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REVIEW ARTICLE

Surgical Sutures: An overview

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Abstract

Sutures are used to close the cuts caused by injuries or to close the incision due to surgery and other medical procedures like wound approximation. They are commonly used on the skin, internal tissues, organs and blood vessels. They are available in the form of monofilament, multifilament/braided and pseudo monofilament. A lubricant is applied on the surface of braided suture material to lower the tissue drag and allow better knotability. They are also available in the form of either absorbable or non-absorbable sutures. Absorbable sutures undergo degradation and loss of tensile strength within 60 d whereas, the non-absorbable sutures retain tensile strength for longer than 60 d. The most important characteristics in biodegradation and absorption of absorbable sutures are the strength and mass loss profiles and the biocompatibility of degradation materials. Synthetic absorbable sutures can be degraded by a hydrolytic mechanism via the scission of ester linkages in the polymeric backbone. This review focuses on suture and their classification in terms of suture manufacturing process. Further it is classified based on sutures absorption ability and the origin of raw material.

Keywords: Sutures, incision, monofilament, multifilament, pseudo monofilament, hydrolytic process.

Introduction

Sutures have been used for at least 4000 years. Archeological records from ancient Egypt showed that Egyptians used linen and animal sinew to close wounds (Abdessalem *et al.,* 2009). Sutures are the most frequently used biomaterial for wound closure and tissue approximation (Chellamani and Veerasubramanian, 2010). They are used to close the cuts caused by injuries or to close the incision due to surgery and other medical procedures like wound approximation. They are commonly used on the skin, internal tissues, organs and blood vessels. There are two different kinds of sutures. One is absorbable sutures that will dissolve on their own. Another one is non-absorbable sutures that will be removed after certain period of time (Raul De Persia *et al.*, 2005). The suture market currently exceeds $1.3 billion annually. US Pharmacopoeia (USP), European Pharmacopoeia (EP) and British Pharmacopoeia (BP) are the official compendium for the suture industry, which sets standards and guidelines for suture manufacture. Suture sizes are given by a number representing diameter ranging in descending order from 10 to 1 and then 1–O to 12–O, 10 being the largest and 12–O being the smallest at a diameter than a human hair (Anand, 2006).

Classification of suture

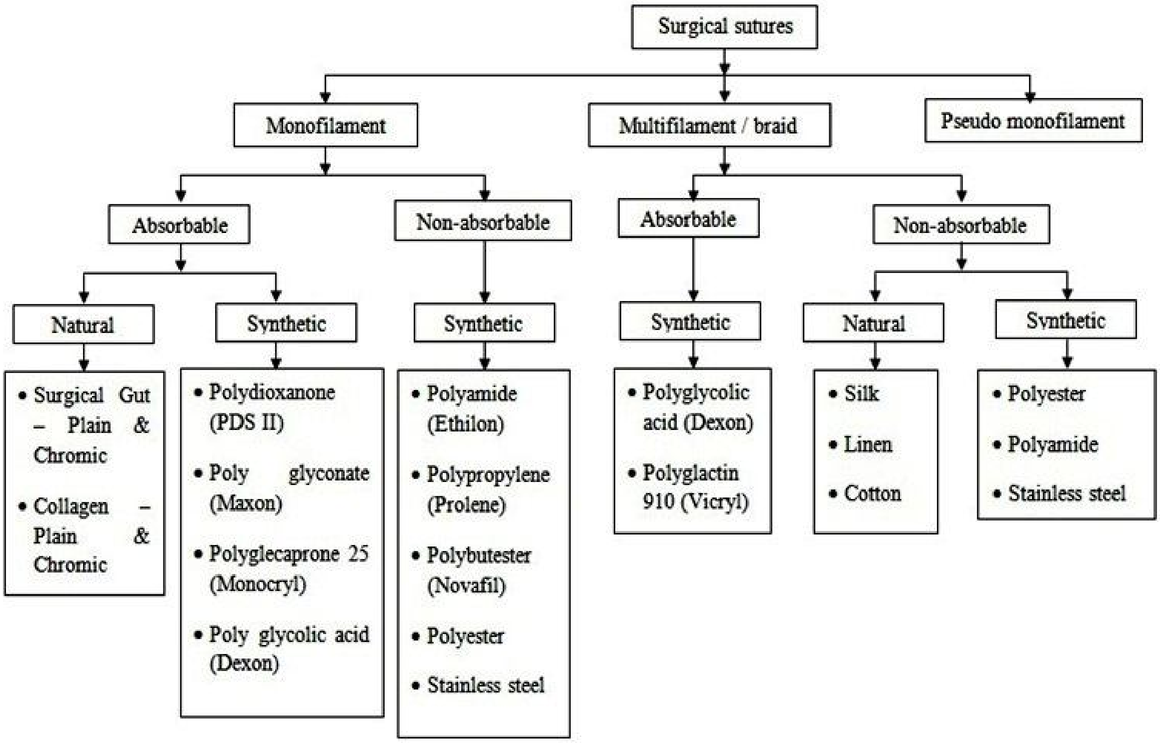
Sutures can be broadly classified in to 3 groups based on their manufacturing process. They are i) Monofilament sutures, ii) Multifilament sutures and iii) pseudo monofilament sutures (Sabit Adanur, 1995; Sathish Bhalerao *et al.,* 1998; Desai, 2005; Stashak and Theoret, 2008). The broad classification of the sutures is shown in Fig. 1.

