left unlocked. The first knot of a running locked suture is tied as in a traditional running suture and may be locked by passing the needle through the loop preceding it as each stitch is placed. This suture is also known as the baseball stitch (see image below) because of the final appearance of the running locked suture line.



*Running locked suture.*

### Vertical mattress sutures

The vertical mattress suture is a variation of the simple interrupted suture. It consists of a simple interrupted stitch placed wide and deep into the wound edge and a second more superficial interrupted stitch placed closer to the wound edge and in the opposite direction. The width of the stitch should be increased in proportion to the amount of tension on the wound. That is, the higher the tension, the wider the stitch (see image below).



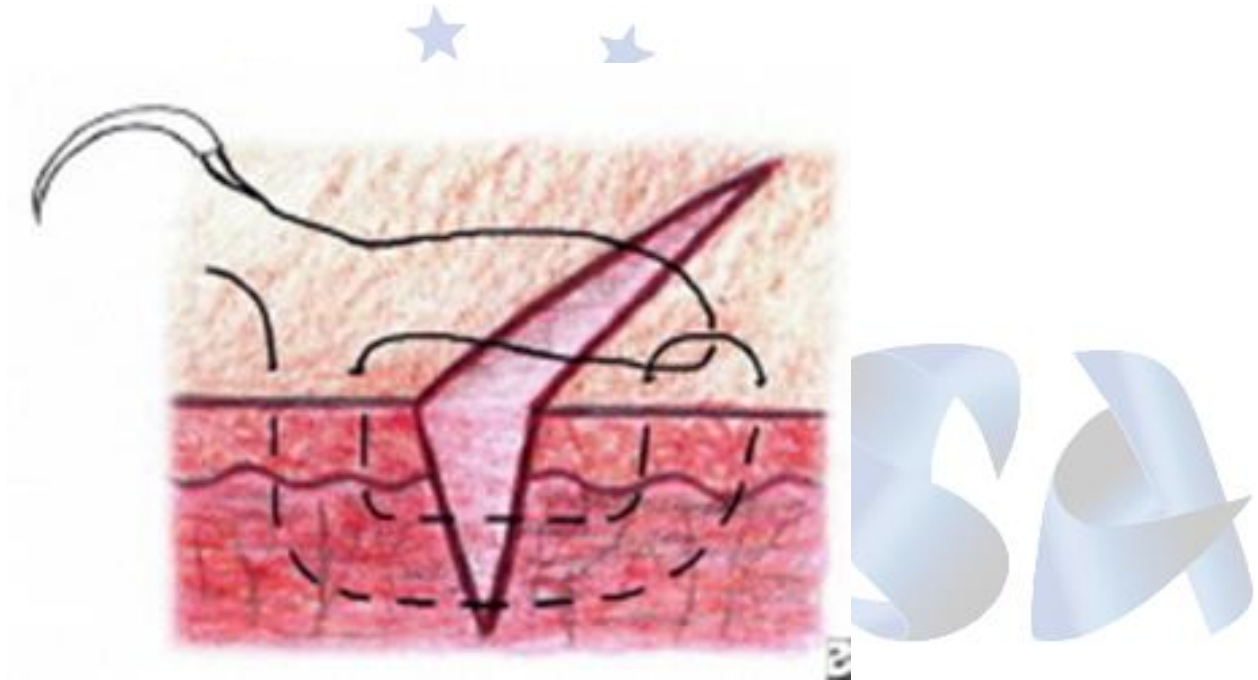
### Half-buried vertical mattress sutures

The half-buried vertical mattress suture is a modification of the vertical mattress suture and eliminates 2 of the 4 entry points, thereby reducing scarring. The half-buried vertical mattress suture is placed in the same manner as the vertical mattress suture, except that the needle penetrates the skin to the level of the deep part of the dermis on one side of the wound, takes a bite in the deep part of the dermis on the opposite side of the wound without exiting the skin, crosses back to the original side of the wound, and exits the skin. Entry and exit points therefore are kept on one side of the wound.



