

## SUTURE REVOLUTION: WEAVING INNOVATION IN WOUND HEALING

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## ABSTRACT

Sutures are essential medical devices used in wound closure, promoting tissue healing and reducing the risk of complications. Over the years, significant advancements in suture materials and technology have enhanced their performance, biocompatibility, and clinical outcomes. This paper explores the evolution of suture materials, including natural and synthetic options, and highlights the development of innovative coatings and antimicrobial properties aimed at improving healing efficiency and reducing infection rates. It also covers its biomechanical properties, degradation profiles, and the considerations of suture selection with respect to tissue response and patient recovery. Overall, this review highlights key areas of progress while offering perspectives on future directions in suture technology, with special emphasis on the roles of material science and clinical application toward optimizing surgical outcomes and beyond.

## INTRODUCTION

Suture is a general term for all materials used to stitch torn tissues. Surgical sutures are imperative in management of surgical and traumatic wounds. Sutures are primarily used to oppose tissues together to assist and accelerate the recovery process after an incident or surgical operation. In addition, sutures also aid in obliteration of dead space, even distribution of stress on the incision line, and maintenance of adequate tensile strength throughout the critical wound healing process until appropriate tissue strength is achieved.<sup>[3]</sup>

In addition to increasing the risk of infection and causing functional issues like pain, impaired tissue function, and chronic wounds, improper wound closure can cause wound dehiscence or prolonged healing. In addition to causing cosmetic problems such as skin color changes, noticeable scars, keloid formation, and tissue distortion, it may also contribute to the loss of soft or hard tissue grafts or implant.<sup>[2]</sup>

In the past, wound closure devices of some form have been utilised; these mechanisms roughly resemble present sutures. Thousands of years before the Common Era (BCE), sutures were inserted into wounds using eyed needles, often made of bone.

Sutures were made from a variety of plants, including hemp, flax, hair, linen, pig bristles, grass, and reeds. Sushruta wrote about suturing with bark, tendon, hair, and silk in 500 BCE. Besides Pare and Lister, other prominent surgeons such as Galen and Antyllus also

discussed the use of old-fashioned sutures. Before the invention of the current suture, which gained popularity in the middle of the 20th century, the mouth of pincher ants was once employed to approximate wounds.<sup>[1]</sup>

Since there are so many different types of sutures available today, it is important to understand their properties in order to choose the right type: the best sutures are easy to work with, provide adequate strength and knot security, can tolerate changes in the wound, including swelling and recoil, have a low risk of infection or inflammation, are easily visible, and are reasonably priced. No suture is known to have all of these qualities.<sup>[8]</sup>

## Background

Suturing is a method that has been used for thousands of years to close cutaneous wounds. While suture materials and other aspects of the technique have changed, the main objectives have remained the same:<sup>[8]</sup>

1. Closing dead space
2. Supporting and strengthening wounds until healing increases their tensile strength
3. Approximating skin edges for a functional and aesthetically pleasing result
4. Reducing bleeding and infection risks.

A poorly executed suture technique or poor choice of suture method might damage the postoperative appearance of a well designed closure or flap. On the other hand, careful suturing cannot completely make up for poor surgical skill. Poor incision placement with

respect to relaxed skin tension lines, excessive loss of tissue, or inadequate undermining may limit the surgeon's options in wound closure and suture placement. Gentle manipulation of the tissue is also crucial to enhance wound healing.

