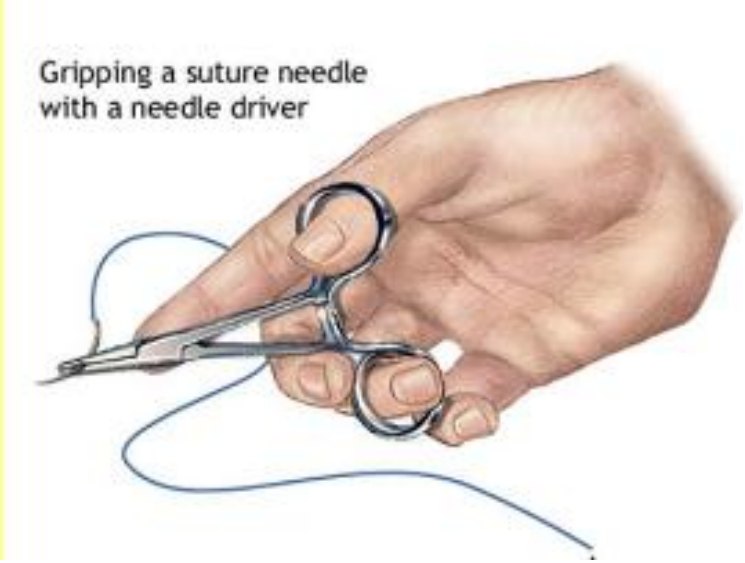


Sutures

INTRODUCTION

- Sutures are the materials used in operation theatre for joining the two edges of the incised surgical or other wound.
- Suture need to be strong & non irritant to skin & body tissues.
- Sutures should be of such materials that can be easily sterilized.

History

2000 B.C: using strings & animal for suturing

Hippocrates: concept of suturing

200 A.D: Gut of sheep intestine was1st mentioned as suture material

900 A.D: 1st surgical gut (catgut) for suturing abdominal wounds by an Arabian surgeon

1500: French army surgeon developed ligation technique for traumatic war injuries

1901: catgut & Kangaroo gut were available in sterile glam tubes

Many materials used: Gold, Silver, metallic wire, silk wire, gut, silk, cotton, tendon, horsehair, linen

Qualities of a suture material

- Adequate tensile strength
- Functional strength
- Non reactivity
- Non capillary
- Flexibility & elasticity
- Easy to handle
- Knotable

Easily sterlisable

Uniformity

Smooth surface

Monofilament

Absorbility

Tensile Strength of Sutures

- Dependent upon
  - Material
  - Size/diameter
  - Condition
    - Wet
    - Dry
    - Knotted
    - Absorption of bodily fluids
      - Hydrophobic
      - Hydrophilic
    - “Abuse”
    - Heat history – “re-autoclaving”

Ideal Suture Material

- Achieve its purpose
- Disappear as soon as its work was accomplished
- Easy to handle
- Stretched, accommodate wound edema & recoils to original length with wound contraction
- Minimal tissue reaction & not predisposed to bacterial overgrowth
- Be non-irritant
- Capable of secure Knot without fraying or cutting

Characteristics of suture material

Physical characteristic

- **Physical configuration:** mono or multifilament
- **Capillarity:** ability to soak up fluid along the strand
- Fluid absorption ability
- **Diameter:** in millimeters, expressed in USP sizes with zeroes
- (no. of 0s', if increased → diameter decreased → tensile strength decreased)
- **Tensile strength:** amount of weight (Breaking load) necessary to break a suture (Breaking Strength)
- **Elasticity:** Inherent ability to regain original form & length after being stretched

Characteristics of suture material

- Handling characteristics
  - Pliability: the material ability to bend
  - Coefficient of friction : the material ability to slip through tissues & ties
  - Knot Strength: force necessary to cause a given type of Knot to slip, partially or completely

Characteristics of suture material

Tissue reaction characteristics:

- Inflammatory and fibrous tissue reaction
- Absorption
- Potentiation of infection
- Allergic reaction

Classification of Sutures

Monofilament	Multifilament
Synthetic	Biological
Absorbable	Non - Absorbable

Suture Material

- 3 ways of classifying suture material:
  - **Natural** *or* **Synthetic**
  - **Absorbable** *or* **Non-Absorbable**
  - **Monofilament** *or* **Braided/Twisted**

Natural
- Silk, linen, catgut

Silk

Catgut

Synthetic polymer
- Polypropylene, polyester, polyamide

Polypropylene

Polyester

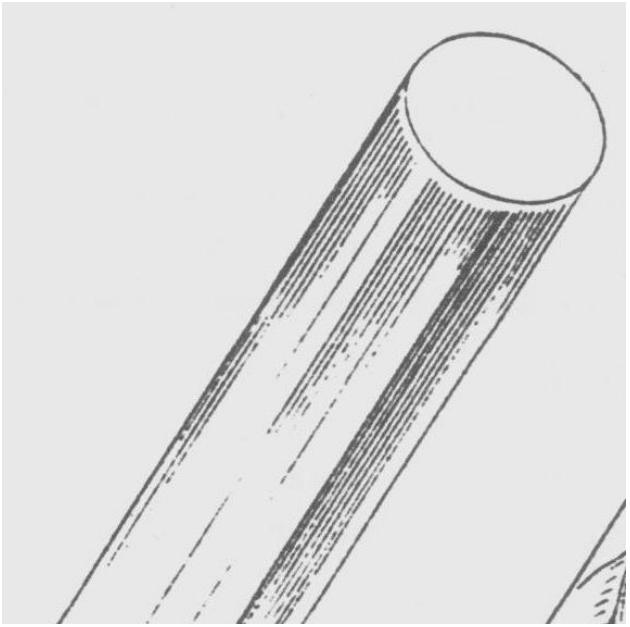
- **Absorbable**
  - *catgut, polydioxanone, polyglycolic acid*
  - Used for deep tissues, membranes, & subcuticular skin closure
- **Non-Absorbable**
  - *polyester, nylon, stainless steel*
  - Used for skin (removed) & some deep structures (tendons, vessels, nerve repairs – not removed)

