Synthecon

Suture Technical Document

An in-depth guide to sutures; exploring the variety of threads, needles and swaging options available.

Contents

Introduction

Surgical sutures have played and will continue to play a critical role in the modern hospital theatre. While the principle behind sutures has not changed much since ancient physicians used the pincers of red ants to assist in the closure of wounds, the nature of the device has evolved tremendously. As technology has advanced, so has the development of sutures. From utilising the most advanced synthetic materials that increase the strength of the suture as well as improving the consistency of absorption, to high tech steel alloys that allow for thinner sharper needles that maintain their point throughout a procedure.

The purpose of a suture is simple: once in place, it holds the tissue together so that the wound may heal effectively. Tissues are held in proximity until enough healing occurs to withstand stress without mechanical support. However, one needs to remember that suture material is a foreign body and thus elicits a reaction from the tissue and as a result needs to be in the body only for as long as it is required. Therefore, a surgeon will choose a suture material that optimises the need to provide support to the wound and minimise the obtrusiveness and the associated trauma of the suture.

Skilful wound closure requires not only knowledge of proper surgical techniques but also knowledge of the physical characteristics and properties of the suture and needle. The goal of this booklet is to review the types of sutures and needles for wound closure and to discuss principles that influence suture and needle selection.

All sutures are made up of three parts. They are:

1. The thread
2. The needle
3. The swage *(where the needle and thread join)*.

In order to correctly classify sutures or to understand which suture to use in a given situation, knowledge of the various characteristics of each element is required.

2. Suture Thread

The suture thread is the material that fulfils the function of holding the wound closed. When one is choosing the ideal suture thread, there are three characteristics that would affect the decision depending on the clinical situation. These are:

1. Type of Suture Material
2. Gauge (thickness) of the material
3. Length

Each of the above three characteristics will be discussed in detail in the following sections.

2.1 Types of suture material

The perfect suture material would have the following properties:

- Sterile
- Fulfil any surgical purpose
- Causes zero tissue injury or tissue reaction
- Easy to handle
- Knots hold without fraying or cutting
- High tensile strength
- Consistent absorption profile
- Resistant to infection

Unfortunately, such a material does not exist. Therefore surgeons and other medical practitioners need to weigh up the relative advantages and disadvantages of existing suture materials in order to make the most appropriate choice. In this booklet we will endeavour to detail those relative advantages and disadvantages of the most common materials.

Broadly speaking, the various suture materials can be broken down by three variables. They are either: absorbable / non-absorbable, natural / synthetic and braided / monofilament. Whether to use absorbable or non-absorbable can be determined by asking the following questions:

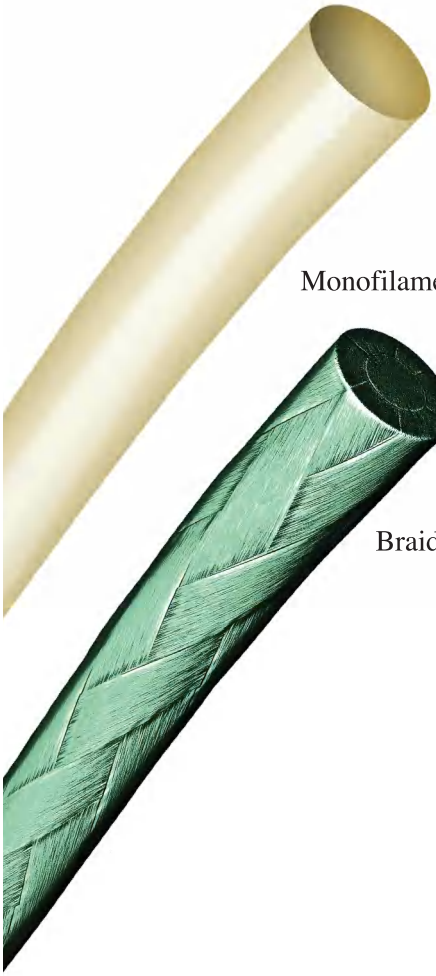
- Does the suture material needs to stay in or come out?
- Do you have post-operative access to the wound?

Does the suture material needs to stay in or come out?

Suture materials can be absorbable or non-absorbable. Typically, in a clinical environment a practitioner would need to ask the question:

If the tissue being sutured will never approximate and provide the required tensile strength on the wound then the suture material needs to remain in position, retaining its strength indefinitely. Examples of this would be orthopaedic implants or vascular grafts. In these situations it is clear that a non-absorbable suture material will be required. However, if the tissue can and does heal, once the healed tissue is providing sufficient support, the doctor would want the material to be removed. This leads to the next question:

A laceration on the skin and the subsequent sutures can be accessed easily whereas a repaired bowel for example is inaccessible without undergoing another surgery. In the latter situation, the only choice for a surgeon in terms of suture material would be an absorbable suture. The former on the other hand can be either absorbable or non-absorbable based on the preference of the surgeon.