Monofilament

A monofilament with its smooth surface can only be made from synthetic material by polymer extrusion method. The important property of the monofilament is a minimal tissue reaction. This is because of monofilament smooth surface. Also the monofilament suture does not allow any bacteria to survive as compared to multifilament sutures. It is also easy to make or place a knot in the depth of the body. The main drawbacks of the monofilament are low knot security and less flexibility. Polyester, polyamide, polypropylene and polydioxanone are used as monofilament suture. Polyester has a high knot-pull tensile strength, good flexibility and low degradation. Polypropylene has excellent tissue drag and stability. Polydioxanone and polyglycolic acid-polycarbonate copolymer are dissolved gradually in body tissue by means of hydrolytic process. The violet dyed monofilament suture is shown in Fig. 2.

Fig. 2. Violet dyed monofilament suture (Chellamani *et al.,* 2012).

Fig. 1. Classification of surgical suture thread based on their manufacturing process.



Multifilament/Braided suture

Multifilament yarns can be twisted together to form a braided sutures. To form a braided suture, in general, eight to sixteen monofilament yarns are to be used. Obviously, due to the manufacturing method, the braided sutures have rough surface which causes tissue drag to be high. A lubricant is applied on the surface of braided suture material to lower the tissue drag and allow better knotability. Braids are also flexible and easy to handle as compared to monofilament sutures. Polyesters, polyamides and silks are commonly used for manufacturing braided sutures. The suture in the form of a braid is shown in Fig. 3.

Fig. 3. Braided suture (Chellamani *et al.,* 2012).

Pseudo-monofilament

The pseudo-monofilament has a core of several twisted materials coated with an extrusion of the same material as the core.

Fig. 4. Pseudo-monofilament (Chellamani *et al.,* 2012).

It has low tissue drag, good knotability and fair flexibility. It has drawbacks like low knot security as like mono filament sutures. The structure of pseudo-monofilament is shown in Fig. 4.

Absorbable and non-absorbable sutures

Surgical sutures can be further classified in two groups. They are i) absorbable suture and ii) non-absorbable suture.

Absorbable sutures: Absorbable sutures undergo degradation and loss of tensile strength within 60 d, either by enzymal degradation and subsequent hydrolytic or by hydrolytic alone (eg.: polyglycolic acid (Dexon)). The absorbable suture can be further classified in two groups. They are i) Natural and ii) Synthetic.

Natural

Catgut: Catgut the widely used suture is derived from animal intestines and is over 99% pure collagen. It is made from the submucosa of sheep intestines or the serosa of beef cattle intestines. It is monofilament and is absorbed by a process of enzymatic digestion. Absorption rate depends on size and also on whether the gut is plain or chromicised. The great advantage of catgut is that being absorbable it can be used even in the presence of infection. Tensile strength loss is faster than absorption.

Collagen: It was evolved to overcome the disadvantages of conventional catgut. The flexor tendons of beefs were converted into dispersed fibrils. The dispersed fibrils were then extruded and reconstituted to form collagen sutures.

