

## UNDERSTANDING ABSORBABLE SUTURES: A REVIEW

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### Abstract

An efficient suture can close a wound both aesthetically and functionally. The type of substance chosen depends on the tissue's needs. Sutures are divided into different categories based on their origin, material of construction, number of filaments, and thickness over time. The chapter discusses the characteristics of suture materials, including those that are monofilament, multifilament, twisted, or braided; absorbable or nonabsorbable; and of various sizes. Along with key suture qualities like elasticity, tissue responsiveness, knot strength, tensile strength, and biodegradability, a wide range of synthetic suture materials are delineated in detail.

## INTRODUCTION

Any surgical procedure's success depends on a successful wound closure. An imperfect seal causes the margins to separate, opening up a possible entry point for microorganisms that can cause infection and scarring. Despite the current usage of tissue adhesives and staples as substitutes, surgical sutures remain the go-to method for a wound that is securely

closed (Bokadia & Ganapathy, 2020). It has been discovered that the sensitivity of the tissue to infection is increased by the presence of a suture in surgical incisions. Elek and Conen found that 10<sup>6</sup> Staphylococcus pyogenes needed to be injected into human volunteers in order to cause a clinical infection that produced pus. The concentration of

the pus-forming dose was dramatically lowered to 100 cocci under the same circumstances, other from the addition of a braided silk suture (Elek, 1957 #621). There are numerous ways that surgical sutures might exacerbate an infection in a wound. The needle's injury to the tissue causes a large inflammatory reaction. The way in which the surgeon manipulates the tissue also seems crucial (Edlich, 1968 #622). The likelihood of wound infection is dramatically increased by sutures that are tied excessively firmly around the borders of the wound. The physical and chemical makeup of the suture may also contribute to the growth of a wound infection. The surgeon has access to several different sutures with a variety of physical and chemical combinations. A basic classification of surgical sutures is provided by measurements of the in vivo degradation of sutures. Those sutures that degrade quickly in tissues, losing their tensile strength within 60 days, can be referred to as "absorbable sutures." "Non-absorbable sutures" are those that retain their tensile strength more than 60 days after being implanted. This phrase is somewhat deceptive because many "non-absorbable sutures" such as silk, cotton, and nylon—lose their tensile strength quickly after the second month and by the sixth month are either disintegrating or so weak that they have little effect on supporting the tissue (Moloney, 1961 #623). Regarding the best suture material to use to close skin lesions on the face, facial plastic surgeons have long disagreed. Nonabsorbable suture material, which is easier to tie, is less likely to break early, and causes a low inflammatory reaction, is preferred, according to many surgeons. Others think these concerns are unimportant and favor absorbable sutures because they don't need to be taken out, which saves the surgeon time and lessens patient discomfort and anxiety. There is no difference in the long-term cosmetic outcomes of repairs with permanent or absorbable suture material in adults with clean wounds to the face or neck. The absorbable sutures since they don't need to be taken out, which saves time for the surgeon and reduces patient discomfort and anxiety. The ancient skill of employing suture material to close wounds was mentioned in Egyptian texts from around 3500 BC. With varied degrees of success, animal hair, vegetable fibers, silk, leather, and gut have all been tried. It

should come as no surprise that there is no agreement among facial plastic surgeons regarding the ideal material for dressing head and neck skin wounds. Sutures made of monofilament are less reactive and glide through tissue with ease. Some monofilament sutures, like nylon, have a bouncy quality that makes them challenging to tie and more likely to unravel. Additionally, if they are knotted in a tight knot, they could damage tissue. Sutures that are braided are simpler to tie since they have less memory. But germs can get into the cracks and spread sickness. Additionally, these sutures grow as they take in fluid, which occasionally causes knots to loosen. Nonabsorbable suture material, in the opinion of many surgeons, is better because it is simpler to tie, less prone to break prematurely, and causes a low inflammatory reaction. Others choose absorbable sutures since they don't need to be taken out, which saves time and lessens patient discomfort and anxiety. The article by LaBagnara on absorbable sutures is good. The ideal suture would be a monofilament that is flexible, has a sufficient tensile strength, retains knots effectively, and dissolves in 7 to 10 days. Such suture materials are not offered now (Khiste, 2013 #624).

## 1- Historical Aspects:

Historically, natural materials like cotton and animal tendons were used as sutures to close wounds. Sutures made of synthetic materials have been utilized since 3000 BCE. Plant fibers, hair, tendons, and wool threads have all been discovered in mummified bodies as evidence of ancient Egyptian use (Snyder, 1977). The Samhita, penned by the Indian physician Susruta circa 500 BCE, is the earliest text to explain suturing methods (Ricci, 1990). He suggested applying black ants to the wound's borders after irrigating it, and then separating the ants' bodies from their heads (Goel, 2016; Pickover, 2019). In addition, he discussed how sheep upper small intestine bowstring was used as suture for amputation, tonsillectomy, rhinoplasty, and anal fistula repair. The term "kitgat," which means "fiddle string," was used to describe the process of making bow strings for musical instruments. A "kit" was a three-stringed violin, and the phrase "catgut" was derived from this. (Ricci, 1990).