Monofilament

Braided

The second variable of that distinguishes suture materials is whether it is made from natural or synthetic fibres. Natural fibres are spun from raw materials existing in the natural world. In the modern context this includes sutures can be made of collagen from mammal intestines or from silk. Synthetic sutures on the other hand are various polymers that absorb at different rates (if at all).

The final variable is whether the sutures are braided or monofilament. Monofilament sutures are made of a single strand whereas a braided or multifilament suture is composed of a number of filaments braded together. Monofilaments have the advantage in that the structure is relatively more resistant to harbouring microorganisms and thus lower risk of infection. Furthermore the monofilament sutures is less traumatic and offers lower resistance as it passes through the tissue. Braided sutures on the other hand are easier to use as they have better pliability and flexibility than monofilament sutures. They handle well and less precision is required in tying in order to get sufficient knot security. Also greater care is required when handling monofilaments as any undue crushing or crimping can weaken the suture and may result in premature suture failure.

- Natural sutures tend to have a slightly higher tissue reaction and risk of inflammation and infection but also tend to have superior knot hold (catgut in particular).
- Monofilaments lower the risk of infection but braided sutures are easier to handle

Summary of relative advantages

Absorbable	Temporary wound support.
Non-Absorbable	Permanent wound support or extraction of suture required.
Natural	Superior knot hold (in the case of Catgut.)
Synthetic	Lower tissue reaction as compared with natural fibres.
Monofilament	Increased resistance to harbouring microorganisms.
Braided	Easier to use. More pliable and flexible. More resistant to damage during suture process.

CATGUT (Chromic and Plain)

Catgut is a natural, braided, absorbable suture.

Surgical gut suture (Plain and Chromic) is an absorbable sterile surgical suture composed of purified connective tissue (mostly collagen) derived from either the serosal layer of beef (bovine) or the submucosal fibrous layer of sheep (ovine) intestines. The chromic catgut contains a chromic salt solution to slow absorption.

Bovine catgut is the preferred catgut material because it has a higher tensile strength. This is due to bovine fibres running longitudinally along the thread as opposed to perpendicularly in ovine catgut.

Indications:

Surgical gut (Plain and Chromic) is indicated for use in general, soft tissue approximation and/or ligation but not for use in cardiovascular and neurological procedures.

Actions:

When surgical gut suture is placed in tissue, a moderate tissue inflammation occurs characteristic of foreign body response to a substance. This is followed by a loss of tensile strength and suture mass, as the surgical gut dissolves. This process continues until the suture is completely absorbed. Many variable factors may affect the rate of absorption, such a the age and health of the patient.

Catgut Key Points:

- Catgut is a natural, braided, absorbable suture.
- Bovine catgut has superior tensile strength than ovine catgut
- Catgut has superior knot security.

POLYGLYCOLIC ACID (PGA)/ POLYGLACTIN 910 (PGLA)

PGA/PGLA Key Points:

- PGA / PGLA are both synthetic, braided, absorbable sutures.
- Used for general soft tissue approximation and ligation.

PGA / PGLA are both synthetic, braided, absorbable sutures.

Polyglycolic acid (Synthabs)as well as Polyglactin 910 (Syncryl) sutures are braided synthetic absorbable sterile surgical sutures. They can be dyed violet or undyed depending on optimum visibility requirements. PGLA contains 10% lactic acid which makes it marginally weaker than PGA. Therefore at a given suture gauge, PGLA will be marginally thicker as a result.

Indications:

PGA / PGLA is indicated for use in general soft tissue approximation and/or ligation, including use in ophthalmic procedures, but not for use in cardiovascular and neurological procedures.

Actions:

PGA / PGLA elicits minimal inflammatory reaction, which is followed by gradual encapsulation of the suture by fibrous connective tissue. Progressive loss of tensile strength and eventual absorption of the suture occurs by means of hydrolysis, where the polymer degrades to either glycolic acid or glycolic and lactic acids which are subsequently absorbed and metabolized by the body. Implantation studies in animals indicate that PGA retains approximately 73% of its original tensile strength at two weeks with complete absorption in 60 to 90 days.

PGA RAPIDE

PGA Rapide is a synthetic absorbable braided suture that has been exposed to gamma radiation. This breaks down the chemical bonds in the material which results in a much faster absorption time. PGA Rapide is a fast absorbing synthetic, braided suture suitable for short term wound support (<2 weeks)

Indications:

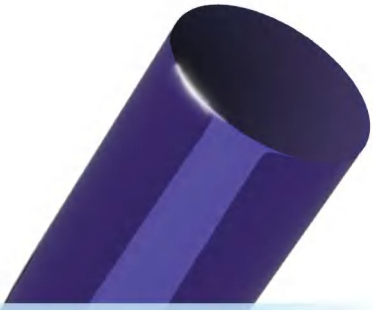
PGA Rapide sutures are used for superficial closure of skin and mucosa where only short term wound support (less than 2 weeks) is required.