To maximize the functional and cosmetic outcomes, dead space must be removed, natural anatomic contours must be restored, and suture marks must be minimized.<sup>[8]</sup>  
<sup>[12]</sup>

The following factors influence the suture technique selection:

- Skin thickness
- Anatomical location and type of wound
- Tension level
- Desired cosmetic outcome

Suture placement improves the accurate approximation of the wound margins, reducing and redistributing skin tension. To increase the possibility of a good epidermal approximation, wound eversion is necessary. To reduce the possibility of scar depression brought on by tissue contraction during healing, eversion is preferred. Inversion is generally undesirable and is unlikely to reduce the likelihood of hypertrophic scarring in a person who is predisposed to hypertrophic scarring.<sup>[8]</sup> <sup>[12]</sup> <sup>[3]</sup> <sup>[13]</sup>

### History

Different suture materials have been proposed or used over many millennia. Bone or metals like copper, silver, and bronze wire were used to make needles. Animal materials (hair, tendons, arteries, muscle strips and nerves, silk, and catgut) or plant materials (flax, hemp, and cotton) were used to make the sutures.<sup>[14]</sup> <sup>[11]</sup>

Suture techniques were described by Hippocrates, the Greek father of medicine, and Aulus Cornelius Celsus, the later Roman physician. The earliest known surgical suture dates to 3000 BC in ancient Egypt, and the oldest suture is found in a mummy from 1100 BC. In 500 BC, the Indian sage and physician Sushruta wrote a detailed description of a wound suture and the suture materials used in it. Catgut or surgical gut sutures were described by the Roman physician Galen in the second century. In the 10th century, the catgut sutures together with the surgery needle were employed in operations by Abulcasis. The gut suture, which involves extracting sheep or cow intestines, resembled the strings used on violins, guitars, and tennis racquets. Because the substance was not always sterilised and disinfected, catgut occasionally resulted in infection.<sup>[11]</sup> <sup>[15]</sup>

All suture threads should be routinely sterilised, according to Joseph Lister, who first tried it with "carbolic catgut" in the 1860s, then chromic catgut twenty years later, and finally sterile catgut with iodine treatment in 1906.<sup>[15]</sup> <sup>[14]</sup>

The twentieth century saw the next major leap: the chemical industry drove the production of the first synthetic thread in the early 1930s, which exploded into the production of numerous absorbable and non-absorbable synthetics. The first synthetic absorbable was based on polyvinyl alcohol in 1931. Polyesters were developed in the 1950s and later, the process of radiation sterilisation was established for both polyester and catgut, the discovery of polyglycolic acid in the 1960s and its implementation in the 1970s. Today, the majority of sutures are made of synthetic polymer fibers, the only materials still in use today are silk and, infrequently, gut sutures, which are the only ancient materials still in use today.<sup>[15]</sup> <sup>[14]</sup>

### Types of sutures

The different types of sutures can be classified in many ways-

1. Absorbable versus non-absorbable: Suture material can be categorised as either absorbable or nonabsorbable. Your physician does not need to remove absorbable sutures. This is because they are naturally broken down by enzymes that are present in your body's tissues.

2. Synthetic versus natural: Secondly sutures can be categorised as either synthetic or natural. However, this differentiation is not really helpful because all suture material is sterilised.

3. Multifilament vs. monofilament : Thirdly, the suture material can be categorised based on its true structure. Sutures made with monofilament have just one thread. As a result, the suture can penetrate tissues more readily. A number of tiny threads are braided together to form braided sutures. Better security may result from this, but the risk of infection may also rise.<sup>[8]</sup> <sup>[10]</sup>

### I. Types of absorbable sutures

A. Gut: Internal soft tissue lesions or lacerations are repaired with this natural monofilament suture. Neurological and cardiovascular treatments should not be performed in the gut. This stitch causes the strongest reaction in the body, which frequently results in scarring. Outside of gynecological surgery, it is hardly frequently utilised.

#### 1. Polyfilament, or the plain gut

Overview: Degrades completely in 10 weeks, maintaining its former strength for 7–10 days.

Benefits and drawbacks: exceptional flexibility that enables adjustment to tissue oedema. Rarely causes tissue damage while passing through the skin. Tensile strength is rapidly lost as a result of poor handling and strong tissue reactivity. Common application: mucosal tissues, which have a good blood supply and recover quickly, are the greatest candidates.<sup>[3]</sup> <sup>[4]</sup> <sup>[7]</sup>

## 2. Chromic gut (polyfilament)

Overview: Degrades completely in 16–18 weeks, maintaining its former strength for 21–28 days.