Catgut was widely used in the 19th century. Catgut is a biodegradable fabric with strong mechanical characteristics. The first effort to utilize sutures coated with an antibacterial substance was made by Joseph Lister in 1868. To achieve this, two different types of fibers were used, one made of typical catgut and the other from the peritoneum of cows. Both kinds of sutures had an antibacterial phenol solution applied to them. As synthetic absorbable sutures became more widely available over time, the use of catgut declined with time. The Dexon suture was introduced to the market in the late 1960s after the US created the first absorbable synthetic sutures in 1962 (Gierek et al., 2018; Schiappa & Van Hee, 2012). New generations of the suture were introduced, and the Dexon material kept getting better (Gierek et al., 2018; Trimboş et al., 1991). There are currently other synthetic sutures on the market with stronger tissue tone preservation qualities, like Vicryl or PDS (Reid, 2011; Reis & San Román, 2004).

## 2- Suture Characteristics:

Any suture material should be evaluated for these five qualities:

### i. Physical Structure

You can use monofilament or multifilament for your sutures. Although monofilament suture material tends to flow through tissues without needing to be sawed, it is more challenging to knot securely. By grasping it with forceps or a needle holder, such material can be readily destroyed, which might result in suture material fracture (Zuhr et al., 2017) (Latona et al., 2018). Although multifilament or braided sutures are more simpler to knot, they have thousands of times the surface area of monofilament sutures (Borle Rajiv et al., 2014).

### ii. Strength

Suture material strength is influenced by its base material, thickness, and handling within the tissues. Although the number assigned also depends on the type of material, for example, absorbable material and non-absorbable material, such as polypropylene, may have different designations, suture material thickness is categorized according to its diameter in tenths of a millimeter (Cuschieri & Zsabo, 1995). Materials like catgut (which is no longer used in the

UK) have a tensile strength that lasts only about a week. Even non-absorbable sutures, meanwhile, may lose some of their strength with time and may not be as strong indefinitely. These synthetic non-absorbable materials, like polypropylene, are likely to maintain their tensile strength indefinitely and do not alter in mass within the tissues, however they are still susceptible to fracture. Silk and other non-absorbable biological materials would undoubtedly deteriorate over time and lose their strength, hence they should never be utilized in vascular anastomoses for risk of late fistula formation (Bucknall, 2012; Capperauld, 1989).

### iii. Tensile Behavior

Depending on their deformability and flexibility, suture materials respond differently. A material's ability to return to its original length after stretching is known as elastic property. Due to this characteristic, the suture can stretch with edematous tissue while also recovering its previous length and shape after the oedema has subsided (Leng et al., 2009; Rao et al., 2015). Sutures can be flexible, changing from a circular to an oval cross-section, or they can be stiffer and have the slightly annoying ability to kink and coil. A lot of synthetic materials have "memory," so they continue to curl up in the shape they took while in the container. A firm yet gentle tug on the suture material helps to reduce this memory, however the lower the knot security, knotting method also significantly affects the malleable firmness of any suture line (Stöckel, 1995; Wondraczek et al., 2022).

### iv. Absorbability

When selecting suture materials for particular wound closures or anastomoses, this property must be taken into account (Figure 1). Suture materials may be non-absorbable or absorbable. To reduce the risks a braided material should be avoided, though, because platelet adhesion may increase the risk of distal embolization in vascular anastomoses. Since artificial grafts and prostheses never entirely heal or integrate into a host artery, non-absorbable materials are typically preferable where persistent strength is needed. Persistent monofilament suture materials, including polypropylene, are therefore employed almost exclusively in these situations (Afewerki et al., 2023; Muhammed Owaise, 2019).

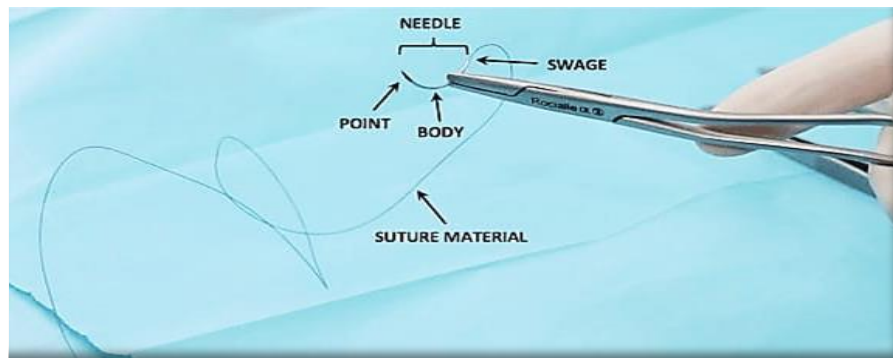


Figure 1: Suture Material

**v. Biological Behavior**

Suture material's biological action within tissues is dependent on the raw materials that make up its components. Proteolysis is a process that breaks down biological or natural sutures, like catgut, but because it's unpredictable and can irritate the nearby environment, these materials aren't frequently employed. Because synthetic polymers are hydrolyzed, it is easier to estimate when they will vanish from the tissues. However, the final outcome is affected and made more unpredictable by the presence of pus, urine, or feces (Terraza, 1989).

