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Review Article

Review On Biological Properties of Suture Materials

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Abstract

Suture is a general term for all materials used to stitch torn tissues. Surgical sutures are imperative in management of surgical and traumatic wounds. Sutures are primarily used to oppose tissues together to assist and accelerate the recovery process after an incident or surgical operation. In addition, sutures also aid in obliteration of dead space, even distribution of stress on the incision line, and maintenance of adequate tensile strength throughout the critical wound healing process until appropriate tissue strength is achieved. Considering availability of a wide variety of suture materials, it’s important to know the differences between various sutures before making an informed decision. Suture material's overall performance is influenced by its physical qualities, handling features, and biological factors. The aim of this seminar paper is to give highlights on the biological properties of suture materials. Suturing is not simply about closing a wound; it is a skill that requires finesse and can significantly impact the healing process, reduce complications, and even affect long-term results. Suture selection involves the choice of both the appropriate type and size of suture material. Sutures may cause different host reactions in living tissues. While the suture remains in the tissue, it can trigger the inflammation cascade through different pathways such as degradation, a foreign body reaction, an allergic reaction, or abrasion. Natural suture materials such as catgut and silk are more immunogenic than synthetic materials because they are degraded by proteolysis in contrast to synthetic suture materials, which are degraded by hydrolysis. Therefore, surgery professionals should choose a suture material with good tissue acceptance.

Key words: biological properties; host reaction; natural suture materials; suture materials; synthetic suture materials

Introduction

Suture is a general term for all materials used to stitch torn tissues. Sutures can be synthetic or natural and have a monofilament or braided construction. Through the history of mankind, various materials were tried to serve this purpose. Plants such as flax, hemp, and cotton and animal tissues such as hair, tendon, silk, and intestines are some examples. The oldest, known suture was on a mummy in ancient Egypt on 1100 BC, and the first written description on surgical wound suturing belongs to the Indian physician Sushruta in 500 BC (Akgun et al., 2018).

Surgical sutures are imperative in management of surgical and traumatic wounds (Wound Closure Manual, 2014; Dennis et al., 2016). Ligating blood vessels and approximating tissues are two common uses of sutures (Chellamani and Veerasubramanian, 2010; Pillai and Sharma, 2010). Sutures are primarily used to oppose tissues together to assist and accelerate the recovery process after an incident or surgical operation (Mackenzie, 2003). In addition, sutures also aid in obliteration of dead space, even distribution of stress on the incision line, and maintenance of adequate tensile strength throughout the critical wound healing process until appropriate tissue strength is achieved. Although staples, tapes, and adhesives may be used to close wounds, sutures are the most common method of wound closure (https://www.dolphinsutures.com, 2014). Sutures have grown tremendously over the previous two decades to become the most important group of biomaterials (Alanbarber et al., 2006; Bloom, Goldberg, 2007).

Considering availability of a wide variety of suture materials, it’s important to know the differences between various sutures before making an informed decision. Suture material's overall performance is influenced by its physical qualities, handling features, and biological factors. During suturing, a high degree of pliability and elasticity is required for effective application. Furthermore, ease of knot placement, good knot security, and the absence of irritating or contagious chemicals are all highly desired characteristics (Hochberg et al., 2009; Ratner et al., 2006). It should be sterile, non-electrolytic, non-ferromagnetic, non-capillary, non-carcinogenic, non-allergenic, simple to use, quick and painless, give great cosmesis, and not serve as a source of bacterial infection. It must be resistant to shrinking, minimum tissue response, simple to sterilize without changing its properties, and cost effective (Tan et al., 2003; Tajirian and Goldberg, 2010).

However, it is also important to note, there is not a single suture material which can fulfil all these properties. Each form of suture has a unique set of characteristics that must be taken into consideration before usage. Since previous few years, an increase has been observed in creation of suture material classes on the basis of their qualities and abilities to promote tissue approximation and wound healing (Kim et al., 2007).

Suture support for different tissues varies widely, with some tissues requiring support for only a few days, while others may require support for weeks or even months. A short-term need for suture support may be met with the use of absorbable sutures. It eliminates the need for stitch removal and the associated discomfort, while also providing maximum tensile strength during the early healing stages (Chu, 2013).