Benefits and drawbacks: exceptional flexibility that enables adjustment to tissue oedema. rarely causes tissue damage while passing through the skin. The chromic salt coating improves handling and reduces tissue reaction.

Common applications include genitalia, mucosa, and skin closure (face).<sup>[3] [4] [7]</sup>

## 3. Fast gut (polyfilament)

Overview: Heat treatment is applied to further degrade protein and facilitate faster absorption in body tissues. Tensile strength in 3–5 days or less than a week.

Benefits and drawbacks: Superior elasticity that permits adjustment for tissue enlargement. rarely causes tissue damage while passing through the skin.

Common application: Skin closure is usually only advised for the face or mucosa.<sup>[3] [4] [7] [10] [17]</sup>

## B. Polydioxanone (PDS)

This artificial monofilament suture is useful for paediatric cardiac surgeries as well as a variety of soft tissue wound repairs, including abdominal closures.

Tensile strength decreases after 36–53 days.

Benefits and drawbacks include low tissue reactivity, high tensile strength, and subpar handling.

Common application: subcutaneous, where great tensile strength is required for the closure of abdominal incisions.<sup>[3] [4] [7]</sup>

## C. Polyglecaprone (MONOCRYL)

This artificial monofilament suture is utilised for soft tissue healing in a variety of applications. It is not recommended to utilise this substance for neurological or cardiovascular treatments. The most popular application for this suture is invisible skin closure. This is a synthetic material copolymer. Tensile strength rapidly decreases; by the first week, 60% of it is gone. Within three weeks, all strength was lost.<sup>[3] [4] [7]</sup>

Benefits and drawbacks: high tensile strength, excellent elasticity, excellent cosmetic outcomes decreased hypertrophic scarring, minimal tissue reaction, good knot security originally; however, the material makes the security unreliable over time, thus it is important to keep ears of material long.

Common application: Suggested for superficial and subcutaneous tissue closure.<sup>[3] [4] [7]</sup>

## D. Polyglactin (Vicryl)

This artificially braided suture works well for bandaging cuts on the hands or face. It is not recommended for use in neurological or cardiovascular operations.

Overview: The entire tensile strength is lost in 28 days.

Benefits and drawbacks include low tissue reactivity, high tensile strength, and secure knotting.

Common application: Subcutaneous tissue and skin closure (avoid using Vicryl dye on the face) are common uses.<sup>[3] [4] [7]</sup>

## II. Types of nonabsorbable sutures

All of these suture types are generally applicable to soft tissue repair, including neurological and cardiovascular treatments.

A. Nylon- A natural monofilament suture. Surgical steel, nylon, and polypropylene are examples of synthetic materials. These materials are monofilaments with high tensile strength.

Overview: polyamide Nylon (monofilaments, Dermalon, Ethilon)

Benefits and drawbacks: outstanding strength in tensile tests. However, because of the strong material memory, there is poor knot security and poor handling.

Common application: Because of its low tissue reactivity, it's great for superficial skin closure. Because of its exceptional adaptability to possibly expanding tissues (oedema), it is the most widely used skin suture.<sup>[17] [7]</sup>

B. Polypropylene (Prolene) a synthetic monofilament suture. Nylon (Supramid, Surgilon, Nurolon, and polyfilaments.

Described as polyamide.

Benefits and drawbacks: superior than its monofilamentous counterpart in terms of knot security, usage, and tensile strength. Its polyfilamentous structure, however, is considered to raise the danger of infection [weasel words]

Common application: Soft tissue, vascular ligations, and superficial skin (particularly face lacerations) are common uses.<sup>[17] [7]</sup>

## C. Silk- A braided natural suture.

A protein generated from silkworms, surgical silk is coated to reduce water absorption and friction.

