# SURGICAL SUTURE

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While suture material is most commonly used by surgeons, but a surgeon's knowledge of its physical and biological properties is very much limited.[1]

Sutures can be classified according to the origin, physical presentation and absorbability of their raw material.

General principles governing suture selection depend on:-

* Physical condition of the patient.
* Wound healing rate of the tissue (type of tissue approximated).[5]
* Infection.[1,5]
* Size of suture material.
* Desirability of permanent support of the tissue.[5]
* Surgical techniques.
* Past experience of the surgeon.

Suture material of synthetic origin tend to be more consistent in their appearance, performance and degradation than suture material of biological origin.

Sutures of polymeric origin tend to be more biocompatable than those of biological or natural origin. While the surgical technique is more important than suture use, correct selection of appropriate material is also pertinent. Often neglected is the correct use of suture material with regard to tension and knotting as well as respect for the needles with which they are placed. Litigations against the profession is on the increase and surgeons are being accused of using the wrong suture material or needles.. Prof: Cliff Synder said it all in 1972. "The fault in making sutures are the manufacture's error, in using them are surgeon's."

Until recently most suture materials were not custom designed specifically as surgical sutures. Instead, they were adaptations of fibres or thread designed for entirely different work. Catgut was developed for use in old musical instrument. Silk and later polyester were developed for clothing industry. Nylon and polypropylene were used by fishermen as fishing lines. Linen from the flax plant, was used to sew shirt button and the button on gentelmen's flies. In past, wounds were sutured with human hair, horse tail hair, ordinary thread, plant fibres and big ants were made to bite wound margins and then decapitated. It was in late 1960s or early 1970s, when material developed especially for and sometimes exclusively for use as surgical suture. It is the effort of polymer chemist and suture industry that made possible the production of synthetic absorbable polymers such as glycosides, lactate, polydioxanone and polycaprolactone.

TABLE – I

GENERAL PRINCIPLES IN THE SELECTION OF SUTURE MATERIAL

| Classification | Tissue reaction | Tensile strength | Knot security | Friction |
|---|---|---|---|---|
| Biological | Greater | More variable | Greater | Greater |
| Syrithetic | Less | More uniform | Less | Less |
| Braided | Greater | Greater | Greater | Greater |
| Coated | – | – | Less | Less |
| Uncoated | – | – | Greater | Greater |

From Ian Capperauld Surgical Suture Part II Surgery 1995. 13:4:(ii)

The need for non-thrombogenic suture for vascular surgery, invented polypropylene sutures; while eye and microvascular procedures demanded the invention of fine microsutures and microneedles. They despite their size, had higher straight and knot tensile strength, good handling and knot handling properties and be totally biocompatable with tissue into which they are implanted. Most recently suturing with stapling devices has come up which is the realization of an old dream of Viscerosynthesis.[21] As a prophylaxis against surgical infection, antibacterial suture material are coming up containing antibiotics having four fold reduction in incidence of wound complication.[8,10,17,19]

The purpose of a suture is to hold a wound together until such time as natural healing process is sufficiently established to make the support from suture material unnecessary and redundant.[1]

The choice of suture material is frequently motivated by an emotional rather than a scientific thought process and to the availability of suture material at the .time of need. Choice is often dictated by what historically the surgeon was taught by his chief, who in turn emulates his own chief. This decision process could, though be well out of date by a period in excess of 50 years.

The most frequently implanted substance into man are the suture material. A conservative estimate would be well over three million individual implants a day through out the world. With such a vast number of implants being made daily, Ian Capperauld suggests more scientific than an emotional approach towards suture selection.[1]

## CLASSIFICATION OF SUTURES

Sutures can be classified according to the,

* Origin of basic raw material (Biological or Synthetic)
* Structure (Monofilament or Multifilament)
* Other agents such as dyes & coating.

But the most important of all is whether the material is absorbable or not absorbable.