### Pulley sutures

The pulley suture is a modification of the vertical mattress suture. When pulley sutures are used, a vertical mattress suture is placed, the knot is left untied, and the suture is looped through the external loop on the other side of the incision and pulled across. At this point, the knot is tied. This new loop functions as a pulley, directing tension away from the other strands (see image below). Pulley stitch, type 1.

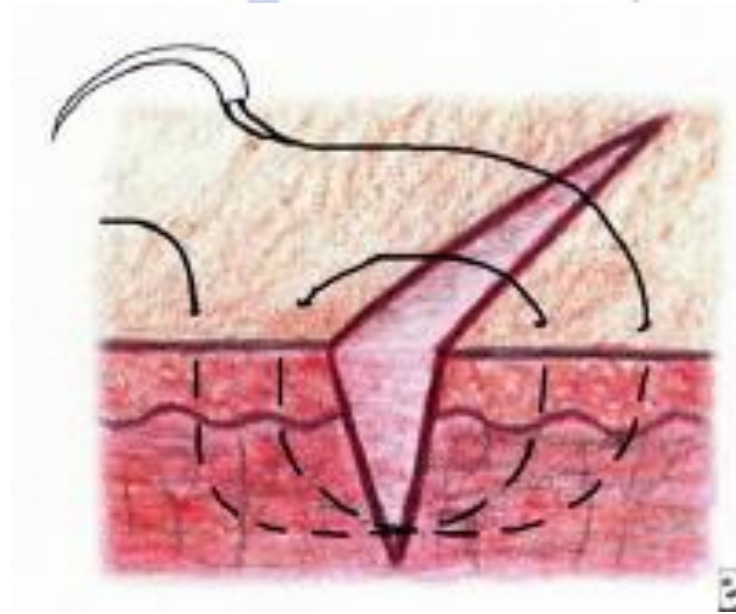


*Pulley stitch, type 1.*



### Far-near near-far modified vertical mattress sutures

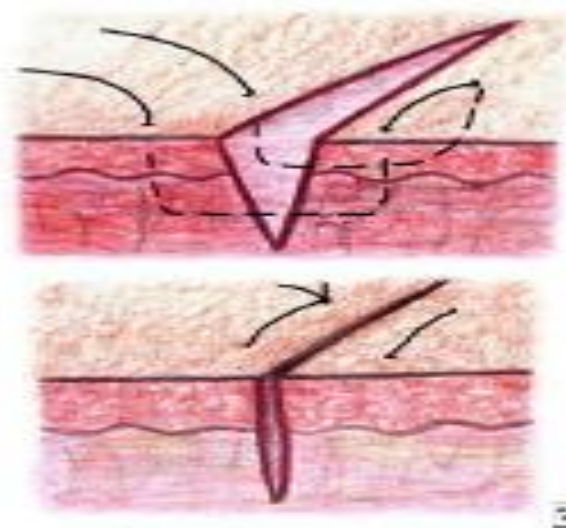
Another stitch that serves the same function as the pulley suture is the far-near near-far modification of the vertical mattress suture. The first loop is placed approximately 4-6 mm from the wound edge on the far side and approximately 2 mm from the wound edge on the near side. The suture crosses the suture line and reenters the skin on the original side at 2 mm from the wound edge on the near side. The loop is completed, and the suture exits the skin on the opposite side 4-6 mm away from the wound edge on the far side. This placement creates a pulley effect (see image below).



*Far-near near-far pulley stitch.*

### Horizontal mattress suture

The horizontal mattress suture is placed by entering the skin 5 mm to 1 cm from the wound edge. The suture is passed deep in the dermis to the opposite side of the suture line and exits the skin equidistant from the wound edge (in effect, a deep simple interrupted stitch). The needle reenters the skin on the same side of the suture line 5 mm to 1 cm lateral of the exit point. The stitch is passed deep to the opposite side of the wound where it exits the skin and the knot is tied .



*Horizontal mattress suture.*

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