Benefits and drawbacks of this material include its high knot security, ease of handling, and exceptional tensile strength. However, because of its strong tissue reactivity, which results in months of tensile strength loss, it is rarely utilised internally.

Common application: Surgical silk is no longer indicated for use due to improvements in sutures. Nonetheless, it is still frequently employed in dentistry to secure surgical tubes to the body's surface or to treat mucosal regions.<sup>[17][7]</sup>

D. Polyester (Ethibond): A synthetic suture that is braided.

Overview: made from polyethylene terephthalate, there are various brands and configurations of this type of suture. Many are dyed for visibility, braided, and silicone-coated.

Benefits and drawbacks: Low tissue reactivity results in high tensile strength, good handling, and secure knots.

Nevertheless, this suture is more costly than its alternatives and may cause more tissue damage during skin penetration.

Common application: Due to its superior handling, it is frequently used in pediatric valvular surgery and as an alternative to surgical steel in orthopedic surgery.<sup>[17][7]</sup>

E. Surgical steel- Description: synthetic mixture of multiple alloys.

Benefits and drawbacks: Outstanding tensile strength and low tissue reactivity mean that deterioration is kept to a

minimum over time. The handling of this suture material is extremely subpar.

Common application: orthopedics, sternum closure.<sup>[17][7]</sup>

### • Sutures Techniques

#### 1. Simple interrupted suture-

Interrupted sutures are easier to apply than running (continuous) sutures, have a higher tensile strength, and are less likely to cause wound oedema and decreased cutaneous circulation. Interrupted sutures also allow the surgeon to make modifications as needed to appropriately align wound edges as the wound is sutured. A 2019 study revealed that high-density suture spacing (about 5 mm apart) could increase early scar formation, but observed that inserting sutures farther apart (roughly 10 mm) resulted in fewer puncture holes, lowers tissue damage, saves surgical time, and conserves suture material.

Interrupted sutures have the drawbacks of taking a long time to place and an increased chance of crosshatched marks (such as railway tracks) appearing across the suture line. To reduce the danger of crosshatching, sutures should be removed early to avoid the formation of suture tracks.<sup>[8][9][13][18][21]</sup>

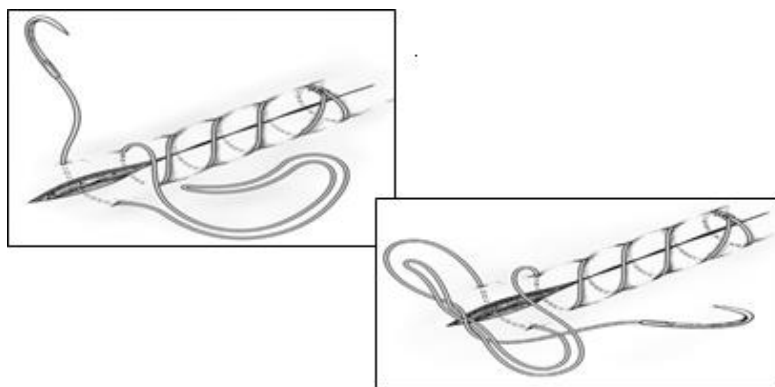


**Fig. 1: Simple interrupted suturing diagrammatic representation.**

#### 2. Simple running suture

Running sutures are useful for long wounds in which wound tension has been minimized with properly placed deep sutures and in which approximation of the wound edges is good. A split- or full-thickness skin transplant can also be secured using this kind of stitch. Simple running sutures are thought to cause fewer knots than interrupted sutures, which should result in less scarring; however, the number of needle insertions is the same. Skin grafts have been secured with tie-over bolsters and basting sutures.