**3- Suture Techniques:**

There are four suture methods that are routinely utilized.

**Interrupted Sutures:**

To prevent needlessly extending the needle hole, it's crucial to spin the needle through the tissues rather than dragging it. As a general rule, the distance from the needle's entry point to edge of incision should be roughly equal to the depth of the tissue being sutured, and each further suture should be spaced at a distance that is twice as great. Each stitch should be positioned at a right angle to the wound's axis and extend deep into the wound. When closing linear wounds, it can be simpler to start with the middle stitch and then add the other sutures one at a time, halving any leftover wound length deficiencies (Beam, 2008).

**Continuous Sutures:**

The initial continuous suture is placed in the same way as an interrupted suture, but all subsequent

sutures are placed continuously until the farthest point of the incision is reached. Each throw of the continuous suture should be placed at a right angle to the incision, which causes the suture material to be visible from the outside of wound. In order to prevent either purse-stringing the wound by applying too much tension or leaving the suture material too slack, it is vital to have an aid who will observe the suture and maintain it at the same tension (Gurusamy et al., 2014).

**Mattress Sutures:**

Mattress sutures are typically used to generate either inversion or eversion of a wound edge, and they can be either vertical or horizontal. As with an interrupted suture, the initial stitch is placed, but after that, the needle is moved either horizontally or vertically and passes over both borders of the incision once more (Gurusamy et al., 2014). Particularly when the margins that need to be anastomosed are uneven in disposition, such sutures are highly helpful in providing an exact approximation of the wound edges.

**Subcuticular Sutures:**

When a skin's aesthetic appeal is crucial and the edges may be easily approximated, this technique is applied. The type of suture material utilized might either be absorbable or not. Non-absorbable suture ends can either be tied loosely across the wound or secured with a collar and bead. When utilizing absorbable sutures, the ends can be tied off with a hidden knot. To approximate the margins of the wound little bites of the subcuticular tissues are

obtained on different sites of the incision and then gently pushed together (Ranjan, 2016).

#### 4- Knotting Techniques of Sutures:

One of the most basic surgical skills, knot tying is frequently done incorrectly. Unfortunately, many surgeons lack a basic understanding of the concepts underlying a secure knot, and an improperly tied knot might compromise a successful surgical procedure. The fundamental ideas guiding knot tying are as follows:

- To avoid strangling the tissues, the knot must be tied tightly.
- The knot must not be able to unwind or slip.
- For as little foreign material as feasible, the knot must be as small as possible.
- The suture material must not be "sawed" during the tying process because this weakens the thread.
- When tying, the suture material must be put out squarely; otherwise, the tension during tightening may cause the thread to fracture or break.
- The reef knot is the typical surgical knot, and typically requires a third throw for security. However, monofilament sutures, such those used in vascular surgery, require six to eight throws for stability.
- A granny knot is a slip knot that calls for two throws of the same kind. It might help in achieving the proper tension in some situations.
- When extra security is needed, a surgeon's knot tied with the two-throw method is suggested to avoid slippage (Levenstein & Biddle, 2011) .
- The last knot in the continuous suture technique could be an Aberdeen knot. The free end of the suture is dragged halfway before being pulled entirely through just before cutting. To prevent unraveling, the ends of the suture should be left around 1-2 mm long when cut after knotting. When using monofilament material, this is very crucial.

#### Effect of suture technique, material and size on knot security:

A vital component in preserving the integrity of a knotted suture is knot security, which is defined as a

knot's capacity to withstand slippage and rupture as load is applied for the reason that the knot is always a surgical seal's weakest link. The success of the surgical procedure may be hampered by knot failure since it could cause a wound to reopen (Edlich & Long, 2007). Many surgeons rely on an anecdotal number of ties (throws) that is widely accepted but is not supported by sufficient scientific evidence. This number varies among surgeons and training programs. According to some reports, using too few throws might cause a knot to break, whereas using more knots than necessarily has no mechanical benefit and adds to the number of foreign objects in the wound that weaken the host's defenses and resilience to infection. Consequently, it's crucial to understand the very minimal throws required for knotting (Tidwell et al., 2012). According to a survey of the literature, studies on knot security and how it relates to surgical procedures and suture materials have been conducted mostly in orthopedic, veterinary, general, and obstetric surgery. In the field of oral and maxillofacial surgery, research is lacking. The authors made the assumption that knot security would depend on suture technique but not suture material or size based on prior research in other specialties. Using 90% security as a cutoff, it is clear that at least 4 throws are typically advised for different suture material and size combinations when using surgeon's and square knots, and at least 5 throws are advised when using sliding knots. However, the particular combination will determine how many throws are necessary to attain knot security. For instance, although a 3-0 Vicryl suture with a surgeon's knot only needs 3 throws, a 3-0 chromic gut suture with a surgeon's knot needs 5 (Silver et al., 2016). According to the logistic regression model, knot security was found to be dependent on suture type, method, and number of throws, but independent of suture size. The authors discovered that 2 throws are never advised for any combination of suture material, size, or technique, just like in prior investigations. Although the minimal number of throws is generally dependent on the suture combination, a minimum of 4 throws is always recommended to achieve knot security (Muffly et al., 2011) .