Action

PGA rapide elicits minimal acute inflammatory reaction in tissues, which is followed by a rapid loss of tensile strength and eventual absorption. Implantation studies in animals indicate that PGA rapide retains approximately 50% of its original tensile strength at one week and only 5% after 3 weeks.

PGA Rapide Key Points:

- PGA Rapide is a rapidly absorbing synthetic braided suture.
- Suitable for short term wound support.



Mocryl Key Points:

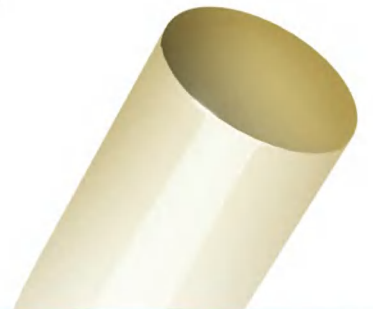
- MoCryl is a synthetic absorbable monofilament
- Generally used for soft-tissue approximation and ligation. It is usually used for subcuticular dermis closures

POLIGLECAPRONE (MoCryl)

MoCryl is a synthetic absorbable monofilament composed of Poly Glycolide Co-Caprolactone.

Indications:
Generally used for soft-tissue approximation and ligation, it is usually used for subcuticular dermis closures. It has less of a tendency to exit through the skin after it breaks down.

Actions:
MoCryl has a low tissue reactivity, has a high tensile strength, and has a half-life of 7 to 10 days. At 1 week, its tensile strength is at 50-60% which reduces to 25% in 2 weeks with full absorption in 80-120 days.



PDO Key Points:

- PDO is a synthetic absorbable monofilament.
- Very slow absorption rate.

POLYDIOXINONE (PDO)

PDO is short for Polydioxanone and is a synthetic absorbable monofilament. PDO has good flexibility and strength but is distinguished from other suture material by a long absorption time.

Indications:
Due to the slow absorption rate of PDO, the suture is indicated for use in situations where an absorbable suture is desired but wound support is required for an extended period of time. Examples of this would be the closure of the rectus sheath in abdominal surgery.

Actions:
PDO has a low tissue reactivity and a very low absorption rate. After 1 week 95% of tensile strength remains with as much as 65% strength remaining after 4 weeks. Complete absorptions will take 180-240 days.

POLYAMIDE (Nylon)

Nylon is a nonabsorbable sterile surgical suture composed of the long chain aliphatic polymers. The suture is provided dyed (black or blue), or undyed (clear).

Indications:
Nylon sutures are indicated for use in general soft tissue approximation and/or ligation, including use in ophthalmic procedures.

Actions:
Nylon sutures elicit a minimal acute inflammatory reaction in tissues, which is followed by gradual encapsulation of the suture by fibrous connective tissue. While Polyamide is not absorbed, progressive hydrolysis of the nylon in vivo may result in gradual loss of its tensile strength over time. As a result it is not recommended for vascular or neurological surgery.

Nylon Key Points:

- Nylon is a nonabsorbable sterile surgical suture
- Suitable for general use including opthalmic procedures.
- While Nylon is non-absorbable, progressive hydrolysis invivo reduces tensile strength.

Silk Key Points:

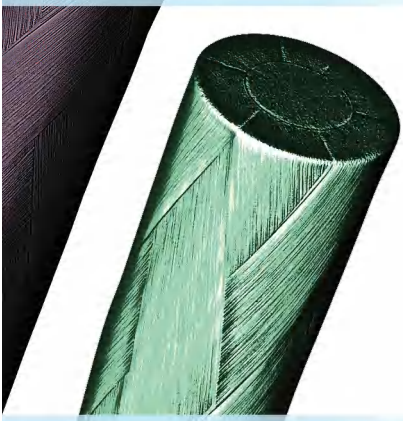
- Silk surgical suture is a nonabsorbable, natural, surgical suture .
- Silk surgical suture is indicated for use in general, soft tissue approximation and/or ligation.

SILK

Silk surgical suture is a nonabsorbable, braided, natural, surgical suture composed of an organic protein called fibroin.

Indications:
Silk surgical suture is indicated for use in general, soft tissue approximation and/or ligation.

Actions:
Silk surgical suture elicits minimal acute inflammatory reaction in tissues, which is followed by gradual encapsulation of the suture by fibrous connective tissue.



Polyester Key Points:

- Polyester suture is a nonabsorbable, braided, sterile, surgical suture.
- The high tensile strength makes it highly suited to orthopaedic procedures.

POLYESTER

Polyester suture is a nonabsorbable, braided, sterile, surgical suture composed of Poly (ethylene terephthalate). It is prepared from fibers of high molecular weight, long-chain, linear polyesters creating a material with a very high tensile strength. Polyester sutures are braided for optimal handling properties, and for good visibility in the surgical field, are dyed green.

Indications:
Polyester suture is indicated for use in general soft tissue approximation and/or ligation,including use in cardiovascular, ophthalmic and neurological procedures. The high tensile strength makes it highly suited to orthopaedic procedures.