Monofilament Suture

- Grossly appears as single strand of suture material; all fibers run parallel
- Minimal tissue trauma
- Resists harboring microorganisms
- Ties smoothly
- Requires more knots than multifilament suture
- Possesses memory
- Examples:
  - Monocryl, PDS, Prolene, Nylon

Mono-filament

- **single strand of material**
- High handling characteristics (passes more smoothly through tissues + tie down easily)
- Less tissue reaction characteristics (resist harboring organisms which may cause suture line infection
- Higher chance of suture breakage
- Lower physical characteristics (lesser tensile strength, pliability & flexibility)



Monofilament

Advantages

- Smooth surface
- Less tissue trauma
- No bacterial harbours
- No capillarity

Disadvantages

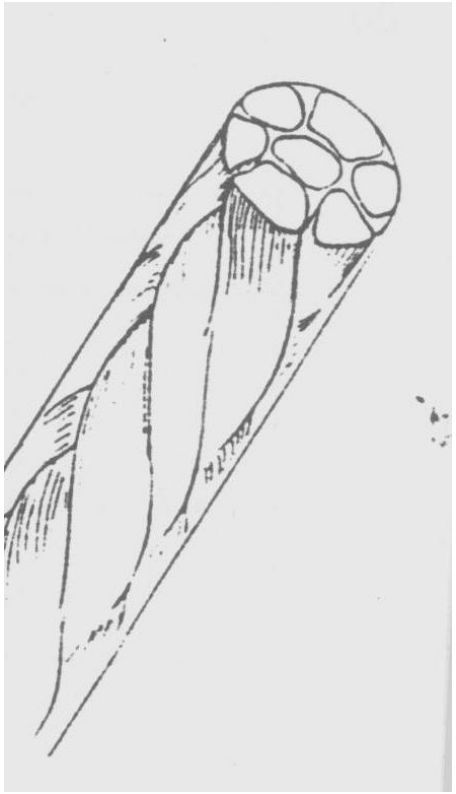
- Handling & knotting
- Ends/knot burial
- Stretch

Multifilament Suture

- Fibers are twisted or braided together
- Greater resistance in tissue
- Provides good handling and ease of tying
- Fewer knots required
- Examples:
  - Vicryl (braided)
  - Chromic (twisted)
  - Silk (braided)

Poly-filament

- several filaments or strands twisted or braided together
- Lower handling characteristics
- More tissue reaction characteristics
- Lower chance of suture breakage
- Higher physical characteristics



Multifilament

Advantages

- Strength
- Soft & pliable
- Good handling
- Good knotting

Disadvantages

- Bacterial harbours
- Capillary action
- Tissue trauma

Synthetic Suture

- Synthetic polymers
- Do not cause intense inflammatory reaction
- Examples:
  - Vicryl
  - Monocryl
  - PDS
  - Prolene
  - Nylon

Synthetic

Advantages

- Non-Absorbables are inert
- Absorbables resemble natural substances
- Absorption by hydrolysis
- Predictable absorption
- Strength

Disadvantages

- Monofilament handling

Biological

Advantages

- Handling & knotting
- Economy

Disadvantages

- Tissue reactions

Absorbable

- Sutures which are broken down & eventually absorbed by either hydrolysis (Synthetic) or digested by lysosomal enzyme elicited by WBC's (natural)

- Mechanism
  - Natural 

Attack & break Down strands
  - Synthetic 

water gradually penetrate suture filaments & break down suture polymer chain

Absorbable

Advantages

- Broken down by body
- No foreign body left
- Examples:
  - "Catgut"
  - Chromic
  - Vicryl
  - Monocryl
  - PDS

Disadvantages

- Consideration of wound support time

A) ABSORBABLE SUTURES

- Absorbable sutures are also known as catgut.
- A tough thin cord made from the treated and stretched intestines of certain animals, especially sheep
- This type of suture are commonly used to suture the inner structure of the body such as:
  - Walls of the organs
  - Rectal sheath
  - Muscles
  - Subcutaneous tissue
  - Peritoneum
  - Intestinal anastomosis

1) Plain catgut

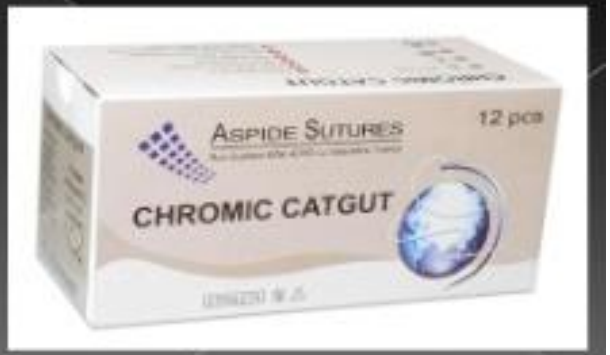
- These sutures are completely digested & absorbed by the tissue.
- Sizes of the absorbable catgut suture vary from 5/0 which is the finest to 2 which is the thickest.
- Catgut has an expensive.
- The raw product of the catgut is submucosal layer of the sheep intestine.
- When these are prepared each pieces is split longitudinally into 3 or 4 ribbons.
- All the fatty & muscle layer are scrapped off in an alkaline bath.

Cont…….d

- The strands are then dried.
- After that catgut is packed in sealed container & is sterilized by cobalt irradiation.
- This makes yellow colored plain catgut which is absorbed rapidly & is absorbed earlier than the chromic catgut.

2) Chromic catgut

- an absorbable sterile strand derived from the intestinal submucosa of sheep and fixed in formalin, used as a surgical ligature and suture.
- surgical catgut that has been treated with chromium trioxide to strengthen it. It is an absorbable suture
- The chromic catgut is of brown color & is absorbed slowly.
- To chromised the catgut, it is soaked in a bath of chromic acid with frequent period of movement of 3 hours.
- The strands are then graded into size
- Then the catgut is packed & sterilized.