Simple flowing sutures have the advantage of being easier to put and reapproximating wound margins more quickly than simple interrupted sutures. Disadvantages include probable crosshatching, the risk of dehiscence if the suture material ruptures, difficulty in making precise modifications along the suture line, and puckering of the suture line when the stitches are inserted in thin skin.<sup>[8][9][13][18][21]</sup>



**Fig. 2- Simple running suture diagrammatic representation.**

3. Running Locked Suture: Due to their higher tensile strength, locked sutures are recommended for moderately tensioned wounds or those that need extra homeostasis due to leaking from the skin's extremities.

If applied excessively firmly, running locking sutures can strangle tissue and raise the risk of affecting the

microcirculation around the site. As a result, only well-vascularized areas should employ this kind of suture. When more homeostasis is required, the running locked suture may be especially helpful on the scalp or in the postauricular sulcus.<sup>[8] [9] [13] [18] [21]</sup>

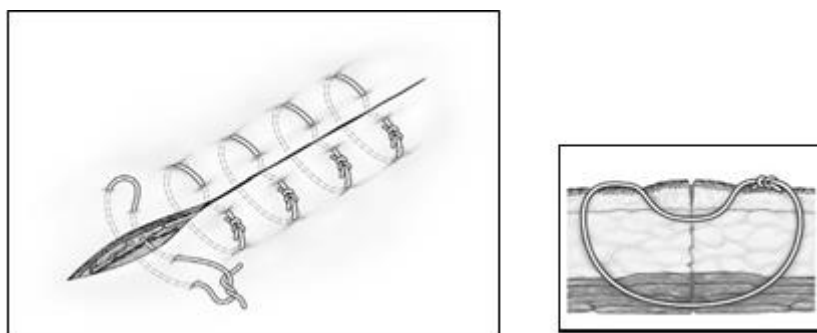


**Fig. 3: Running Locked Suture diagrammatic representation.**

4. Vertical mattress suture: This type of suture is very helpful for minimizing strain across the wound, maximizing wound eversion, and decreasing dead space. Crosshatching is one of this suture's drawbacks. Because of the increased tension across the wound and the four places where the stitch enters and exits the skin, there is a higher chance of crosshatching.

To lower the chance of scarring, it is advised to remove this suture between five and seven days before the

epithelial suture tracks have fully formed. Supports can be positioned between the suture and the skin to reduce contact if the suture needs to be left in place for an extended period of time. When the wound grows due to postoperative oedema, using bolsters reduces the risk of tissue strangulation. With this suture, it's extremely crucial to take symmetric bites and place each stitch correctly.<sup>[8] [9] [13] [18] [21]</sup>



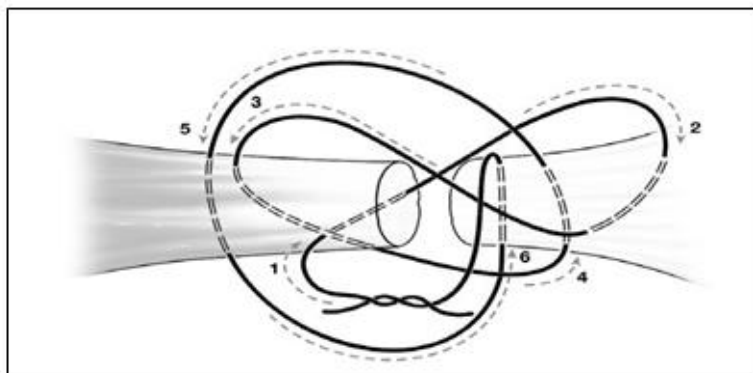
**Fig. 4: Vertical mattress suture diagrammatic representation.**



5. Far-near near-far modified vertical mattress suture: A modified vertical mattress suture that is far-near near-far. When tissue expansion is required, the far-near near-far variation of the vertical mattress suture—which essentially works as a pulley suture—can be utilised intraoperatively. When starting to close a wound that is under a lot of strain, this suture is also helpful. The placement of buried sutures is made easier by approximating the incision boundaries by placing pulley stitches first. If wound tension has been sufficiently dispersed following the insertion of the hidden and surface sutures, the pulley stitches can be either left in

place or removed once wound closure is complete.<sup>[8] [9] [13] [18] [21]</sup>