Actions:
Polyester suture elicits a minimal acute inflammatory reaction in tissue, followed by a gradual encapsulation of the suture by fibrous connective tissue. Implantation studies in animals show no meaningful decline in polyester suture strength over time. The polyester fiber suture material is pharmacologically inactive.

POLYPROPYLENE

Polypropylene monofilament surgical suture is a synthetic nonabsorbable suture. Characteristics include; clear monofilament (undyed) and blue monofilament and has a high tensile strength.

Indications:
Polypropylene is indicated for use in general, soft tissue approximation and/or ligation, including use in cardiovascular, neurological and ophthalmic procedures.

Actions:
Polypropylene elicits minimal acute inflammatory reaction in tissues, which is followed by gradual encapsulation of the suture by fibrous connective tissue. Polypropylene monofilament surgical suture is not absorbed, nor is any significant change in tensile strength retention known to occur in vivo which makes it suitable for vascular and neurological procedures.

Polypropylene Key Points:

- Polypropylene is a synthetic, nonabsorbable monofilament suture.
- Polypropylene is not absorbed, nor is any significant change in tensile strength retention known to occur in vivo

Suture Material Quick Reference Tables

Below are summary tables that classify suture materials based on the three classifying variables as discussed previously followed by the table of suture material absorption rates.

Material	Absorbable/ Non Absorbable	Natural/ Synthetic	Braided/ Monofilament
Plain/Chromic Catgut	A	N	B
PGA/PGA Rapide	A	S	B
PGLA	A	S	B
MoCryl	A	S	M
PDO	A	S	M
Nylon	N	S	M
Silk	N	N	B
Polyester	N	S	B
Polypropylene	N	S	M

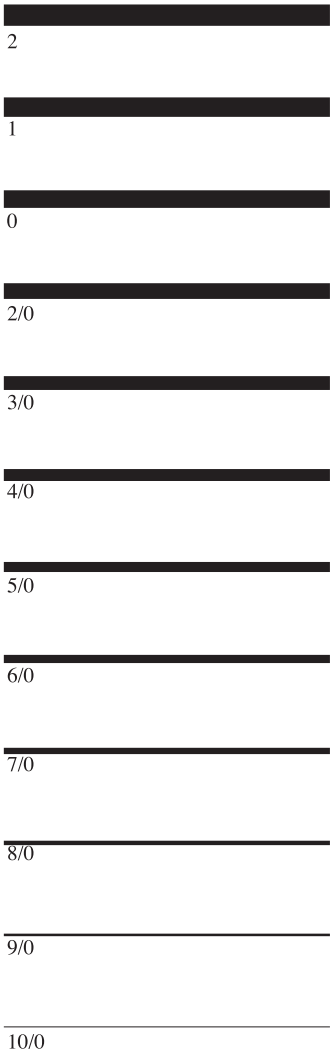
		Retention Strength %				Complete Absorption in:
		1 Week	2 Weeks	3 Weeks	4 Weeks	
Absorbable	Plain Catgut	40 %	5 %	-	-	70 days
	Chromic Catgut	55 %	25 %	5 %	-	90 days
	PGA (Synthabs)	90 %	75 %	45 %	-	60 - 90 days
	PGA Rapide	±50 %	20 %	5 %	-	40 - 60 days
	PGLA (Syncryl)	90 %	75 %	45 %	-	54 - 70 days
	MoCryl	±60 %	25 %	5 %	-	80 - 120 days
	PDO	95 %	85 %	80 %	65 %	180 - 240 days

2.2 Gauge

The United States Pharmacopeia (USP) classification system for sutures was established in 1937 and refers to the diameter of the suture strand and is denoted by a number where the smaller the number, the thinner the thread. For sizes smaller than zero, multiple zeroes are counted. For example 0 is larger than 00 (2/0) which is in turn larger than 000 (3/0). Naturally, the thinner the suture, the lower the tensile strength of the strand.

2.3 Length

The length of the material as an attribute is not critical in identifying and classifying sutures but does play a role. Longer strands of material provide an opportunity to place more sutures per pouch, thus reducing the total number of sutures used in a procedure and reduces the cost to the patient. However, the extra passes through the tissue places strain on the needle often resulting in unacceptable performance towards the end.