3) Atraumatic catgut

- It is another type which is used for ligating small blood vessels.
- Dexon (Polyglycolic acid) is also an absorbable suture synthetically prepared.
- It is available in various sizes such as 3/0 to 2.
- This suture is used as ties for small blood vessels & also for suturing peritoneum ,rectal sheath etc.

Non- absorbable

material which tissue enzymes can't dissolve, remains

encapsulated when buried in tissues or removable post-op when used as skin suture

- Examples:
  - Prolene
  - Nylon
  - Stainless steel
  - Silk*

  (*not a truly permanent material; known to be broken down over a prolonged period of time—years)

Nonabsorbable

- Retain majority of breaking strength for more than 60 days
- Three classes
  - Class I – silk, monofilament, and sheathed
  - Class II – cotton and linen
  - Class III – metallics
- Classes I and III most common as Class II are prone to contamination and infection

Non - Absorbable

Advantages

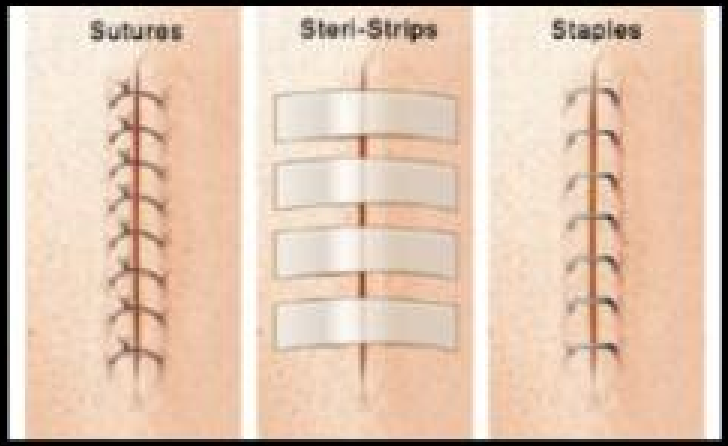
- Permanent wound Support

Disadvantages

- **Foreign body left**
- **Suture removal can be costly and inconvenient**
- **Sinus & Extrusion if left in place**

6) Non absorbable sutures

- These types of sutures are not absorbed.
- These sutures are used for closing or suturing outer surface of the body such as skin.
- These sutures are cheaper ,easy to handle ,easy to sterile ,have smooth surfaces & knot securely with the ends cut short.



Cont.....d

- But these kind of sutures are liable to cause stitch infection & stitch sinus.
- The infection cab be arrested by only removing the stitch .
- For this reason sutures on the superficial surface of the skin should always be interrupted suture & never be continuous suture.
- Because the disadvantage of the continuous suture is when infection occurs on one site it is difficult to remove the infected stitch from the site without removing the rest of the stitch.
- While stitching ,preferably all knots are to tied at the one side of the surgical wound.

Types of non absorbable sutures

a) Silk suture: these suture are non absorbent. Their sizes vary from 10/0 to 2 . These are used for skin closure after abdominal operation.

b) Linen suture : these sutures are also non absorbent .their sizes vary form 3/0 to 2 . These are used for skin closure in hernia operation.

Cont…….d

c) Monofilament Nylon suture (Ethilon) : These are non absorbable suture. Their sizes vary from 10/0 to 2. these sutures are used as tension sutures in hernia repair.

d) Stainless steel wire: these are non absorbent sutures used in areas of known infection.

- It is also used for secondary repair of disrupted wound.
- It is further used for surgery of ligament ,tendons.
- It is again used for repair of cleft lip .hair lip cleft palate ,hernia operations ,thoracic & orthopedic surgery.

Cont…..d

e) Prolene –Ethifex merseline : These non absorbent sutures are used for cardiovascular & plastic surgery.

f) Metal Clips : these non absorbent types of suture are of various types such as :

- Michael clips
- Trazies
- Van petz

Cont……d

- The chemical composition of the suture determines the rate of occurrence of skin infection.
- Though catgut & silk sutures have been used for centuries throughout the world ,amongst the non absorbable suture.
- Silk suture causes increased infection rate .

Suture Degradation

Suture Material	Method of Degradation	Time to Degradation
"Catgut"	Proteolytic enzymes	Days
Vicryl, Monocryl	Hydrolysis	Weeks to months
PDS	Hydrolysis	Months