Therefore, the objective of this review is to give highlights on the biological properties of suture materials.
Reasons for Suturing

Suturing is not simply about closing a wound; it is a skill that requires finesse and can significantly impact the healing process, reduce complications, and even affect long-term results (Dennis et al., 2016). It is a procedure that involves stitching a wound or laceration shut using a needle and thread. Suturing is important for several reasons, including: i) Promoting healing: suturing helps to close the wound and promote healing by bringing the edges of the wound together. ii) Reducing scarring: proper suturing can help reduce the appearance of scars by minimizing the amount of tissue damage and reducing the risk of infection. iii) Preventing infection: suturing can help prevent infection by closing the wound and reducing the risk of bacteria entering the wound. iv) Reducing bleeding: suturing can help reduce bleeding by closing the wound and promoting clotting (Vengopalan, 2000).

Ensuring Adequate Wound Closure

A well-executed suture ensures adequate wound closure, providing the foundation for proper healing. Precise placement of sutures helps align the wound edges, facilitating the natural healing process and reducing the risk of complications. By meticulously bringing together the tissue layers, surgery professionals create an environment conducive to cellular regeneration and optimal healing outcomes (Weitzul, R.,and Taylor, S., 2005).

Minimizing Infection Risks

suturing also plays a significant role in minimizing the risk of wound infections. When sutures are placed accurately, they create a protective barrier against external pathogens. By ensuring a snug closure and minimizing gaps, surgery professionals reduce the chances of bacterial infiltration. This attention to detail helps create an environment conducive to sterile wound healing, safeguarding the patient's well-being (Meyle, J., 2006).

Promoting Aesthetic Results

suturing directly influences the aesthetic outcome of wound closure. When sutures are placed with care, the resulting scar can be minimized, leading to improved cosmetic results. By considering factors such as tension distribution, and wound alignment (Olga, S., and James, S., 2017).

Facilitating Proper Tissue Healing

Proper suturing aim to restore the structural integrity of damaged tissues. By precisely approximating tissue layers, sutures provide support and stability during the healing process. This accurate realignment helps tissues heal in their anatomically correct position, reducing the likelihood of complications such as dehiscence or poor wound healing (Olga, S., and James, S., 2017).

Enhancing Patient Comfort

suturing can greatly influence patient comfort during the healing process. Careful placement of sutures helps distribute tension evenly along the wound, minimizing discomfort and reducing the risk of wound dehiscence. By paying attention to details such as suture depth and tension, surgery professionals can ensure a more comfortable and less disruptive healing experience for the patient (Olga, S., and James, S., 2017).

Suture Size and Suture Material Selection

Suture selection involves the choice of both the appropriate type and size of suture material. Use of too large a suture results in excessive foreign material in the wound and needlessly alters the architecture of the sutured tissue (Dart, A. and Dart, M., 2017).

Sutures are usually gauged using the metric system which measures suture diameter. The older USP system also still persists, in which sutures are graded in increasing diameter from the finest 0000000000 (usually written '10-0') up to 0, then 1, 2, 3 on up to 10 (Dart, A. and Dart, M., 2017).

The size of suture materials is varied in different tissues of animal (Table 1). The surgery professionals make a decision on appropriate suture material for a certain application based on various conditions (Edlich, 2014): i) As tissue thickness, flexibility, healing speed, and scarring proclivity vary among different body tissues and also with age and health status, a suture material should be chosen according to the patient's age, weight, health status, and incision location. The presence of infection and specific characteristics of wound might affect suture material choice. ii) Number of tissue layers in closing a wound, tension in wound, depth of tissue which needs to be sutured, oedema presence, timing of suture removal, inflammatory reactions and adequate strength, have a crucial role in selecting material for suturing in wound management. iii) surgery professionals should choose a material with a higher ratio of strength-to diameter, constant diameter, sterility, pliability, good tissue acceptance, and predictability of function (Dart, A. and Dart, M., 2017).

Tissue	Type of suture material	Suture size (USP size code)	
		Small animal	Large animal
Skin	Nylon, Prolene	0 to 2/0	3 to 1
Subcutis	Poly glycolic acid, Polydioxanone, Polyglactin 910	0 to 3/0	2 or 1
Fascia	Poly glycolic acid, Polydioxanone, Polyglactin 910	0 to 3/0	0-2/0
Skeletal muscle	Poly glycolic acid, Polydioxanone, Polyglactin 910	0 to 3/0	3 to1
Tendon	Nylon, Prolene	0 to 3/0	1 or 0
GIT	Catgut	3/0 - 4/0	0-2/0
Urinary tract	Catgut	2/0 - 4/0	0-2/0
Uterus	Catgut	3/0 - 4/0	0-1

Table 1: Suture Size and Suture Material Selection

Source (Vengopalan, 2000)

Classification Of Suture Materials

Surgical sutures can be classified in to two on the basis of the suture materials degrading property (Vengopalan, 2000).

