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Suture Materials: A Perio Perspective

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Introduction

Sutures are natural or synthetic biomaterial devices used to connect blood vessels and align tissues [1]. Its primary function is to reunite and secure tissues after separation due to surgery or trauma. The purposes of wound closure include erasing the dead space, regular distribution of tension along the deep suture lines, keeping the tractile strength across the wound until the tissue tractile strength is sufficient and aiming to approximate the epithelial portion of the closure. Sutures are the most commonly used material for mechanical wound closure, even though there are other methods like staples, tape, and adhesive [2].

History of Suture Materials

Suture have been introduced since at least 4000 years [3]. Archaeological records from antiquity In Egypt and India shows that linen, animal sinew, flax, wool, grass, Cotton, silk, pig hair, and animal intestines were used for wound closure [3,4].

- The famous Sushurta Is said to have used bark sutures, Tendons, hair and silk as suture materials in surgery [5-9].
- First detailed description of wound sutures and suture materials used are described by Sushruta in his "Sushruta Samhita", Written in 500 BC for he was the author of the first systematics report. Reports say that Egyptians, Babylonians, Greeks, and all Arab operations began in India in ancient times [9].
- The Greek physician Claudius Galen (131-211 AD) was the first to describe about Notochord or enteric thread as suture material.
- Surgeon Antilus (300 CE) performed bone and joint resection, tracheostomy, and initial surgery, Surgery of traumatic aneurysms using notochord material [10,11].
- Usage of Dried sheep intestine (for surgical ligation) is recommended in Vagbataratha Kaumdi (AD 700), Commentary by HariKrishna Astanga Hridaya by Vaghbhata-II and similar works [12-15].
- Europa, Salerno and Rogelio recommend gut strings as sutures, A material especially suitable for large visceral wounds in the abdomen.
- Abul Qasim (late 10th century), famous Arab surgeon, A detailed description of the suturing technique has been prepared.
- Ambroise Pare (1510–1590), a Frenchman was originally a barber and became one of the best surgeons – Thin strips of linen and silk were used by him [16-22].
- Vascular ligation, First introduced by Joseph Lister in 1860 Intestinal suture was sterilized with carbolic acid and chromic acid catgut in 1880 [23,24].
- Around 1900, the catgut industry was firmly established in Germany on the use of sheep casings in the sausage industry in many ways.
- Conventionally, sterilization was performed, but with the introduction of iodine sterilization, which Claudius established as later standard method in 1902. He has been preparing on it for almost half a century [25].
- Suede and silver wire - It was developed in the 18th century with chemical modifications.
- Introduction of steel wire and synthetic non-absorbent fibers such as Strong nylon, polyester and polypropylene (PP) during World War II, expanded the chemical composition of the suture material.
- 1906, witnessed the development of the first truly sterile intestinal tract sterilized by Sporicidal treatment with iodine proposed by the German - Surgeons Franz Kuhn (1866–1929) and Braun, Melsungen [10].
- In 1908, the Kuhn Catgut began industrial production. Gut Silk dominated the suture market until the 1930s.
- Catgut is often deprecated in Countries with increased risk of Creutzfeldt-Jakob disease (CJD), also is still higher than with use of modern synthetic suture materials having Improved sterilization process.
- Cotton and processed natural materials began to be used as sutures in 20th century.
- Polybutester is a newer type of polyester which is available in a monofilament suture. It is a copolymer composed of polyglycol terephthate and polybutylene terephthate.

Polybutester has a lower coefficient of friction and lower tissue reactivity than the older polyester sutures [26].

Characteristics of Suture Materials
An ideal suture material is not, and should not be, completely biologically inert. It cannot provoke a tissue reaction, and easier for the surgeon to tie securely.

An Ideal Suture Should have the Following Properties
1. Easy to use
2. Minimize tissue reaction
3. Does not support bacterial growth
4. Has high tensile strength
5. Easy to sterilize
6. Does not cause allergic reactions
7. No carcinogenic effects
8. Sterility
9. Flexibility for ease of use
10. Knot security
11. Consistent tensile strength across suture types and sizes.

Properties of Suture Materials
Biological Properties
Absorption Capacity
Yarn deterioration capacity within the organization in synthetic polymers, this happens by hydrolysis [27].

Sterility
guaranteed by various techniques provided with the use of ethylene oxide, or Cobalt-60, gamma rays.

Tolerance
Thread's ability to cause minimal inflammatory response of tissue. Based on the material used, it shows the greatest response to catgut which is further decreased with the use of silk, cotton, linen, polyester, polyamide, resorbable plastic, polypropylene, steel and titanium.

Physical Properties
Resistance
Thread's ability to resist the tensile force on the ends, measured up to the height of a simple knot. Materials such as Steel, plastic and natural thread have the greatest resistance. Conversely, resistance is characteristic of gut, silk, polypropylene, polyglycolic acid, nylon, polyester and steel.