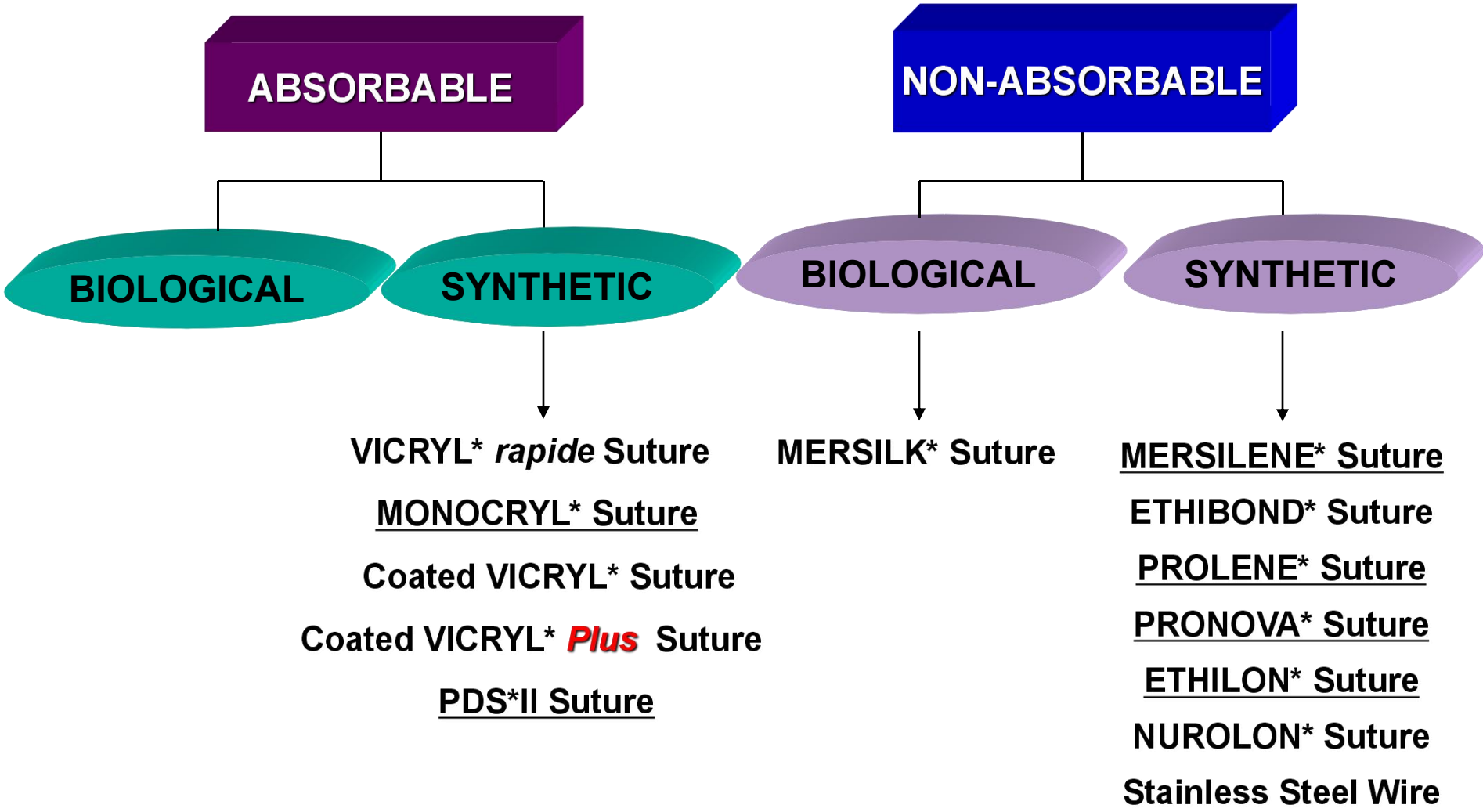
Common Nonabsorbable Sutures

Monofilament	Polypropylene (Prolene* & Surgilene+) Nylon (Ethilon* & Dermalon+)
Braided	Polyester (Mersilene*) Silk Nylon (Surgilon* & Nurolon+)
Braided & Coated	Polyester & Polybuterate (Ethibond*) Polyester & Silicone (Tichron+) Polyester & Teflon (Tevdek#) Silk & Beeswax
Multifilament Sheathed	Multistrand Nylon & Polyethylene Sheath (Supramid$)
*Ethicon Inc., +Davis & Geck Inc., #Deknatel Inc., $S. Jackson Inc.	

Suture Sizes – Two Systems

- United States Pharmacopœia (USP)
  - Complex relationship between diameter, tensile strength, and knot security
  - Precise criteria vary with suture class, natural or synthetic, and absorbability
  - Whole numbers from 5 to 12-0
  - Allows comparison among different types
- European
  - Diameter in mm
  - Differences in tensile strength of materials make comparisons difficult
- Sutures function best when their strength and tissue strength are similar.

ETHICON Sutures



Monofilament version VICRYL* Suture available for use in ophthalmic surgery
MERSILENE* Suture - trochanter suture is braided

C/I	Color &	Me-mory	Knot Security	Hand-ling	TissReactivity	Absorbtion Rate	Tensile Strength	Raw Material	Absorbable
Allergy to collagen or chromium	-	Low	Poor	Fair	Mod.	1-2 weeks	0 % 7-10 days	Beef Flexor Tendon	**Collagen**
Allergy to collagen or chromium	Yellowish brown blue dyed	Low	Poor	Fair	Mod. High	5-7 Weeks	0% at 7- 10 days	Sheep Intestine	**Catgut**
Where extended approximate of tissues is needed	Undyed Violet	Low	Fair	Good	Low	60-90 days	50% at 2-3 weeks	Copolymer lactide & glycolide coated with polyglactin370 + calcium stearate	**Vicryl (polyglactin910)**
Where extended approximate of tissues is needed	Undyed	Low	Fair	Good	Low	90-120 days	50% at 1wk. 20-30% at 2wk. lost at 3wk.	Copolymer of glycolide & epslim-caprolactone	**Monocryl (poligleca pone25)**
Where extended approximate of tissues is needed	Dyed green	Low	Good	Fair	Low	90-120 days	50% at 2-3 weeks	Polyglycolic acid 1st synthetic (1970)	**Dexon (polyglyco lic acid)**
Heart valve prosthesis	Clear violet	High	Poor	Fair	Low	180-210 days	70% at 2wks 50% at 4wks 25% at 6wks	Polydioxano ne	**PDS II (polydioxa pone)**

C/I	Color & Material	Memory	Knot Security	Handling	Tissue Reactivity	Absorbtion Rate	Tensile Strength	Raw Material	Non-Absorbable
Allergy to Silk	Black White	Poor	Good	Good	High	Gradual encapsulation by Fibrous C.T	Good	Organic protein Called Fibroin (silk)	**Silk**
Permanent tensile strength retention needed	Clear Black	High	Poor	Poor	Low	Gradual encapsulation by Fibrous C.T	Good	Long chain aliphatic polymers nylon 6	**Dermalon** **Ethilon** **Monosof (nylon)**
Not Known	Clear Blue	High	Poor	Poor	Low	Nonabs-orbable	High	Isotactic crystalline stereoisomer of polypropylene	**Prolene-Surgilene surgipro**
Not Known	Clear Blue	Low	Poor	Fair	Low	Gradual encapsulation by Fibrous C.T	High	polybutester	**Novafil**
Not Known	Clear Dyed	Fair	Good	Good	Mod.	Gradual encapsulation by Fibrous C.T	High	Polyester polyethylene terephthalate	**Ethibond** **Mersilene** **Dacron Ti-cron**
Allergy to 316 L Steel	Silver Metallic	Poor	Good	Poor	Low	Nonabs-orbable	High	316 L Stainless steel	**Stainless steel suture**