#### 5- Classification of Suture Materials:

An ideal suture material should be easy to sterilize, have high tensile strength, hold knots securely, cause little tissue reaction, not favor bacterial growth, and be absorbable once its purpose has been served. It should also not act in an electrolytic, capillary, allergenic, or carcinogenic manner. Different sutures are needed depending on the tissue involved since no one suture has all these qualities. Based on the tissue configuration, the biomechanical characteristics of the wound, and the biological interaction of the materials used, the suture material

is selected (Bourne et al., 1988; Edlich et al., 2010). There are various color options for the sutures. For identifying the various anatomical structures in some circumstances (like vascular surgery), the color serves as a signal. Even when covered in blood, the color makes sutures easier to see, which facilitates stitch removal (Bourne et al., 1988; Goel, 2016). Sutures can either be monofilament or multifilament, absorbable or non-absorbable and constructed of natural or synthetic materials (Figure 2).

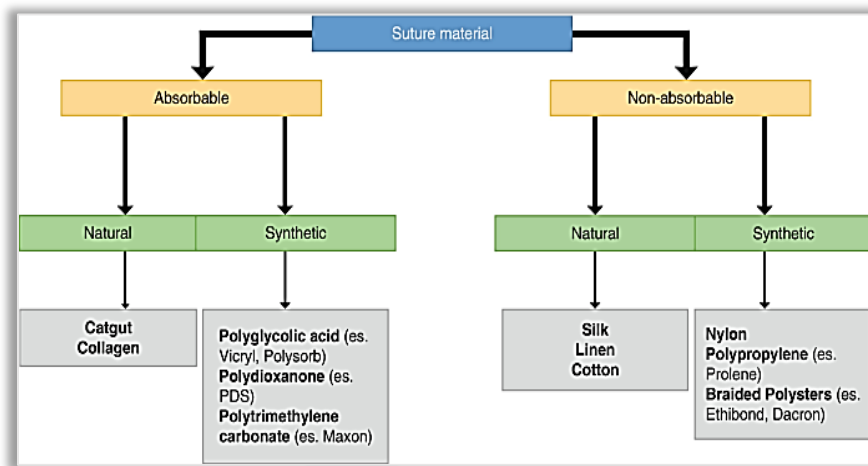


Figure 2: Schematic Classification of Suture Material

5.1- Absorbable Sutures:

The term "absorption" typically refers to the suture's ultimate removal from the place of implantation. For the majority of absorbable synthetic polymer sutures, hydrolytic bond scission occurs prior to absorption, whereas enzymes are thought to be in charge of the degradative alterations and absorption of sutures made from natural polymers (Benicewicz & Hopper, 1991; Low et al., 2020). The strands of braided or multifilament sutures are knitted together. Because they lack grooves and a rough surface for objects to stick to, non-braided sutures generate less reactivity in the body and are less likely to become infected. However, they have the drawback of losing at the surgical knot due to the lack of grip. Rapidly degrading sutures are regarded as absorbable since they lose their tensile strength early on (Chu, 2013; de la Harpe et al., 2021). In absorbable sutures, biodegradation and absorption characteristics are

particularly crucial. Because of the biodegradation property, absorbable sutures do not cause the same kind of long-lasting, persistent inflammation as nonabsorbable sutures do. According to research (Breed et al., 1999; Breuninger, 1998), the rate at which absorbable sutures dissolve influences the degree of scar formation. Enzymatic absorption, as with catgut, or hydrolytic absorption, as with synthetic absorbable polymers, are also possible. The duration needed for a material's tensile strength to decrease to half its initial value is known as the half-life. The amount of time before a thread totally dissolves is referred to as the dissolution time. Thread diameter, tissue type, and the patient's overall health are only a few of the variables that affect these times (Kamaly et al., 2016; Kariduraganavar et al., 2014).

The following organic compounds are covered in absorbable suture materials:

- Catgut
- Reconstituted collagen.

Following is an overview of synthetic matter:

- Aliphatic polyesters
- Polyglycolic acid
- Poly(glycolide-co-L-lactide) copolymer
- Poly- p -dioxanone (PDS)
- Additional glycolide-based copolymers (such as Poly (glycolide-trimethylene carbonate), Poly(glycolide-co-ε-caprolactone) copolymer, Triblock copolymer of poly (glycolide

trimethylene carbonate and dioxanone), poly(glycolide co-trimethylene carbonate co-caprolactone), poly(glycolide co-lactide co-trimethylene carbonate co-caprolactone) copolymer, or polyglytone 6211

- Polylactide (PLA) and
- Polyhydroxyalkanoates (PHA).