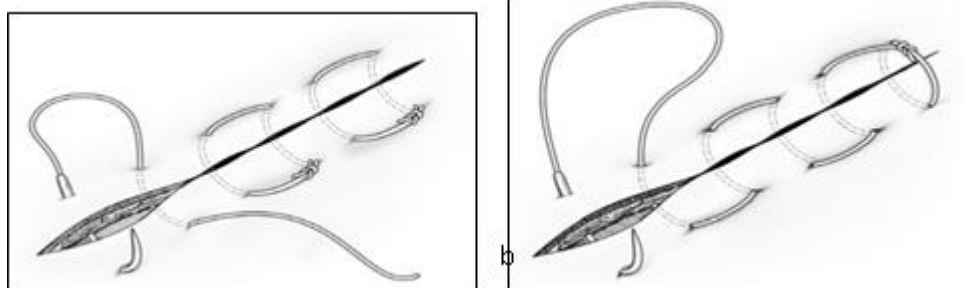
6. Suture pulley: The pulley suture allows for more stretching of the wound margins and is utilised when more wound closure strength is sought. It has been demonstrated to significantly minimise the size of the defect, streamline reconstructive procedures, and allow for the repair of major head and neck skin cancer deformities in a clinic setting as opposed to an operating room.<sup>[8] [9] [13] [18] [21]</sup>



**Fig. 6: Suture pulley diagrammatic representation.**

7. Horizontal mattress: patterns can be interrupted or continuous, with sutures parallel to the wound edges. Each stitch is equivalent to two simple interrupted

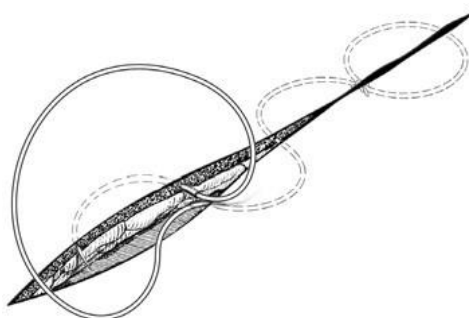
stitches. Horizontal sutures constrain minor blood vessels along the wound edges.<sup>[8] [9] [13] [18] [21]</sup>



**Fig.7: Horizontal mattress diagrammatic representation.**

8. Subcuticular sutures in motion: A buried version of a running horizontal mattress suture is called a running subcuticular suture. It is implanted by taking horizontal bites through the papillary dermis on alternating sides of

the wound (see the figure below). The suture may remain in place for a few weeks and there are no visible suture marks.<sup>[8] [9] [13] [18] [21]</sup>



**Fig. 8: Subcuticular sutures diagrammatic representation.**

### • Suture removal

The location and level of tension the wound was closed under determine how long it will take to remove the sutures. Although this depends on the physician and the circumstances, sutures on the head and neck are often taken out five to seven days after surgery, and those on the trunk or extremities are usually taken out between ten

and fourteen days. To remove sutures, elevate the knot by gradually pulling one tail of the suture towards one side of the wound while holding it in place using forceps. Then, right beneath the knot, cut the opposite side of the suture with stitch-cutters or fine suture scissors. By pulling in the opposite direction from the wound, the suture can then be extracted from the tissue.<sup>[20]</sup>