PRINCIPLES OF SUTURE SELECTION

When a wound has reached maximal strength, sutures are no longer needed

Foreign bodies in potentially contaminated tissues may convert contamination to infection

Where cosmetic results are important, close and prolonged apposition of wounds and avoidance of irritants will produce the best results

PRINCIPLES OF SUTURE SELECTION

Foreign bodies in the presence of fluids containing high concentrations of crystalloids may act as a nidus for precipitation and stone formation

Use the finest suture size that match with the natural strength of the tissue

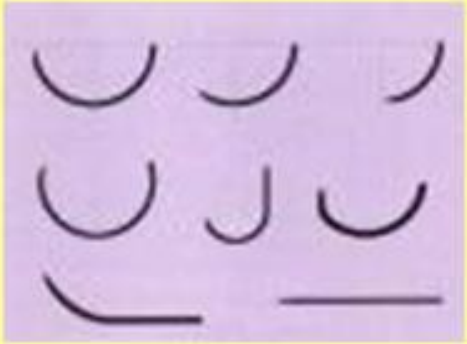
The composition and properties of a suture are the crucial elements in the decision of what type to use

SELECTING THE SUTURE MATERIAL

Ligatures	Coated VICRYL, MERSILK, NUROLON, Catgut:3/0-0
Skin	VCRL* rapide, ETHILON, Undyed MONOCRYL, PROLENE: 6/0-2/0
Subcuticular	Undyed MONOCRYL, Coated VICRYL, clear PDSII, PROLENE with beads & collars: 4/0-2/0
Fascia under Tension	PROLENE, ETHILON, PDSII: 2/0-1
Muscle	Coated VICRYL, Dyed Monocryl, PDSII, Catgut:: 3/0-2
Stomach/Bowel	Coated VICRYL, Dyed MONOCRYL, PDSII: 3/0-1
Tendons	PROLENE, ETHIBOND /EXCEL, Stainless Steel Wire, PDSII: 3/0-1
Blood Vessels	PROLENE, ETHIBOND EXCEL: 8/0-2/0
Oculoplastic	VICRYL* rapide, MONOCRYL, ETHILON, Plain Catgut: 5/0-6/0
Cornea/Sclereal	ETHILON, Monofilament VICRYL, Monofilament MERSILENE: 11/0-9/0
Nerves	ETHILON: 10/0-5/0

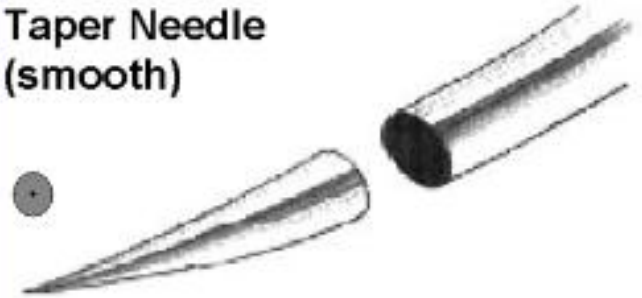
Surgical Needle

- **Curvature**
  - * Most common, general use in all tissues
  - – ¼
  - – 3/8 *
  - – ½ *
  - – 5/8
  - – J-shaped



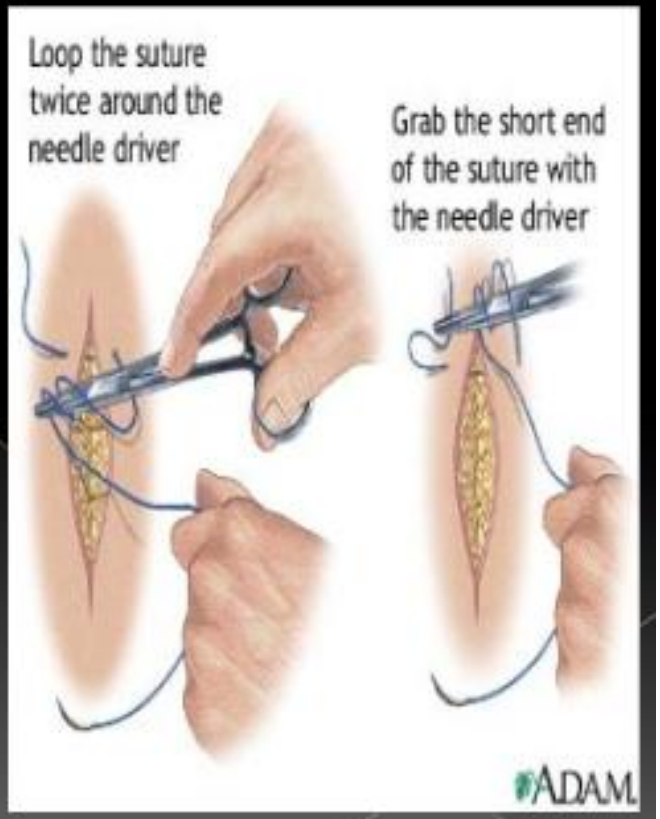
Conventional Cutting Needle

Taper Needle (smooth)