Synthetic

Dexon, vicryl and PDS are the available synthetic absorbable suture.

Polydioxanone: It is in monofilament form and it is derived from the polymer of Polydioxanone. It is absorbed by hydrolysis in 180 to 190 d. It losses 26% of tensile strength after 14 d of implantation, 42% after 28 d and 86% after 56 d of implantation. After 6 weeks of implantation this suture still has half-life of tensile strength. It has good knot security, minimal tissue drag and minimal foreign body reaction. The main drawback of this suture is poor handling characteristics due to its stiffness and memory.

Polyglyconate: It is the copolymer of glycolic acid and trimethylene. It is in monofilament nature. It is absorbed by hydrolysis starting at day 60 and complete by day 180. It retains the tensile strength for more than 21 d. The half- life of the breaking strength is around 28 d. It has good handling characteristics, best knot security of all synthetic monofilament absorbable sutures. It is superior to nylon and polybutester for tendon repair.

Poliglecarprone: It is in monofilament form and it is the copolymer of caprolactone and glycolide. It is absorbed by hydrolysis in 90 to 120 d. It losses 50% of tensile strength at 7^{th} d of implantation, 75% of tensile strength at 14^{th} d and 100% of tensile strength at 21^{th} d of implantation. It has excellent knot security, minimal tissue reaction and good handling characteristics due to its decreased flexibility and minimal memory. Due to rapid loss of tensile strength after implantation, it should be used for tissues that heal rapidly.

Polyglycolic acid: It is the braided structure sutures. It is synthesized from glycolic acid. It is absorbed by hydrolysis in 100 to 120 d. It loses its tensile strength by 33% within 7 d of implantation and by 80% within 14 d of implantation.

It is widely used in clean and contaminated wounds. It has superior tensile strength as compared to catgut sutures and it has good suture handling characteristics. It has drawbacks like poor knot security and poor stability in alkaline environment.

Polyglactin 910: It is available in braided form. It is the copolymer of glycolic acid and lactic acid and it is coated with calcium stearate. It is absorbed by hydrolysis over a period of 100 to 120 d. It retains tensile strength for first 14 to 21 d of implantation. It is also available in coated form. The coated form polyglacting 910 suture is easier to handle and it has less tissue drag, minimal tissue reaction and stable in contaminated wounds. It has advantages like stable in alkaline environment, higher tensile strength and knot strength.

Non-absorbable sutures

Non-absorbable sutures retain tensile strength for longer than 60 d (eg.: Polypropylene (Prolene)). As like absorbable sutures, the non-absorbable sutures are also classified in two groups. They are i) Nature and ii) Synthetic.

Natural

Silk: It is available in braided form. It is made of cocoon of silk worm larvae. Sometimes it is coated with oil, wax or silicone. It loses its strength after two years. It has excellent handling characteristics and knot security. It is mostly used in ophthalmology (Chatterjee, 1975). The main drawbacks of this sutures are coating reduced the knot security, incites tissue reaction, infection and capillarity.

Linen: It is made from flax. It is available in twisted form. It can be used for general surgery, gynecology, cardiovascular surgery, gastrointestinal surgery and plastic surgery. The Linen suture is not absorbed and hence it does not loss the tensile strength (Shalon Suturas, 2013). It gains 10% of tensile strength when it is wet. It is also available in treated with silicone and polyvinyl solution (B braun sutures Linatrix, 2013). It has better handling characteristics and excellent knot security.

Cotton: It was introduced as a suture material in 1939 to replace silk suture during World War II. It is extracted from hairs of seed of cotton plant. It gains tensile strength and knot security when wet. It slowly losses tensile strength after implantation, with 50% loss of tensile strength at 6 months, and 70% loss of tensile strength at 2 years. However it is not absorbable sutures. It has better knot security than silk. Disadvantages of cotton suture are its capillarity, tissue reactivity, inferior handling ability due to electrostatic properties and ability to potentiate infection (Boothe, 1993).