Below there is a table describing absorbable sutures, their characteristics and importance (Table 1).

Table 1: Absorbable Suture Materials:

Suture	Types	Raw material	Tensile strength retention in vivo	Absorption rate	Tissue reaction	Contraindications	Frequent uses	How supplied
Catgut	Plain	Collagen derived from healthy sheep or cattle	Lost within 7-10 days Marked patient variability Unpredictable and not recommended	Phagocytosis and enzymatic degradation within 7-10 days	High	Not for use in tissues that heal slowly and require prolonged support Synthetic absorbables are superior	Ligate superficial vessels, suture subcutaneous tissues Stomas and other tissues that heal rapidly	6/0-1 with needles; 4/0-3 without needles
Catgut	Chromic	Collagen derived from healthy sheep or cattle Tanned with chromium salts to improve handling and to resist degradation in tissue	Lost within 21-28 days Marked patient variability Unpredictable and not recommended	Phagocytosis and enzymatic degradation within 90 days	Moderate	As for plain catgut Synthetic absorbables superior	As for plain catgut	6/0-3 with needles; 5/0-3 without needles
Polyglactin	Braided multifilament	Copolymer of lactide and glycolide in a ratio of 90:10, coated with polyglactin and calcium stearate	Approximately 60% remains at 2 weeks Approximately 30% remains at 3 weeks	Hydrolysis minimal until 5-6 weeks. Complete absorption 60-90 days	Mild	Not advised for use in tissues that require prolonged approximation under stress	General surgical use where absorbable sutures required, e.g. gut anastomoses, vascular ligatures. Has become the 'workhorse' suture for many applications in most general surgical practices, including undyed for subcuticular wound closures. Ophthalmic surgery	8/0-2 with needles; 5/0-2 without needles
Polyglyconate	Monofilament Dyed or undyed	Copolymer of glycolic acid and trimethylene carbonate	Approximately 70% remains at 2 weeks Approximately 55% remains at 3 weeks	Hydrolysis minimal until 8-9 weeks. Complete absorption by 180 days	Mild	Not advised for use in tissues that require prolonged approximation under stress	Popular in some centres as an alternative to Vicryl and PDS	7/0-2 with needles
Polyglycolic acid	Braided multifilament Dyed or undyed Coated or uncoated	Polymer of polyglycolic acid. Available with coating of inert, absorbable surfactant poloxamer 188 to enhance surface smoothness; 87% excreted in urine within 3 days	Approximately 40% remains at 1 week Approximately 20% remains at 3 weeks	Hydrolysis minimal at 2 weeks, significant at 4 weeks. Complete absorption 60-90 days	Minimal	Not advised for use in tissues that require prolonged approximation under stress	Uses as for other absorbable sutures, in particular where slightly longer wound support is required	9/0-2 with needles; 9/0-2 without needles
Polydioxanone (PDS)	Monofilament Dyed or undyed	Polyester polymer	Approximately 70% remains at 2 weeks Approximately 50% remains at 4 weeks Approximately 14% remains at 8 weeks	Hydrolysis minimal at 90 days. Complete absorption at 180 days	Mild	Not for use in association with heart valves or synthetic grafts, or in situations in which prolonged tissue approximation under stress is required	Uses as for other absorbable sutures, in particular where slightly longer wound support is required	Polydioxanone suture (PDS) 10/0-2 with needles
Polyglycaprone	Monofilament	Copolymer of glycolite and caprolactone	21 days maximum	90-120 days	Mild	No use for extended support	Subcuticular in skin, ligation, gastrointestinal and muscle surgery	8/0-2 with needles

## 5.2- Non-absorbable Sutures:

Nonabsorbable sutures are made of synthetic materials that the body cannot break down. Silk sutures are natural fiber non-absorbable sutures. The threads from a silkworm's cocoon are used to make silk sutures. It is relatively inelastic, virgin or braided, and when used in cataract surgery, it causes reduced astigmatism because it causes tissue necrosis, which leads to an early release of the incision. The degumming procedure, which eliminates the unnecessary material totaling to 30% of the raw silk's original volume, prepares the braided silk. In order to be compact, this is necessary. The benefit is that the suture doesn't absorb fluid or become floppy or brittle. On the other hand, the gums within the fiber are not removed from virgin silk during processing. This enables the twisted silk-worm fiber filaments to adhere to one another and form the strong, delicate suture material utilized in cataract surgery (Goel, 2016 #610).