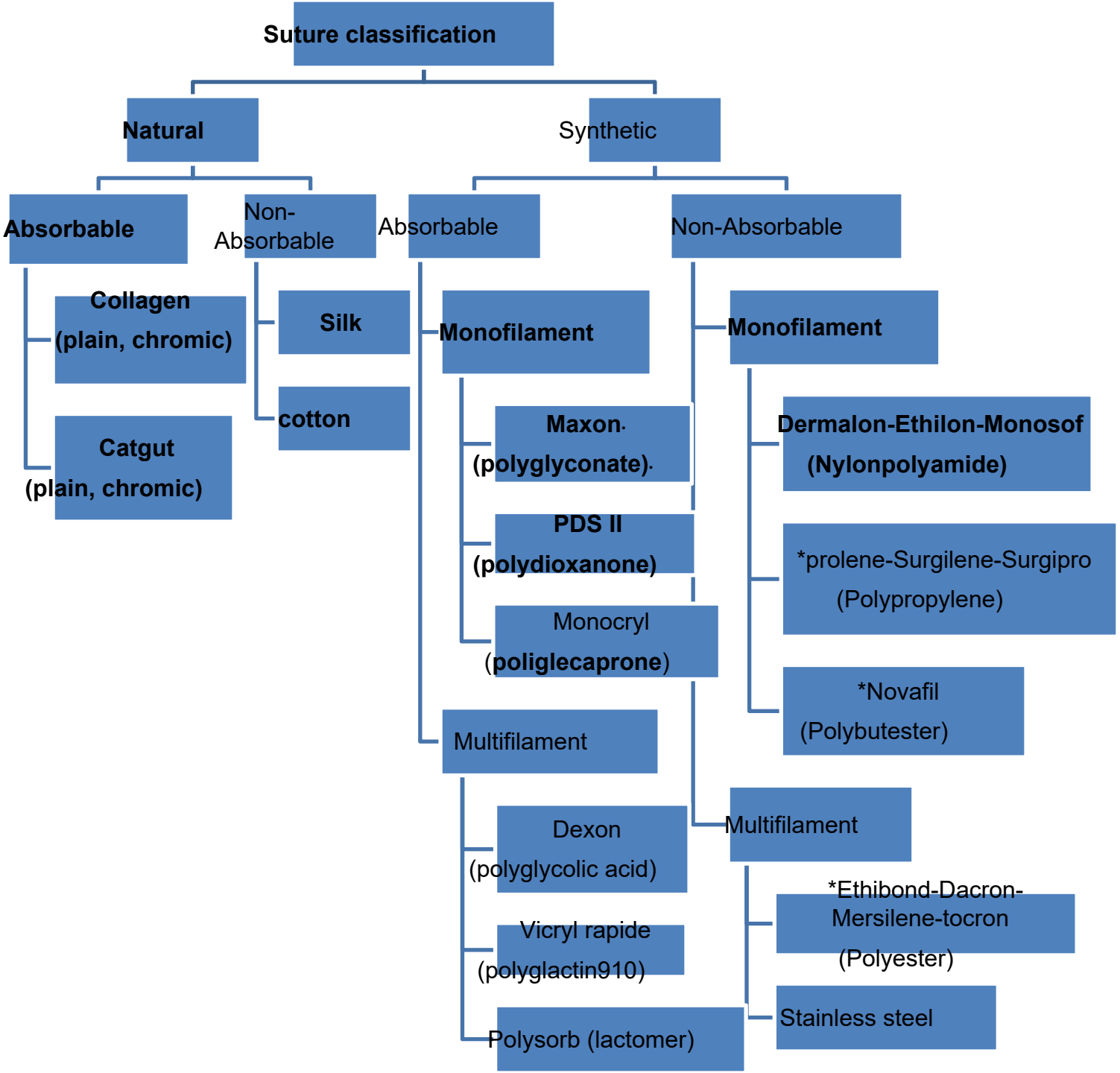
Methods of suturing

- The wound edges are brought into close proximity.
- The stitches are then applied with sufficient tightness.
- On the other hand the stitches should not be too tight because extremely tight stitches may Cause ischemia of the tissues that may lead to delayed healing.
- Also for the interrupted & continuous stitches the distances between stitches should be equal & all the knots in the interrupted stitches are placed at the one side of the surgical wound.



When can I remove the sutures?

- **Face:** 3-4 days
- **Scalp:** 5 days
- **Trunk:** 7 days
- **Arm** or **leg:** 7-10 days
- **Foot:** 10-14 days


Suture classification
Natural
Synthetic
Absorbable
Non-Absorbable
Absorbable
Non-Absorbable
Collagen (plain, chromic)
Catgut (plain, chromic)
Silk
cotton
Monofilament
Maxon (polyglyconate)
PDS II (polydioxanone)
Monocryl (poliglecaprone)
Multifilament
Dexon (polyglycolic acid)
Vicryl rapide (polyglactin910)
Polysorb (lactomer)
Monofilament
Dermalon-Ethilon-Monosof (Nylonpolyamide)
*prolene-Surgilene-Surgipro (Polypropylene)
*Novafil (Polybutester)
Multifilament
*Ethibond-Dacron-Mersilene-tocron (Polyester)
Stainless steel

New introduced sutures

- VICRYL (polyelatine- 916)
- PROLENE (Polypropylene)
- POLYSTER (ethibond)
- POLYDIXONE SUTURE
- These material have reduced the rate of infection at the suture sites.