Absorbable sutures are digested during healing process by the tissue in which they are placed. Further total loss of mass has to be demonstrated, if the suture is to qualify as being an absorbable suture.[2,3] Non-ab-

sorbable sutures are not affected by the digestive action of body fluid, they remain in the body until they are cast off or removed.[5]

## A. ABSORBABLE SUTURES

1. Natural

i. Natural suture are catgut of biological origin and are protein in nature, their absorption and digestion is by proteolytic enzymes present in tissue fluid. The source is submucosa of sheep or serosa of intestine. Their fibres are then chrome tanned to delay absorption and twisted under tension and polished to achieve monofilament profile. Chrome tanning also reduces inflammatory response to tissue. Absorption is variable and has a range of 60-120 days.[3] In some cases catgut been found in wound even after 3 years. Despite its unpredictable and variable absorption, very little strength is reported after 8-9 days. In tissue like stomach, duodenum and ileum there is functional loss of strength after 24-hours of implantation and has lost effective tensile strength by 30-32 days.[3] Plain catgut loses its straight tensile strength by 53% and chromic catgut by 40% when knotted.[3] Serilization is achieved by Gamma radiation or ethylene oxide. Packing is done in a fluid which retains its ideal handling characteristic, the fluid is 89% Isopropanol, 10% water and 1% Triethanolamine.[4]

ii. Collagen is also of biological origin from ox Achilles tendon; rolled monofilament, undyed and uncoated.

iii. Fascia Lata

Other Lata. e.g Kangro tendon.[5]

2 Synthetic.

i. Polyglycolic Acid (PGA) is available in two forms, the braided form is "Dexon" while the monofilament is "Maxon". It is man made homopolymer of glycolide. In monofilament form the flexibility is insufficient, therefore, braided form is used for general surgical use. Recently special coating of monofilament with polycaprolactone and glycolide has provided sufficient flexibility.[1] The straight pull tensile strength is 1.2 times greater than catgut but knot pull tensile strength is much better.[3] Properties of the PGA sutures are:

* Loss of strength on knotting is only 20% (see catgut)
* Retains strength in wetting.
* Knot slippage is rare.
* Does not swell.

TABLE – II

CHOICE OF SUTURE SIZE

| Classification | Suture pull-out value and size of catgut | Breaking Strength (kg) and size | Breaking Strength (kg) of silk |
|---|---|---|---|
| – Fat | 0.20 | 0.31:6/0 | 0.20:7/0 |
| – Penitoneum | 0.86 | 1.50:5/0 | 0.82:5/0 |
| – Muscle | 1.27 | 1.27:4/0 | 1.70:4/0 |
| – Fascia | 3.77 | 3.70:2/0 | 3.70:2/0 |

Adopted from Ian Capperauld Surgical Sutures: Part II, Surgery 1995. 13:4:(ii)

TABLE – III

METRIC GAUGING OF SUTURE MATERIAL

| Metric number | Former gauge: Catgut/collagen | Former gauge: Non-absorbable, synthetic Absorbable |
|---|---|---|
| 0.1 | — | — |
| 0.2 | — | 10/0 |
| 0.3 | — | 9/0 |
| 0.3 | — | 8.0(virgin silk) |
| 0.4 | — | 8/0 |
| 0.5 | 8/0 | 7/0 |
| 0.7 | 7/0 | 6/0 |
| 1.0 | 6/0 | 5/0 |
| 1.5 | 5/0 | 4/0 |
| 2.0 | 4/0 | 3/0 |
| 3.0 | 3/0 | 2/0 |
| 3.5 | 2/0 | 0 |
| 4.0 | 0 | 1 |
| 5.0 | 1 | 2 |
| 6.0 | 2 | 3 and 4 |
| 7.0 | 3 | 5 |
| 8.0 | 4 | 5 |

The reason for the difference in size between catgut and non-absorbable and synthetic absorbable is that the sizing of catgut is done when the catgut has swollen as a result of being in the conditioning fluid in which it is presented to surgeon.

Adopted from Ian Caperauld Surgical Sutures 1995, 13:4(84b)

* Absorption is by hydrolysis, uniform and predictable, it begins on 10th day and is complete by 120 days.

ii. Polygalactin 910 "Vicryl". A Man-made copolymer of glycolide and lactate, is available in braided form. To reduce the tissue drag, the braided filaments are coated with calcium stearate, glycolide and lactate. Absorption is uniform and predictable, commencing at 40 days and complete between 60 and 90 days after implantation. Strength is greater than P.G.A especially after 14 days. The inflammatory response is mild to moderate. Sterilization is by ethylene oxide.

iii. Polydioxanone "PDS": PDS is man-made new copolymer, a polyester of paradioxanone, which is melt and a monofilament profile is achieved. It is the only suture which retains unique flexibility in mono filament form. Its strength is greater than that of all commonly used monofilament sutures other than steel. More than 80% strength is retained at 2 weeks, 70% at 4 weeks and more than 30% at 8 weeks.[3] Absorption is by hydrolysis, beginning at 90 days and complete in 210 days.[3] Tissue reaction is milder than other sutures. Handling properties compare favourably with those of catgut and knot security is good. Its monofilament profile makes it particularly useful in potentially infected tissues like colon, biliary system, stomach etc. Sterilization is by ethylene oxide.

iv. Polyglecaprone- "Monocryl": It is a Man-made copolymer of glcolide and caprolactone, in ratio of 72:25; it has clear, undyed monofilament.[1]

v. Polyglyconate-"Maxon": It is Man-made copolymer of 1,4-dioxane 2,5-dione and trimethylene carbonate; monofilament, dyed or undyed.