4.1. Absorbable Suture Materials

These sutures disintegrate and degrade after implantation, either due to enzyme degradation and subsequent hydrolysis or just hydrolysis by itself. Generally absorbable sutures are used for deep tissue temporary closure till the critical wound healing period or in tissues where they are difficult to remove. They may cause additional inflammation, which may result in further scarring, if applied on the surface. It is recommended that a rapid-absorbing suture be used if absorbable sutures are to be used superficially (https://www.medscape.com, 2020). However, newer, absorbable sutures may last for extended periods of time, and this is something to keep in mind. Enzymatic degradation is used to absorb natural materials, but non-enzymatic hydrolysis is used to absorb newer synthetic absorbable sutures. The absorbable suture is further categorized into two types. These are natural absorbable sutures and synthetic absorbable sutures (Stashak and Theoret, 2008).

Natural absorbable sutures

The submucosa of sheep intestines or serosal layer of bovine intestines are used to prepare strands of purified connective tissue. These strands are twisted to form the catgut suture material. Surgeons used to prefer catgut earlier, but due to its low tensile strength, unpredictable absorption, and greater tissue reactivity compared to synthetic suture materials, their use has been significantly reduced (Shao et al., 2016). The most commonly natural absorbable sutures used in practice are listed below (Table 2).

Synthetic absorbable sutures

Nowadays, the majority of absorbable sutures are synthetic and are made from a variety of absorbable polymers (Pillai and Sharma, 2010). The duration of time needed for them to be absorbed ranges between short term (around 50 days): Used in episiotomy or in fast–healing tissues (skin mucosa) e.g.: Polyglactin 910 fast, polyglycolic acid fast. Mid-term (around 60 to 90 days): Used in soft tissue approximation, ophthalmology, gynecology, urology and maxillofacial. e.g.: Polyglactin 910, polyglycolic acid, poliglecaprone-25. Long term (approximately 180 to 390 days): Used in vascular surgery, abdominal wall closure and orthopedics. e.g.: Polydioxanone polyester p-dioxanone, poly 4-hydroxybutyrate (Chellamani et al., 2013). The most commonly synthetic absorbable sutures used in practice are listed below (Table 2).

Absorbable suture materials	
Natural origin	**Synthetic origin**
catgut	Polyglycolic Acid (PGA)
Collagen	Polyglactin 910 (Vicryl)
kangaroo tendon	Polydioxanone (PDS)

Table 2: Natural and Synthetic Absorbable Sutures

Source (Vengopalan, 2000)

Non-Absorbable Suture Materials

Non-absorbable suture materials are not degraded during the healing process although they do become encapsulated with fibrous tissue and remain permanently within the tissue unless they are extruded or removed. They are designed for use where prolonged mechanical support is required until sufficient healing has occurred to maintain tissue apposition. Non-reactive non-adsorbables can be buried within tissues or organs to support slow healing tissues. They do not need to be removed as they are generally well tolerated by the body (Yedke, et al., 2013).

Non -Absorbable material resists biodegradation and retains its tensile for more than 60 days and thereby necessities its removal. When used in internal organs/structures it gets encapsulating by fibrous tissue. Such material is required where long term immobilization of tissue is necessary. When tissues apposed are subject to movements and heel slowly (Vengopalan, 2000).

Natural non-absorbable sutures

The most commonly natural non-absorbable sutures used in practice are listed below (Table 3).

Synthetic non-absorbable sutures

The most commonly synthetic non-absorbable sutures used in practice are listed below (Table 3).