Tissue Adhesives

Before Curing

- Sterilizable
- Easy in preparation
- Viscous liquid or liquid possible for spray
- Nontoxic
- Rapidly curable under wet physiological conditions (pH 7.3, 37°C, 1 atm)
- Reasonable cost

After Curing

- Strongly bondable to tissues
- Biostable union until wound healing
- Tough and pliable
- Resorbable after wound healing
- Nontoxic
- Nonobstructive to wound healing or promoting wound healing

Natural Tissue – Fibrin Glue

- First reported in 1940
- Mimics blood clot – major component fibrin network
- Excellent tissue adhesive but insufficient in amount for larger wounds
- Nontoxic if human protein sources are used to obtain fibrin

Synthetic Systems: Poly-Alkyl-2-Cyanoacrylates

- Discovered in 1951
- “Crazy Glue”
- $H_2C=C(CN)—CO_2—R$
- R = alkyl group
  - CH_3 (methyl)
  - H_3CCH_2 (ethyl)
- Release small amount of formaldehyde when curing
  - amount lessens with length of alkyl chain

Characteristics of Currently Available Adhesive Systems

	Fibrin Glue	Cyanoacrylate
Handling	Excellent	Poor
Set time	Medium	Short
Tissue bonding	Poor	Good
Pliability	Excellent	Poor
Toxicity	Low	Medium
Resorbability	Good	Poor
Cell infiltration	Excellent	Poor

Other Experimental Systems

- Gelatin-based adhesives
  - Mimic coagulation but without fibrin
- Polyurethane (-HNOCO-) based adhesives
  - Capped with isocyanate to rapidly gel upon exposure to water
  - More flexible than current cyanoacrylate adhesives
- Collagen-based adhesives

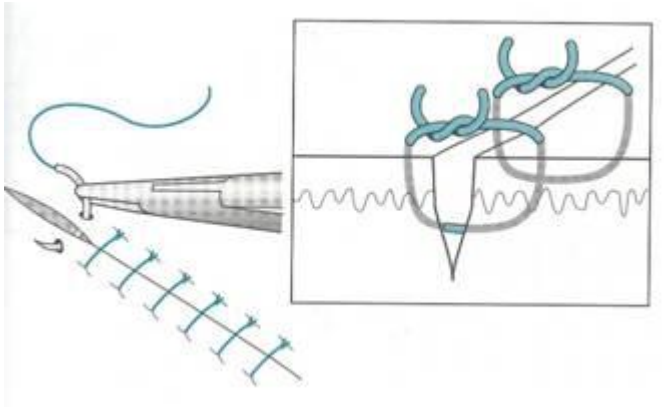
Wound Closure

- Basic suturing techniques:
  - Simple sutures
  - Mattress sutures
  - Subcuticular sutures

- Goal: “approximate, not strangulate”

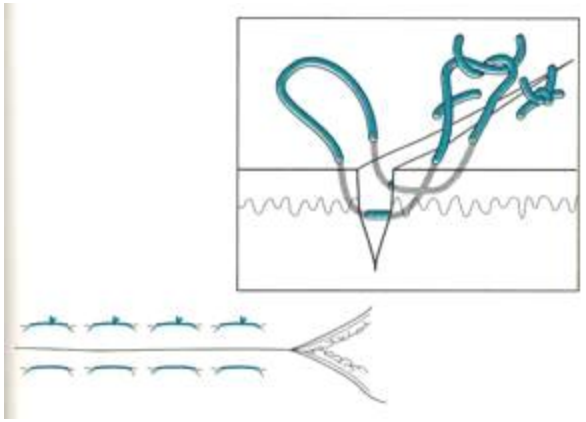
Simple Sutures

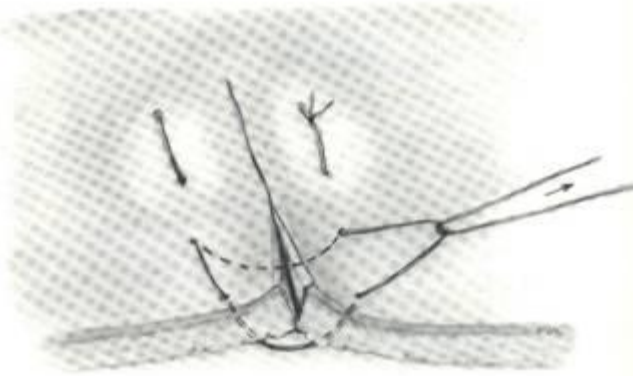
- Simple interrupted stitch
  - Single stitches, individually knotted (keep all knots on one side of wound)
  - Used for uncomplicated laceration repair and wound closure



Mattress Sutures

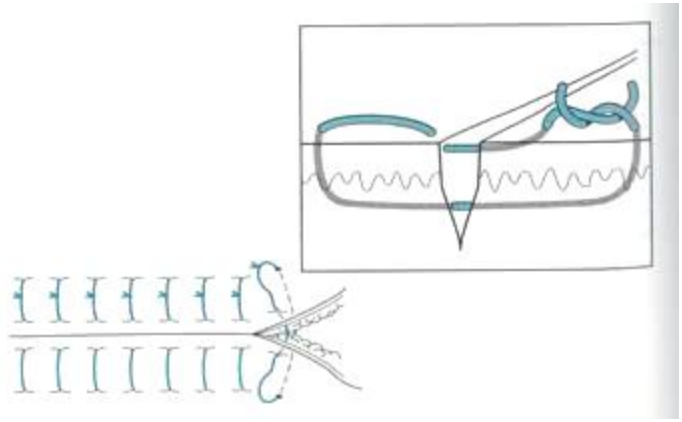
- Horizontal mattress stitch
  - Provides added strength in fascial closure; also used in calloused skin (e.g. palms and soles)
  - Two-step stitch:
    - Simple stitch made
    - Needle reversed and 2nd simple stitch made adjacent to first (same size bite as first stitch)