**B. NON-ABSORBABLE SUTURES**

1. Natural

i. Silk: It is derived from thread spun by larva of silk worm by degumming of surface albumin layer. The braided multifilament, dyed or undyed, coated or uncoated silk is known for excellent handling properties and knot security. Marked inflammatory reaction, tissue drag and braiding are its main disabilities as braiding induces capillary attraction and hence harbour the infective agent in interstices. Tissue drag is overcome by waxing or silicon coating reducing knot security, a third throw is always necessary. Fragmentation occurs and all tensile strength is lost by 9 months.[3] Sterilization is by Gamma radiation, however boiling and autocalaving may also be used.

ii. Cotton. It is cellulose in nature and occurs as multifilament. Most of the properties are similar to those of silk except that strength of cotton increases when wet, where as silk loses 20% of strength when wet. Cotton is cheaper than all other sutures. It is available as dyed or undyed and uncoated.[1]

iii. Linen. It derived from falx plant; twisted multifilament, dyed or undyed and uncoated.[1]

2. Synthetic.

i. Polyamide: "Nylon". It can be monofilament or multifilament, dyed or undyed, generic name Nylon 6 or Nylon 66; trade name Ethilon or Dermalon (monofilament) and Nurolon (braided) or Surgilon (braided nylon). In monofilament form there is decreased tissue reaction, strength is remarkable and 16% strength is still there even after one year. It is almost inert in nature, though a case has been reported by R-J-Schechter of a Nylon toxicity which occurred after 4-months in a patient who under went vitrectomy. The sign and symptoms disappeared after removal of sutures.[24]

Its disadvantages are poor handling, poor knotting, and its "Memory to untie" where as in braided form, although the knotting and handling difficulties are overcome to some extent, there remains some disadvantages like increased tissue reaction, loss of strength within 6 months and early fragmentation. It may need removal in sepsis. Sterilization is by Gamma radiation but can tolerate autoclaving upto three times.

ii. Polyester: monofilament or multifilament, dyed or undyed, coated or uncoated; trade name Ethibond (polybutylate coating) or Tri. Cron (silicon coating), and Mersilene or Dacron (uncoated).[1] Polyesters are known for having high and permanent tensile

strength, inducing only modest tissue reaction and having good knot security. They are widely used in cardiovascular sur-gery. In braided form, the strands tend to adhere, resulting in poor handling and dif-ficult knotting, the reason for coating with polybutylate. This brings smoothness to the fibres but compromises knot security.

iii. Polybutylester: monofilament, dyed or un-dyed, polybutylene terphthalate and polytetramethylent ether glycol; trade name Novafil. Its "Mesh" forms are used for pair of vascular defects and Hernias.

v. Polyethylene: It is available in monofilament form as a strong suture, induces minimal tissue reaction, excellent knotting and handling due to its soft surface. Mesh form is also available. Progressive loss of strength occurs by fragmentation. Sterilization is done by Ethylene oxide or Gamma radiation. It melts at 132 C so autocaving can not be done.

v. Polypropylene: monofilament, dyed or undyed; trade name is Prolene. It has a permanent high tensile strength, the most inert suture, better handling properties of knot security than Nylon. It has no memory to untie. Fragmentation does not occur within tissues. Its mesh forms are used in the repair of prolapse rectum. When used to suture blood vessels the blood loss is much less. Available in vivid blue colour which facilitates visualization during surgery. Sterilization is by Ethylene oxide.

vi. PVDF. (Polyvinylidene fluoride) monofilament, dyed or undyed. Its trade name is Trofilene.

## C. NON ABSORBABLE METAL SUTURES.

Stainless steel. Maintain tensile strength indefinitely. Monofilament or multifilament.

i. Vitallium

ii. Tantalum

iii. Silver

## D. SURGICAL STAPLES AND CLIPS[21,22]

i. Absorbable. The concept of Viscero-synthesis.

ii. Non-Absorbable

## SUTURE SELECTION

Several factors have to be considered while selecting appropriate suture material for individual patient. Table – I gives general principles for suture selection.