Next, the major types of synthetic materials are covered:

- Poly (ethylene terephthalate)
- Polyamides: Nylon 66, Nylon 6
- Polyolefins (polyethylene and polypropylene (PP))
- Polytetrafluoroethylene (PTFE)
- Vinyl fluoride polymer (VFP)
- Stainless steel

## 5.3- Natural Materials for Absorbable Sutures:

The two most familiar organic components for absorbable sutures are catgut and collagen. Due to its abundance, type I collagen is the foundation of the majority. This collagen, which comes from several animals, has considerable structural variation, which makes it an excellent material for human implantation (de Castro Bras, 2009; Kew et al., 2011). Recently, a review of the intricate structure and characteristics of collagen biomaterials was published (Li, 2007). Sheep or goat intestines are used to make catgut. Sutures come in two varieties: plain and chromic. The two are both monofilaments. Chrome salts, which are brown in color, are used to treat metallic, slowing the body's absorption process and reducing tissue reactivity in nearby tissues. The uniformly fine-grained tissue structure, high elasticity, and tensile strength of catgut are some of

its distinctive qualities. Once in contact with tissue, plain catgut typically retains its strength for around 7 days while chromic catgut retains its strength for nearly twice as long. Catgut has low knot security but is simple to handle (Shah et al., 2020). In order to preserve their flexibility, catgut sutures are packaged in alcohol solutions (ethanol or isopropanol), sterilized by gamma-irradiation or ethylene oxide. Alcohol is not required for packing when using chromic catgut, which also has better handling properties. Compared to untreated catgut, the surfaces of the glycerin-treated sutures are homogenous and thicker due to the glycerin treatment. The body can quickly break down materials because to the structure of catgut. Since 98% of it is collagen, proteolysis contributes significantly to the biodegradation process (Cooper Jr, 2002). The substance must undergo 70 to 90 days for proteolytic methods to completely digest it. Catgut works best on wounds in places where tissue heals quickly. Because the catgut suture is made of a foreign protein, utilizing it has the drawback of causing a higher amount of tissue reactivity in the surrounding tissue. In general, chromic catgut tends to trigger more severe tissue response. Collagen can be extracted from collagen-rich tissues using salt solutions or by tissue enzymatic digestion. But unlike native collagen, reconstituted collagen displays a variety of polymorphic aggregation morphologies. Long cattle flexor tendons are used to prepare collagen sutures that have been reconstituted. Cleaning, freezing, slicing, treating with ficin, and swelling in diluted cyanoacetic acid are all performed on the tendon. They are almost solely utilized in microsurgery since they can only be produced in a single size.

## 5.4- Artificial components for absorbable sutures:

Synthetic absorbable sutures have taken the place of naturally occurring collagen-based absorbable sutures. The five fundamental building elements of synthetic absorbable sutures are trimethylene carbonate, L-lactide, p-dioxanone, -caprolactone, and glycolide. They are produced from aliphatic absorbable polyesters. The two "hard" segments, or rigid and less flexible, L-lactide and glycolide are the most crucial of these building blocks. The 'soft' segments that produce additional malleable suture

strands are the building components caprolactone, p-dioxanone, and trimethylene carbonate. The fastest in vivo absorption of absorbable sutures is achieved with 100% glycolide, whereas the longest absorption period is achieved with 100% or almost 100% L-lactide or p-dioxanone. Their findings imply that crystalline properties require a glycolide-lactide copolymer to include more glycolide than 70% mol%. Synthetic absorbable sutures used for wound closure applications need to be somewhat crystalline to get the right level of tensile strength that will be maintained throughout hydrolytic degradation. This is due to the fact that completely amorphous or extremely low-crystalline xenobiotic polymers would lose their effectiveness as biomaterials for wound closure far too rapidly. (Khiste et al., 2013). It has been reported that the entire absorption of 100% pure L-lactide PLLA takes more than 5.6 years due to high levels of crystallinity and hydrophobicity. All commissary artificial absorbable sutures have at most one hard segment (glycolide or L-lactide) but PDS or PDSII contains the soft p-dioxanone as well (Vazquez-Armendariz et al., 2020). Even though there are times when manifold kinds of soft constituent is coupled with a hard building block, the hard segments have always made up the majority (more than 50%) of the structure. Here are a few instances:

- Glycolide, which makes up 72% of Monosyn, contains one hard segment, and trimethylene carbonate and -caprolactone have two soft segments each.
- Glycolide, which makes up 60% of Biosyn, contains one hard segment, whereas p-dioxanone and trimethylene carbonate have two soft segments each.
- Glycolide, which makes up 67–75% of both Maxon and Monocryl's hard and soft segments, respectively, are 32.5% in Maxon and 25% in Monocryl's trimethylene carbonate.
- The sole synthetic monofilament suture with two hard segments Caprosyn, is made up of two hard segments (L-lactide and glycolide) and one soft segment (caprolactone and trimethylene carbonate) (Bezwada et al., 1995).

The FDA just recently gave Tephaflex, an absorbable suture based on 4-hydroxybutyrate, their seal of

approval. Instead of using the conventional artificial chemicals used to make aliphatic absorbable polyesters, Tephaflex is bioengineered from microorganisms.