USP sizes (not to scale)

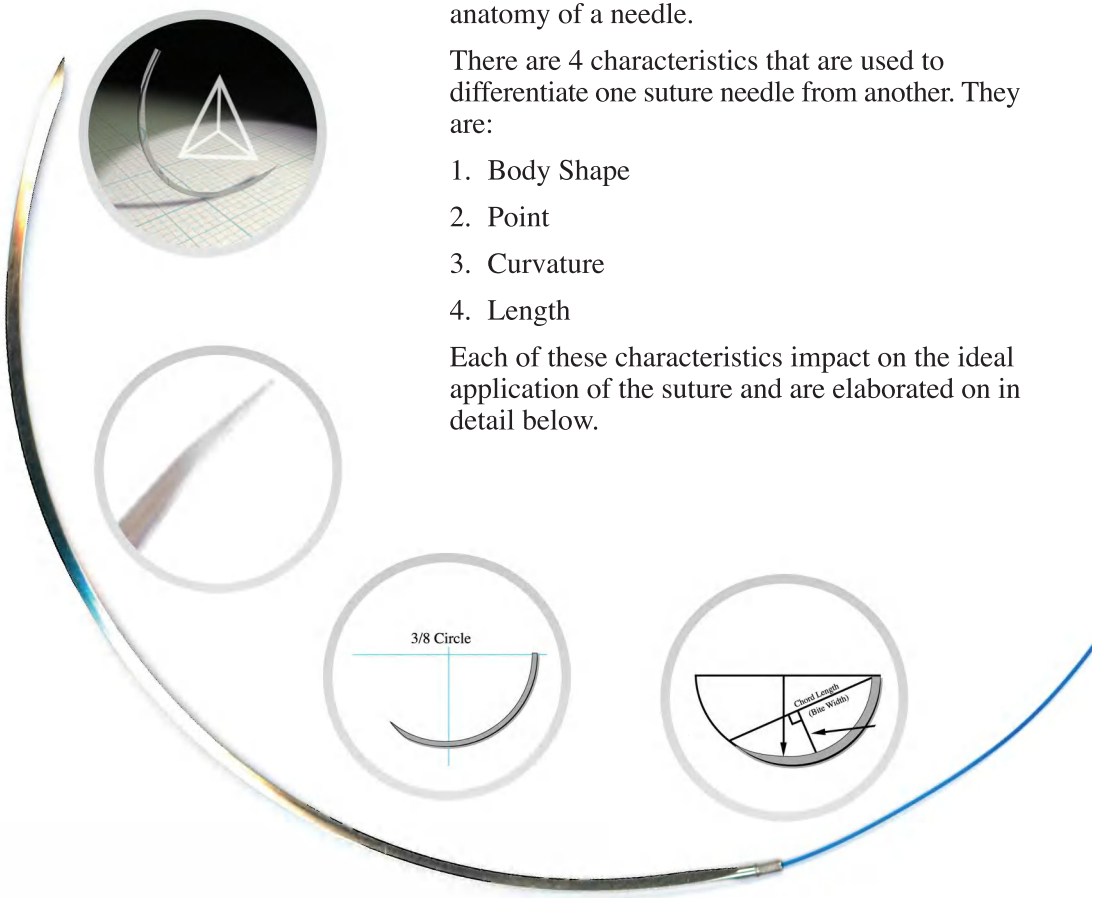
3. Suture Needles

The perceived quality of a suture is usually derived from the quality of the needle. A poor quality needle or a needle that is not suitable for a given purpose creates unnecessary trauma to the tissue and may make the suture action unbearable. As is the case with the suture thread, there are a number different types of suture needles that have different surgical applications. In order to differentiate the different needles it is important to understand the anatomy of a needle.

There are 4 characteristics that are used to differentiate one suture needle from another. They are:

1. Body Shape
2. Point
3. Curvature
4. Length

Each of these characteristics impact on the ideal application of the suture and are elaborated on in detail below.



3.1 Body shape

The body of the needle creates friction as it passes through the tissue and the higher the friction, the greater the difficulty for the surgeon to press it through the tissue. In response, manufacturers create different shaped needle bodies to reduce this friction. However, as always, there is the need to balance the ease of use of the suture (in this case the perceived sharpness of the needle) with the trauma it does to the tissue it passes through. Depending on the type of tissue and the surgical application, different needle bodies are preferred. These variations in needle shapes and their respective applications are detailed below.

3.1.1 Taper Point Needle

A taper point needle has a round shaft and tapers to a point. It has no cutting edge and is thus the least traumatic needle but also generates the greatest friction. Therefore its uses are primarily in soft tissues such as gastrointestinal, fascia and vascular where the lowest possible amount of tissue trauma is desired and the tissue is soft enough to not be hampered by the lack of a cutting edge on the needle.

Taper Point Key Points:

- A taper point needle has a round shaft and tapers to a point.
- Least traumatic.

3.1.2 Conventional Cutting Needle

A conventional cutting needle is generally referred to as just a 'cutting' needle. The body is triangular in shape with the point of the triangle acting as a cutting edge through the tissue. A conventional cutting needle's cutting edge is on the inside of the needle curve. It is slightly more traumatic on the tissue but the cutting edge provides greater penetration.

Cutting needles can be used in general skin closure, subcutaneous tissue, plastic or reconstructive surgery and sometimes for ophthalmic surgery.

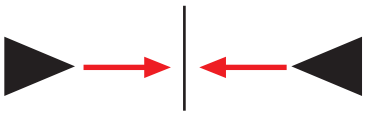
Conventional Cutting Key Points:

- A cutting needle is triangular in shape, with the "point" of the triangle acting as the cutting edge on the inside of the curve.