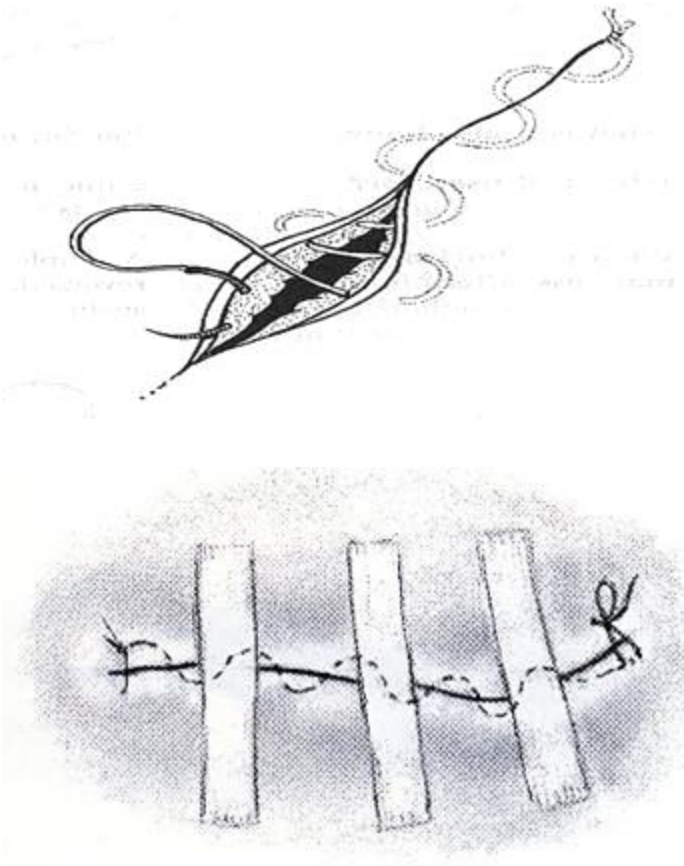
Mattress Sutures

- Vertical mattress stitch
  - Affords precise approximation of skin edges with eversion
  - Two-step stitch:
    - Simple stitch made – “far, far” relative to wound edge (large bite)
    - Needle reversed and 2nd simple stitch made inside first – “near, near” (small bite)



Subcuticular Sutures

- Usually a running stitch, but can be interrupted
- Intradermal horizontal bites
- Allow suture to remain for a longer period of time without development of crosshatch scarring

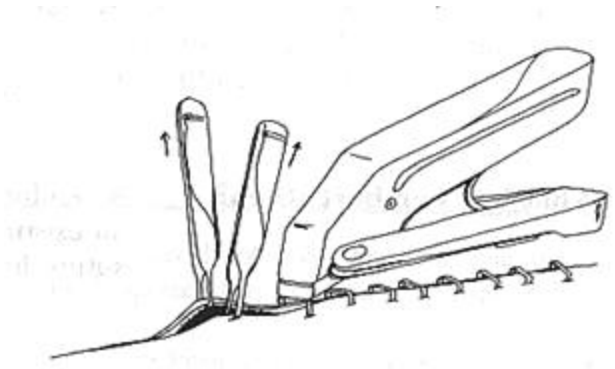


Steri-strips

- Sterile adhesive tapes
- Available in different widths
- Frequently used with subcuticular sutures
- Used following staple or suture removal
- Can be used for delayed closure

Staples

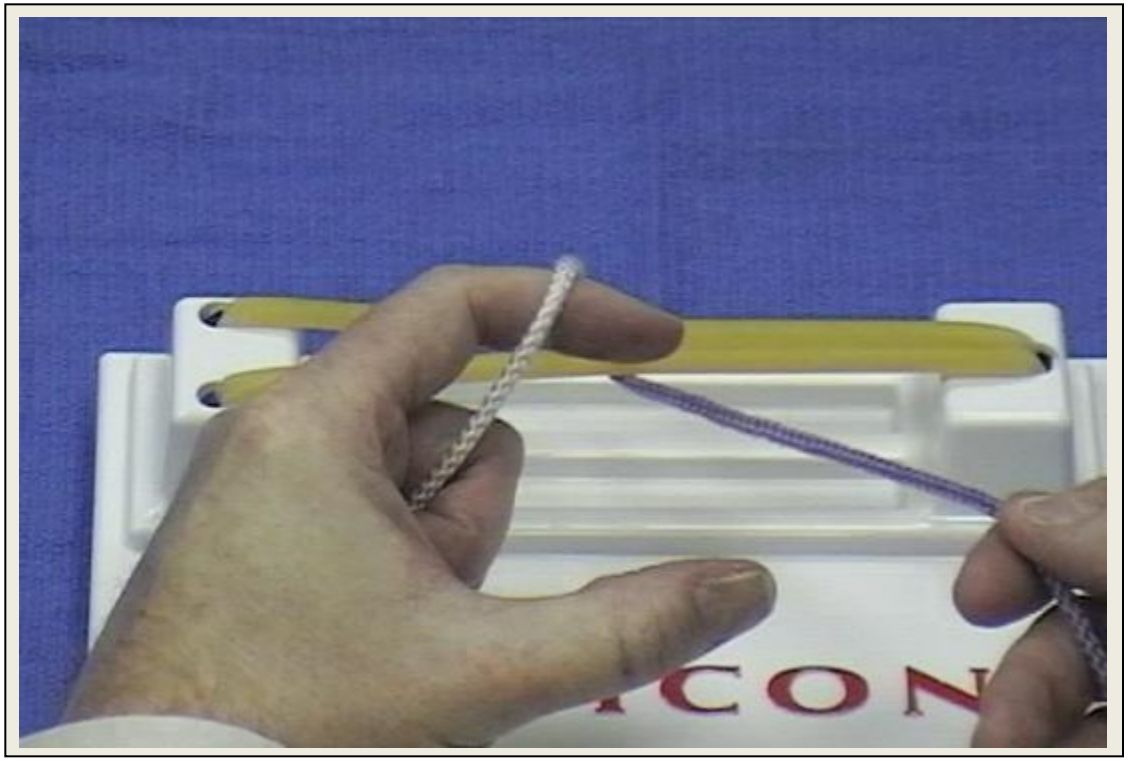
- Rapid closure of wound
- Easy to apply
- Evert tissue when placed properly



Two-Hand Square Knot

- Easiest and most reliable
- Used to tie most suture materials

(click image to start video)



Instrument Tie

- Useful when one or both ends of suture material are short
- Commonly used technique for laceratio repair

(click image to start video)