### **Polyglycolic acid (Dexon):**

Early in the 1970s, polyglycolic acid (PGA) was used as the first synthetic absorbable suture (Frazza and Schmitt, 1971; Schmitt and Polistina, 1967). Under the brand name Dexon, it was created by Davis and Geck, which is currently a part of Covidien. Dexon sutures come in a number of types. Dexon "S" is an uncoated PGA suture. Dexon II possess a polycaprolate plating, while Dexon Plus has a poly(oxyethylene-oxypropylene) copolymer coating. There are now 100% pure PGA sutures available from businesses other than Covidien, namely Medifit® (Japan Medical Supply Co.). Dexon suture fibers are created by spinning PGA chips in a melt. At a temperature higher than the fibers' glass transition temperature (about 36°C), the fibers are reclined to a number of hundred times their initial length. They are then heat-set to ameliorate dimensional firmness and reduce diminution. They are then braided to make final, various-sized multifilament braid suture forms. (Bjarnason et al., 1993).

### **Poly(glycolide-co-L-lactide) copolymer (Vicryl, Vicryl Rapide and Polysorb):**

The glycolide-L-lactide random copolymer is what gives Ethicon's absorbable sutures Vicryl and Vicryl Rapide their distinctive appearance. 2-10% of an amorphous polyglactin 370 mixture, 50:50 and calcium stearate is applied to multifilament braided Vicryl sutures. Vicryl Rapide is a kind of Vicryl that has undergone irradiation therapy for faster absorption. The sutures have been used in the skin closure of young children because they can be discharged under native rather than general anesthesia (Canarelli et al., 1988; Duprez et al., 1988). In oral surgery, it has also been employed (McCaul et al., 2000). Due to the predominance of L-lactide in Panacryl suture, its absorption acts more like that of PLA than PGA, i.e., it takes at least 1.5 years or longer for Panacryl to be entirely absorbed in living tissues. Some documented postoperative

complications have been linked to protracted absorption profile in vivo (Farnsworth, 2002; Vakili et al., 2005). It is well established that an extended in vivo disintegration period for absorbable sutures

increases the danger of late-stage tissue responses in patients and negate the benefit of gradual degradation (Böstman, 1991). The picture below describes the vicryl suture material used in intestinal



closure (Figure 3).

Figure 3: Vicryl Suture Material in Intestinal Closure

**Poly- p -dioxanone (PDS, PDS II, PDS Plus Mono Plus, Surusynth):**

Synthetic absorbable sutures (Dexon and Vicryl) were only available in braided form in big sizes prior to the release of PDS monofilament absorbable sutures because the stiffness of the high density of ester functional groups led to the bigger (e.g., 2/0) monofilament forms of these two sutures. To facilitate handling and improve knot security, monofilament absorbable sutures must be somewhat large in size but flexible. This is due to the fact that monofilament sutures exhibit less tissue reactivity and generally drag and tear less tissue when they pass through tissues than braided sutures. By reducing the density of the ester functional group in Dexon, the molecular pliancy can be increased within the glycolide family and lessen the frequency of hydrogen bonding. This method enables reasonable flexibility in the production of monofilament absorbable sutures. The first commercially available monofilament absorbable sutures that come from the glycolide family are PDS and PDSII sutures. Poly(ester-ether) is the name given to them. These artificial, biodegradable monofilament sutures are created by polymerizing 1,4-dioxanone-2,5 dione or p-dioxanone monomer, which is produced when

metallic sodium and chloroacetic acid are combined with a significant amount of ethylene glycol (Ulery et al., 2011).

**Copolymer of poly (glycolide and trimethylene carbonate) Maxon:**

Maxon; a poly(ester-carbonate) and contains 32.5% of trimethylene carbonate (36 mol%) (Katz et al., 1985). Two phases make up the polymerization process (Casey and Roby, 1982). The prime step is creation of the random copolymer of 1,3-dioxan-2-one (trimethylene carbonate) and glycolide. The catalyst is stannous chloride dihydrate ( $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ ), and the initiator is diethylene glycol. At roughly  $180^\circ\text{C}$ , the polymerization takes place. In the middle block, the weight ratio of trimethylene carbonate to glycolide is 15:85. In order to prevent the copolymer from crystallizing after the middle block has been synthesized, temperature of reaction bath is increased to around  $220^\circ\text{C}$ . Additionally, glycolide monomers are added as the end blocks are introduced into the reaction bath in order to generate the final triblock copolymer. Ethylene oxide is used to sterilize Maxon suture; no coating is necessary (Katz et al., 1985).

## **Poly (glycolide-co- $\epsilon$ -caprolactone) copolymer; Monocryl, Monocryl Plus, Suruglyde:**

A copolymer having the building components hard glycolide and soft caprolactone is used to create absorbable monofilament sutures like Monocryl, Monocryl Plus, and Suruglyde. Suruglyde is manufactured by SURU International, and Monocryl Plus is an antimicrobial-capped version of Monocryl. According to Ethicon, the pliability of Monocryl monofilament suture is its most significant feature (Bezawada et al., 1995). Due to the presence of the  $\epsilon$ -caprolactone co-monomer unit, Monocryl has a low glass transition temperature, which accounts for its natural pliability. Monocryl suture looks to have better handling properties because it seems to have less out-of-package memory.