3.1.3 Reverse Cutting Needle

A reverse cutting needle is differs from the conventional cutting needle in that its cutting edge is on the outer curve of the needle. Its uses mirror that of the conventional cutting but is generally preferred due to the reduced risk of tissue failure. In the diagram below it can be clearly seen that tension on the suture material is on the 'cut' edge of the conventional cutting needle puncture wound whereas it is on the flat edge of the reverse cutting puncture wound. This lowered surface area makes it more likely for the suture material to pull through the tissue when using a cutting needle. Where the tissue is very tough such as a tendon, this risk is almost non existent and therefore the marginally better penetration of the conventional cutting needle is often preferred.

Today, most surgeons prefer the reverse cutting needle except on particularly tough tissue such as tendons.



Conventional Cutting Needle

Reverse Cutting Needle

Reverse Cutting Needle Key Points:

- A reverse cutting needle differs from the conventional cutting needle in that its cutting edge is on the outer curve of the needle.
- Reverse cutting needles lower the risk of tissue failure compared to cutting needles.

3.1.4 Taper Cutting Needle

The taper cut needle has a round tapered body as in the taper point needle but instead of a tapered point it has a honed reverse cutting point. The taper cut needle is used in areas where the atraumatic quality of the taper point needle is desired but extra penetration is required.

Taper Cutting Key Points:

- The taper cut needle is used in areas where the atraumatic quality of the taper point needle is desired, but the extra penetration is required.

3.1.5 Spatula

A spatula needle is flattened on both the inner and outer curve of the needle and has two cutting edges in a horizontal plane. Spatula needles are used in opthalmic surgery for muscle and retinal repair. The horizontal cutting edges "ride" along scleral layers as opposed to cutting through them.

Spatula Key Points:

- Spatula needles are used for opthalmic surgery.

3.2 Needle Point

In addition to the body shape, variations on the point of the needle impact on the suitability of a suture for a given purpose.

3.2.1 Blunt Point

Blunt point needles have a rounded piercing tip without any sharp edges that does not cut through friable tissue. For tissue where the cells are very large (liver and kidney), the rounded needle pushes between cells rather than cutting through them. Rather counter intuitively, the blunt needle is less traumatic in these situations.

3.2.2 Protect Point

If a surgeon's technique involves significant use of his/her hands, the risk of needle stick injuries are high with very sharp needles. Protect point needles are taper point needles with a slightly rounded point that can still pass through soft tissue but less likely to penetrate the surgeon's glove.

3.2.3 Premium Point

For applications where maximum penetration is demanded, a premium point suture needle is recommended. A premium point is essentially a finely sharpened point and can be achieved in a couple of ways. Firstly, creative tip geometry with additional cutting edges can provide additional sharpness. Alternatively, more of the needle body is machined away providing a longer thinner tip. However, while this method provides superior results a very hard grade of stainless steel is required to prevent the very thin point from sustaining damage during the suturing process.

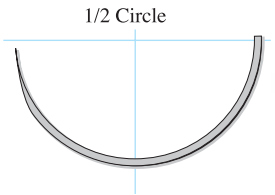
The Synthecon Cosmetic Premium needle for example is just such a needle. It is forged from 300 series surgical steel which allows the point to be machined to as much as a third of the length of the needle.

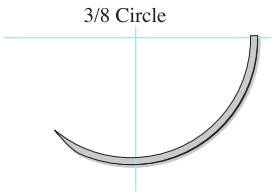
3.3 Needle Curvature

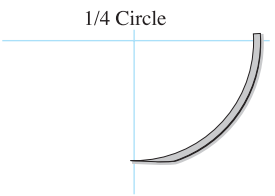
Suture needles tend to be curved and the curve is represented as a fraction of a circle. They are either 5/8, 1/2, 3/8, 1/4, straight or J shaped as shown in the diagrams to the right.

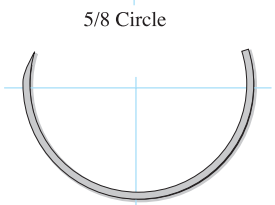
A curved needle allows the needle to pass in and out of the tissue with minimal manipulation (and thus trauma) of the tissue. As the curvature of the needle changes, so does the action of the hand / needle holder to pass it through the tissue. For example, an increased needle curvature results in the action of the needle holder being more of a rotation than a lateral movement of the hand. While this may be more uncomfortable for the surgeon, in areas where there is not a lot of room for lateral movement of the hand such as internal abdominal surgery, a 1/2 circle or even a 5/8 circle needle will be preferred. Where space is not a concern such as on or around the skin surface, the more comfortable action of the 3/8 circle needle will be preferred.