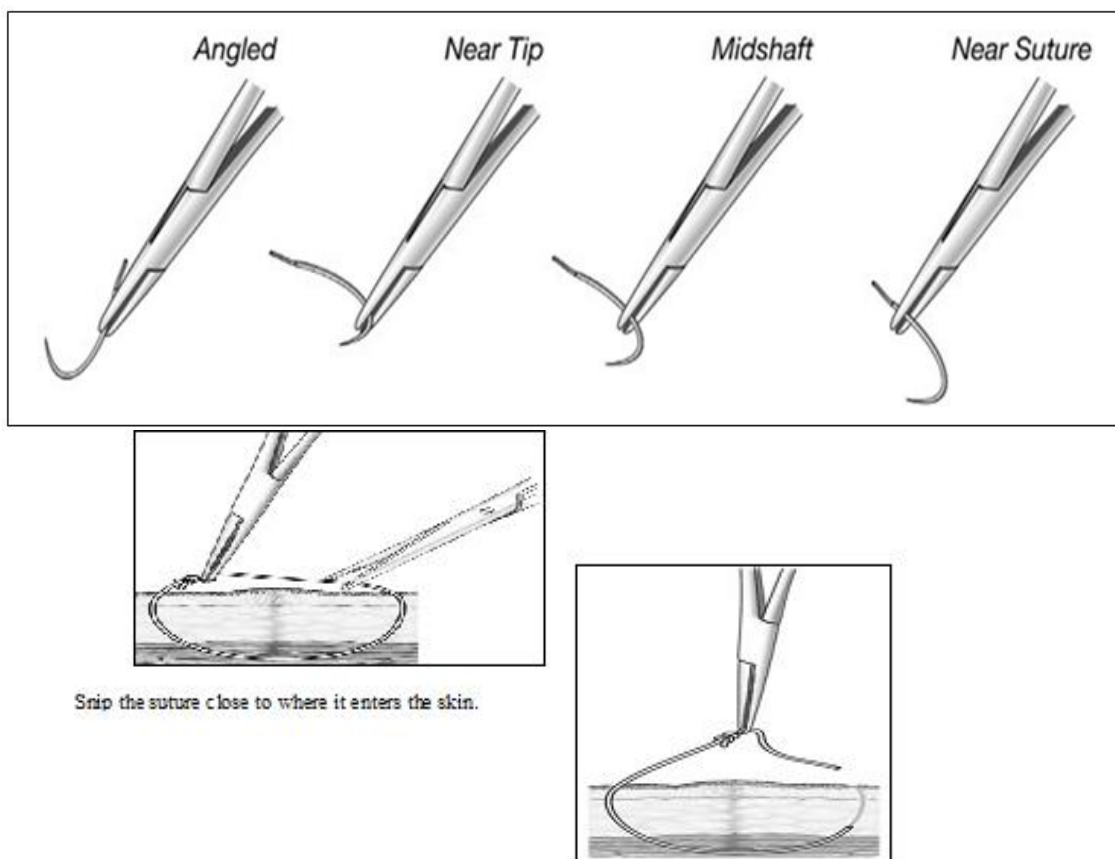


Fig. 9: Suture removal techniques.

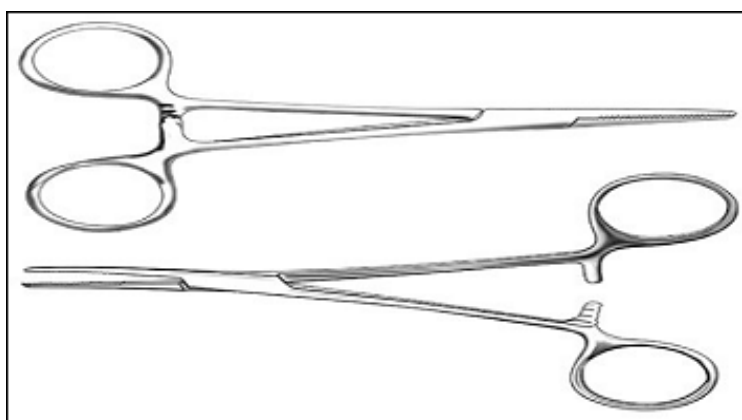


Fig. 9.2: Suture removal curved and open scissors.

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