## **Poly (glycolide-trimethylene carbonate-dioxanone) triblock copolymer (Biosyn):**

Glycomer 631, a triblock copolymer, is used to create Biosyn absorbable suture. Glycolide makes up 60% of it, followed by  $p$ -dioxanone and other building blocks (Pillai & Sharma, 2010). At the end of 28 days, only around 8% of the original malleable breaking firmness of Biosyn sutures was still present, which is comparable to Vicryl suture's rate of tensile strength loss in vitro. Biosyn in-vivo half-life is 90 to 110 days. Monocryl, on the other hand, was absolutely engrossed within 90 days. According to (Molea et al., 2000), Biosyn exhibits tissue response between Monocryl and PDSII. For instance, the three-month tissue reaction scores for Monocryl, Biosyn, and PDSII were 8, 20, and 28 respectively. Whereas Biosyn's tissue score was extremely similar to that of Monocryl, indicating that both drugs were practically entirely effective.

## **Polyglytone 6211 (Caprosyn):**

Caprosyn, a modern synthetic monofilament suture from Covidien, an eminently quickly absorbed suture preserves 50% tensile firmness at 5 days and nearly total intramuscular absorption after 56 days (Gouletsou et al., 2021).

## **Polylactide-based absorbable sutures (Orthodek):**

The only coated braided PLA suture that is marketed commercially is Orthodek. As long as its relatively moderate absorption, it is not advised for use in

tissues related to the heart, eyes, or nervous system. Instead, it should be used in tissues that need prolonged support, such as bones' tendons, ligaments, and other connecting tissues.

## **Poly-4-hydroxybutyrate (TephaFlex):**

TephaFlex is the newest innovation to synthetic absorbable suture materials (Martin & Williams, 2003). TephaFlex is non-inflammatory and biocompatible, according to studies. Their biodegradation happens naturally, and the byproducts of the breakdown are metabolites the body already has. P4HB is produced by a fermentation technique as opposed to a chemical synthesis procedure in the market. Therefore, it doesn't have any leftover metal catalysts that can cause undesirable consequences like burning. P4HB is not just biocompatible; the body really tolerates it quite well (Nelson et al., 1981) is produced when P4HB is hydrolyzed. The body quickly eliminates this metabolite through the Krebs' cycle and has a short half-life of only 35 minutes (Sendelbeck & Girdis, 1985). This is significant since a chemical is biologic, if it stays in body for a prolonged span, the higher concentration that has developed over time may still produce undesirable tissue reactions. Last but not least, polyester has a lower  $pK_a$  (acid dissociation constant) than PGA and PLLA materials, making it less acidic. The handling throughout the wound closure process is the main distinction between P4HB and conventional sutures. An implanted polymer with a lower Young's modulus will handle better and have a different breaking strength retention profile (Xu et al., 2022).

## **3.5- Absorbable sutures utilization in discrete surgical procedures:**

Patients undergoing abdominoplasty, mastopexy, and reduction mammoplasty were included in prospective multicenter randomized research comparing barbed sutures with smooth sutures. On one side of the body for each patient, barbed sutures were used instead of or in combination with deep dermal sutures. On the opposite side, smooth sutures with deep dermal and subcuticular closure were employed as a control. 229 patients in total received treatment (114 with rapid-absorbing polymer and 115 with slow-absorbing polymer). The barbed suture required

fewer deep dermal sutures than the smooth suture, which resulted in a faster mean dermal closure time (12.0 vs 19.2 minutes). While the slow-absorbing barbed suture had a higher frequency of mild suture extrusion, the rapid-absorbing barbed suture displayed a complication profile comparable to that of the smooth suture. Barbed sutures had a similar complication profile to smooth sutures but were able to close the dermis more quickly (Rubin, 2014 #611). The most frequent side effects following an abdominal wall midline incision are still incisional hernias. The function of the suture material utilized to close the abdominal wall is still debatable. Braided suture materials with antibacterial activity (Vicryl plus, Ethicon, Inc.) were created to reduce bacterial adhesion to surgical sutures. When compared to slowly absorbable sutures after midline abdominal incision, rapid absorbable sutures with antibacterial coating (Triclosan) do not raise the hernia incidence when wound infection rates are reduced by coating the fast absorbable suture with Triclosan. Patients with a BMI more than 30 kg/m<sup>2</sup> are substantially more likely to develop an incisional hernia (Justinger et al., 2012).

### Conclusion:

Based on qualities including absorbability, material origin, and thread structure, surgical suture materials can be categorized. Although natural threads are still utilized, a wide range of synthetic sutures have mainly taken the place of them in the previous few decades. Suture-related complications have been significantly decreased thanks to the standardization of packaged suture material.

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