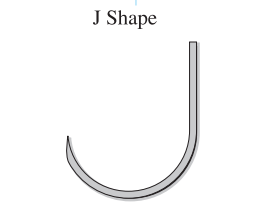
A 'J'needle is a 1/2 circle needle with a long stem thus making the needle resemble the letter 'J'. In situations where there is a small deep incision, such as those made for laproscopic surgery, there is insufficient space to use a normal suture needle on the lower layers of tissue. Therefore the J needle can be grasped on the long stem a lowered into the wound to suture the lower layers.



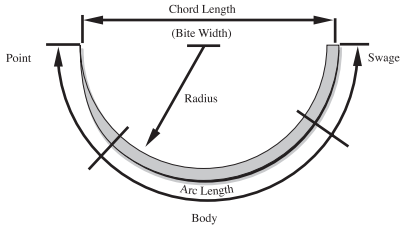


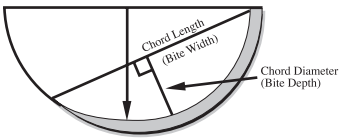






3.4 Needle Length





The final characteristic used in classifying suture needles is the length of the needle. Measured from the swage (where material joins needle) to the point along the circumference of the curvature. This is the Arc Length and is the measurement that is included on the suture package. Other measurements that are sometimes quoted are:

- Bite Depth - distance from body of the needle to the centre of the needle curve circle (radius)
- Bite Width - linear distance from needle point to swage

It needs to be reinforced that the standard measurement of needle length as denoted on suture packaging is the ‘Arc Length’.

4. Swage

The swage is the point where the material joins with the needles. It creates a single, continuous unit of suture and needle. There are three different types of swage.

- Drill swage: A hole is drilled into the base of the needle (sometimes with a laser). The suture material is placed in this cavity and then the needle is crimped over the suture. This is the least traumatic swage and is generally preferred. All Synthecon sutures from 2 USP to 8/0 USP utilise drilled swage.

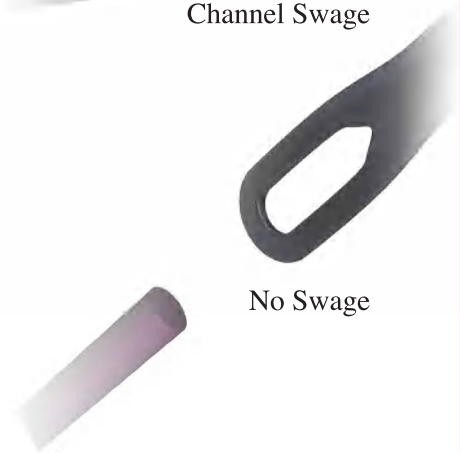
- Channel swage: A needle is created with a spoon shaped channel at the base of the needle into which the suture material is introduced. The channel is crimped around the suture to secure it into place.

- Non Swaged: Alternatively, the suture may be passed through an eye, similar to that found in a sewing needle. Several disadvantages are associated with the use of a nonswaged needle. Tissue passage of a double strand of suture leads to more tissue trauma. In a swaged needle, the suture is less likely to become unthreaded prematurely. Also, decreased handling helps maintain suture integrity.

The quality of the swage is critical to the performance of the suture. A high quality needle and the strongest thread become meaningless if the needle detaches during surgery. Creating the optimum swage is a balancing act: too much force when crimping the needle fatigues the swage and risks breakage; too little and the thread detaches.

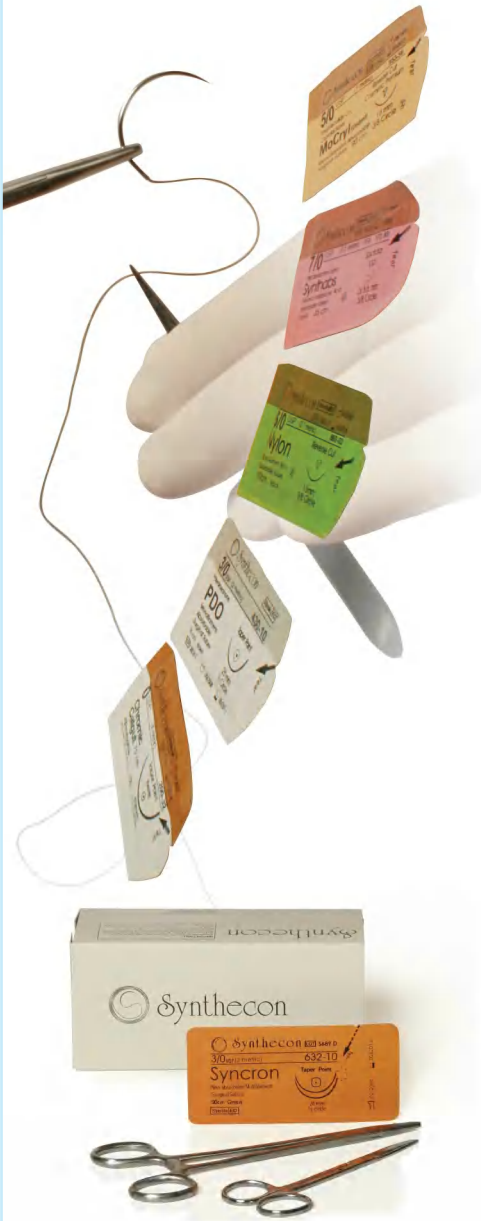
Drill Swage

Channel Swage



No Swage

5. Which Suture?



Selecting the correct suture for a given application is an act of optimisation. A suture needs to be placed with the lowest possible force, creating the least amount of trauma, providing the right amount of support for a would for only as long as it takes for the tissue to heal all the while minimising the risk of infection.