Synthetic

Polyester: Polyester suture is a braided multifilament available in plain and coated forms. Coatings, which include polybutylate, Teflon, and Silicone which decrease drag when the suture is drawn through tissue. This suture is one of the strongest nonmetallic sutures available and undergoes little or no loss in tensile strength after implantation in tissues. Once properly placed, polyester sutures offer prolonged support for slowly healing tissues. The main disadvantages of polyester suture are its poor knot security, high coefficient of friction and tissue reactivity particularly in contaminated environments.

Polyamide: Nylon and polymerized caprolactum are examples of readily available polyamide sutures. It is available as both monofilament and multifilament form. After implantation, monofilament nylon sutures losses about 30% of its original tensile strength by 2 years because of chemical degradation. Multifilament nylon loses essentially 100% of its tensile strength after 6 months in tissue. The main drawbacks of polyamide suture are its poor handling characteristics and knot security.

Polypropylene: It is available in monofilament form. It is synthesized from polyolefin plastics. It retains tensile strength without reduction after implantation. It has higher knot security than all monofilament non-metallic synthetics suture materials. It is the best suture for skin closure. However, the tensile strength is less as compared to all monofilament nonmetallic sutures.

Polybutester: It is the monofilament form of suture. It is the copolymer of polybutylene, polyglycol and polytetramethylene terephtalates. It retains its breaking strength after implantation. It has good handling characteristics and knot security. It provides prolonged support for slow healing tissues. The main drawback of this suture is marginal knot quality, that is, if the force is applied to this suture, it causes fibers to interlock.

Stainless steel: Stainless steel is the only metallic suture still widely used. It is available in both monofilament and braided form. It is biologically inert and non-capiallary in nature. It can be easily sterilized by autoclaving process. It has the highest tensile strength and greatest knot security of all suture materials and maintains this strength on implantation in tissues. It is good for suturing tissues that heal slowly. The monofilament form stainless sutures are used effectively in contaminated and infected wounds, because it does not support infection. Disadvantages of stainless steel suture are its tendency to cut tissues, poor handling characteristics (especially in knot tying) and diminished ability to withstand repeated bending without breaking.

Absorption behavior of suture materials

After implanting the absorbable suture in tissue, the suture materials are broken down by enzymal and hydrolytic process. Table 1 is an illustration of structural factors of polymers that could control their degradation (Bronzino, 2000). The most important characteristics in biodegradation and absorption of sutures are the strength and mass loss profiles and the biocompatibility of degradation materials. Although there is a wide range of strength and mass loss profiles among the available absorbable sutures. They have one common characteristic: Strength loss always occurs much earlier than mass loss. The vast amounts of published information are available about the biodegradation phenomena of synthetic absorbable sutures. It shows that these synthetic absorbable sutures can be degraded by a hydrolytic mechanism via the scission of ester linkages in the polymeric backbone. The observed wide range of strength and mass loss profiles of absorbable sutures is attributable not only to the chemical differences among the absorbable sutures but also to a variety of intrinsic and extrinsic factors, such as pH, electrolytes, stress applied, temperature, γ–irradiation, microorganisms and tissue type. A study of the effect of superoxide ion on the degradation of absorbable sutures has been reported. Superoxide ion can act as an oxygen nucleophile agent to attack the ester linkage in absorbable suture polymers and it induces hydrolytic degradation (Dumitriu, 2002).

Table 1. Structural factors to control the polymer (absorbable sutures) degradability.

Factors	Methods of control
Chemical structure of main chain and side groups	Selection of chemical bonds and functional groups
Aggregation state	Processing, copolymerization
Crystalline state	Polymer blend
Hydrophilic/hydrophobic balance	Copolymerization, introduction of functional groups
Surface area	Micropores
Shape and morphology	Fiber, film and composite

Conclusion

Sutures are used to close the cuts caused by injuries or to close the incision due to surgery and other medical procedures like wound approximation. They are commonly used on the skin, internal tissues, organs and blood vessels. Compared to monofilament sutures, multifilament sutures have good handling properties as well as knot security. However, the multifilament sutures have the property of capillarity which helps to capillary the wound fluid. Hence, it causes to spread infection throughout the wound site.

Due to the advanced polymer science research, compared to non-absorbable sutures, the available absorbable sutures leads less tissue reaction after implantation and during absorption process.

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