Non-Absorbable Suture Materials	
Natural origin	**Synthetic origin**
Silk	Polyamide (Nylon)
Silkworm gut	Polypropylenes (prolene)
Cotton	Polyesters

Table 3: Natural and Synthetic Non-Absorbable Sutures

Biological Properties of Suture Materials

Sutures may cause different host reactions in living tissues. While the suture remains in the tissue, it can trigger the inflammation cascade through different pathways such as degradation, a foreign body reaction, an allergic reaction, or abrasion. Sutures can remain inert, be partially degraded, or be totally degraded by the host (King et al., 2013). The amount of degradation is dependent upon the absorbability of the specific suture material. Generally, a suture that loses its tensile strength within 60 days is considered absorbable. However, the new generation of absorbable suture materials may hold their tensile properties far beyond this limit. The absorption rate may vary due to the suture composition or the tissue sutured. Host reactions and infection also affect the absorption process. Nonabsorbable sutures do not biologically degrade but can also lose their integrity over time (Akgun et al., 2018).

The biological response of the local tissues against sutures can be influenced by different factors (see below Table 4) (Akgun et al., 2018). The suture material and its absorbability, configuration, and size in particular are important. Natural materials such as catgut and silk are more immunogenic than synthetic materials because they are degraded by proteolysis in contrast to synthetic sutures, which are degraded by hydrolysis. Hydrolysis is a less immunogenic process compared to proteolysis (Robinson et al., 2005). Nonabsorbable sutures cause less inflammation in contrast to absorbable sutures and usually induce a fibrous layer formation around the suture, which prevents a host response. More irritation is seen with braided suture than with monofilament sutures. This can be explained by the surface topography of the suture. The smooth texture of monofilaments causes less response in the host (Akgun et al., 2018).

	Local tissue reaction	
	Less	**More**
Material of the suture	Synthetic	Natural
Architecture of the suture	Monofilament	Braided
Picks per inch in braided suture	More	Less
Twist angle in braided suture	High	Low
Size of the suture	Thinner	Thicker
Type of suture	Non-absorbable	Absorbable

Table 4: Effect of Suture Properties on Local Tissue Reactions

With the development of newer sutures/suture material in the current scenario, the distinct properties of each one should be familiarized so that the most suited product is best utilized.

Tissue absorption: capacity of body to dissolve a suture over time is referred to as absorption. Tissue reactivity: inflammation is a common response to foreign elements, which may impede wound healing and increase the likelihood of infection. capillarity: The capacity of sutures to disperse fluids over their whole length. It is crucial when bacteria are present (Geiger et al., 2005; Molokova et al., 2007). The tissue absorbable ability, tissue reactivity and capillarity of the most commonly sutures used in practice are listed below (Table 5).

Suture material	Tissue absorbability	Tissue reactivity	Capillarity
Type A – Plain chromic catgut	absorbed in 3-7 days	high tissue reactivity	more capillary
Type B - Mild chromic catgut	absorbed within 20 days	high tissue reactivity	more capillary
Type C - Medium chromic catgut	absorbed within 20 days	high tissue reactivity	more capillary
Type D - Extra chromic catgut	absorbed within 40 days	high tissue reactivity	more capillary
PolyGlycolic Acid (PGA)	absorption at 100-120 days	little tissue reaction	less capillary
Polyglactin 910 (Vicryl)	Absorption at 40-90 days	little tissue reaction	less capillary
Polydioxanone (PDS)	Absorption at 40-90 days	little tissue reaction	less capillary
Silk	Non absorbable	high tissue reactivity	less capillary
Prolene	Non absorbable	little tissue reaction	less capillary

Table 5: Biological Properties of the Most Commonly Sutures Used in Practice

Conclusion And Recommendations

Sutures may cause different host reactions in living tissues. While the suture remains in the tissue, it can trigger the inflammation cascade through different pathways such as degradation, a foreign body reaction, an allergic reaction, or abrasion. The biological response of the local tissues against sutures can be influenced by different factors. Natural materials such as catgut and silk are more immunogenic than synthetic materials because they are degraded by proteolysis in contrast to synthetic sutures, which are degraded by hydrolysis. Surgical sutures are imperative in management of surgical and traumatic wounds. Suturing is not simply about closing a wound; it is a skill that requires finesse and can significantly impact the healing process, reduce complications, and even affect long-term results. Considering availability of a wide variety of suture materials, it's important to know the differences between various sutures before making an informed decision.

Based on the above conclusion, the following recommendations are forwarded:

- In closing the wound, synthetic sutures materials should be used than natural suture materials, to minimize the inflammatory reaction.
- Surgery professionals should choose a suture material with good tissue acceptance.
- Further research on biological properties of suture materials should be conducted so that the most suited product will be utilized.

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