* Absorbable sutures should be used in tissues with have short healing period.
* Non-absorbable sutures are used when healing time is prolong and post operatively they could be under tension.
* If in doubt regarding the length of wound healing, a monofilament, nonabsorbable suture should be used.
* Avoid non-absorbable suture in gastric and duodenal mucosa around the cystic duct and the urinary system.
* Synthetic Absorbable suture can be used in small diameter blood vessel especially if growth in diameter of these vessels is expected.
* Fascia takes 9 months to regain 75% of its original tensile strength, therefore, a non absorbable suture is indicated for fascial closure. Capperauld recommends synthetic absorbable suture such as Polydixanone for safer use of fascial closure with extremely low dehiscence and extrusion rate.[2]

## SUTURE SIZE

In general the smallest size of suture that will suffice is the best choice. The result is:-

* Reduced initial foreign body reaction.
* Reduce eventual size of the retained foreign body if non absorbable is used.

* The smaller is the size of the suture, the smaller will be the bulk of knot. Most episodes of extrusion of sutures material can be attributed to many throws on the knot.

* Most synthetic suture materials are secure with double throw, followed by a single throw, followed by double throw. The first throw determines the tension required to approximate wound edges and need to be double to prevent spring back of throw and third throw locks the knot completely.

Many surgeons try to achieve the tension of first throw by pulling hard on the second throw, this will work with material of low coefficient of friction and especially with monofilament, however braided material can not have initial throw tightened by pulling hard on second throw, because the material locks with lose first throw. Failure to observe this could result in post operative haemorrhage from ligature, alleged to have slipped, when in fact the knot was improperly tied in first place. Pulling hard on the second throw to tighten the first often weakens the material, which could break post operatively. The size of suture material chosen should match the tissue into which it is implanted. (Table–II, III). Suture, therefore, needs to be as strong as tissue in which they are implanted.[2,20] The modern method of describing suture material is based on metric system where upper and lower limits are set in millimeters and the gauge size is simply 10 times the lower figure Table–II, III.

## TISSUE REACTION

Biological material tend to cause a greater tissue reaction than synthetic material. Catgut may provoke a massive cellular reaction principally involving neutrophils, to produce proteolytic enzymes for its breakdown. Absorption of synthetic absorbable is by hydrolysis. Synthetic non-absorbables tend to produce a giant cell reaction which may appear dramatic but this is the norm of the material. The old adage that greater the tissue reaction the stronger is the healing is just not true.[3]

## ALLERGY TO CATGUT

Pure collagen (collagen pure catgut. C-p) does not produce allergic reaction.[5] According to Carrol- RE, it is highly improbable for C.P catgut to cause antigenicity.[15] However grave sensitivity in the form of granuloma have been reported to catgut contaminated with gloves powder.[23] Delayed hypersensitivity to intradermal chromic catgut have been reported.[16]

## COMMON ERRORS IN SUTURE USE[3,6,7]

Some common errors which may cause distress to patient, try the patience of surgeon and result in litigation against surgeon.

* putting too many throws on the knot increases foreign body size and can lead to extrusion.

* Use of synthetic absorbable suture for subcuticular skin closure and placing the suture in a "Intracuticular" rather than in subcuticular fashion (i.e too near to surface) can lead to pseudo-hypertrophic scar formation.

* Suture may be damaged by clamping with instrument. This can lead to wound breakdown. It is especially im-portant when handling monofilament, that the surface polish is not damaged, the most serious damage which can lead to subsequent wound breakdown is a nick to the surface of the material. The surface of monofilament may some time be nicked if it is dispersed badly from foil pack or if reversed cutting needle passes across an underlying previously placed suture.

* The needle may be bent or broken if held at the battened or pointed end,

instead of the junction of the upper one third and the lower two third.

* Failure to record in the case notes, not only the type and size of the material used but also the manufacturer, product code and batch number.

* Inadequate tying of the knot can cause knot slippage with subsequent haemorrhage or dehiscence of wound.

## COMPLICATIONS OF SUTURE

1. Stone formation (9)
2. Tumor cell adherence at site of suture (11)
3. Local stoma complication (12)
4. Delayed reaction to suture (14)
5. Calcified suture may be confused with recurrence of malignancy in irradiated breast. (13)
6. Allergy to catgut. (15,16,23)
7. Silk suture produce the most artifacts in MRI.

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