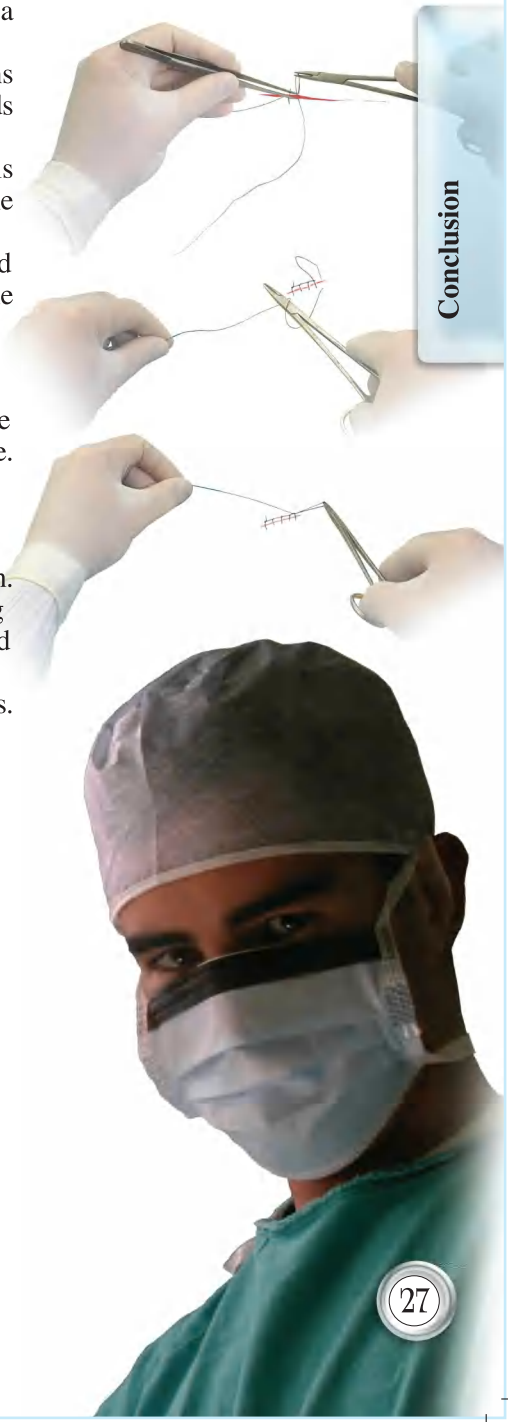
What makes the above balancing act difficult is that there are many variables that are specific to the patient. The reality of suture selection is that it is a combination of convention learned through experience and doctor preference. A chromic 2/0 can replace a PGA 2/0 which can in turn replace a MoCryl 2/0 and do an acceptable job as all three are absorbable sutures. So each doctor, over the course of their career would have weighed up the relative strengths and weaknesses of the different needles and threads to build up their list of preferred sutures. They will also have learnt in which clinical environments their standard suture selection will need to be adjusted. For example accelerated absorption may occur in patients with fever, infection, or protein deficiency and may lead to an excessively rapid decline in tensile strength. Accelerated absorption may also occur in a body cavity that is moist or filled with fluid or if sutures become wet or moist during handling prior to implantation. In these cases, surgeons may switch to a slower absorbing material or (more likely) opt for a thicker version of their existing suture material.

6. Conclusion

In summary, although on the surface a suture is a simple combination of needle and thread, the reality is that there are thousands of combinations of your basic suture elements giving you thousands of potential products. Choosing which suture is the correct one for a given surgical application is thus a challenging task. This document details the wide array of suture options available, demonstrating the differences between them and the surgical implications to assist in selecting the most appropriate suture for a given purpose.

In a clinical environment, the final product to be used is driven by convention and doctor preference. For example, one doctor may prefer the knot security of a chromic catgut suture but another may prefer any of the synthetic materials to the natural fibres of catgut due to lower tissue reaction. Nevertheless, the value here is in understanding the nature of the suture, the various material and needle variations for classification purposes as well as their relative advantages and disadvantages.

Happy Suturing.



Synthecon

1 Power Road, Isando
PO Box 26, Isando, 1600
Republic of South Africa
Tel: **011 974 3220** • Fax: **086 505 0537**
info@synthecon.co.za • www.synthecon.co.za