Capillarity
Fluid properties of propagation along capillaries in all directions even for small-diameter pipes against gravity. Based on the material of the suture, it corresponds to the absorption capacity of the liquid in which the thread is Immersed and can be supplied to dry areas.

Hydrophilic
Characterized by capillary action. Hydrophilicity stands for chemical affinity with which the suture acts on liquid molecules, For example water.

Flexibility
means suture adaptability. This is the ability of the thread to fold and twist without breaking.

Plasticity
Thread ability to form new shape.

Elasticity
The ability of a thread to deform and lengthen and return to original length.

Manipulability
Describes the ductility of the suture and means ease of manipulation and knot it, so it seems to be correlated with Fluency.

Fluidity
The ability of a thread to execute fluidly and there are no difficulties in organization. It depends on the smoothness and approximately the coefficient of friction, that is, on its structure. Monofilament sutures are generally more fluid than multifilament sutures.

Length and Diameter
Affect thread maneuverability [29].

Classification of Suture Materials
According to the Source
- Natural
- Synthetic
- Metallic

Sutures are also Classified Depending on their Resorbability
- Absorbable
- Non- absorbable

These Can be Further Divided Based on Physiological Configuration
- Monofilament type
- Multifilament type

Absorbable Suture
All suture materials that are digested by body enzymes or hydrolyzed by the tissue fluids are absorbable. They undergo degradation and lose its tensile strength within 60 days [29,30].

Natural Absorbable Suture Material
Catgut (Surgical Gut)
which is made up of collagen harvested from small intestine of sheep or goat.[31] One of the staple absorbable suture materials through 1930s while physician use silk or cotton where a non-absorbable material was needed. It is of two types the plain gut and the chromic [30,32,33]. The use of these suture material reduced due to poor knot stability and tensile strength and high reactivity of Fast absorbing gut which is the newer form and which is not treated with chromic salts. Catgut completely absorbed between 35 to 60 days [28, 30].

Surgical Cotton
multifilamented suture material derived from staple Egyptian cotton fibers with minimal tissue reactivity [28].

Collagen
multifilamented absorbable suture which resembles catgut, which is prepared from bovine deep flexor tendon filament. Collagen is absorbed within 60 days. It has minimal tissue reactivity [28].

Synthetic Absorbable Suture Materials
Polyglycolic Acid (Dexon)
PGA is the polymer of glycolic acid, the simplest linear aliphatic polyester, introduced in 1970 [30] and it is the first synthetic absorbable suture material. PGA has excellent tensile strength, knot stability, delayed absorption and reduced tissue reactivity [31]. PGA and its copolymer used as synthetic absorbable suture material and also evaluated in biomedical field [29,30].

Polyglactin 910 (Vicryl)
Polyglactin was introduced in 1974, which is braided with clear undyed or violet dyed form. It is the copolymer of lactide & glycolide. Vicryl is degraded by hydrolysis and cause tissue reaction. Also, it is manufactured with coating of polyglactin 370 & calcium stearate which provides excellent handling and smooth tie down properties [30].

Polydioxanone (PDS)
which is made from paradioxanone. It is useful when extended wound tensile strength is [30]. PDS is absorbed within 180 days after [29]. PDS II a newer product that has decreased stiffness & smooth handling. It has slight tissue reactivity [28].

Polytrimethylene Carbonate (Maxon)
Maxon is the copolymer of glycolic acid & trimethylene carbonate. It is developed to combine the excellent tensile strength, knot stability of PDS with improved handling properties. Maxon is the most supple, manageable material than PDS and has 60% less rigidity, minimal memory, expensive. It provides great wound support [30].

Nonabsorbable Suture
Sutures that cannot be digested by tissue fluids. They are removed during the end of healing by surgeon [29].

Natural Non-Absorbable Suture Materials
Silk
silk is made from natural protein filaments by silkworm larva. The modern silk which is braided, soft, easy to handle & tie and has low tensile strength, moderate tissue reactivity, more inflammatory reaction, high capillary quality. Silk is avoided in area which is prone to infection especially distal extremities. It can also be used during cutaneous surgery around eyelids & lips [29,30].

Linen
Linen is the glucose material made from flax. It can be twisted to form fibre to make a suture. It had good knot stability and used for tying pedicles and as ligature [29,30]. Linen has minimal tissue reactivity [28].

Synthetic Non-Absorbable Suture Materials
Nylon
Nylon was introduced in1940, which is the synthetic polyamide polymer and also the first synthetic suture material. Mostly used in cutaneous surgery as a monofilament (Ethilon, Dermalon) and as multifilament braided (Nurolon, surgilon). Nylon is of two types that is non absorbable & slowly absorbable [29,30]. A study comparing clear monofilament nylon & PGA in build suture demonstrated less clinical inflammatory response with nylon [31]. Nylon has high tensile strength, excellent elastic property, minimal tissue reactivity & low cost [28].

Polypropylene (Prolene/Surgilene)
It is the plastic suture formed by polymerisation of propylene by means of a catalyst. Polypropylene is the extremely inert suture, which has very smooth surface with low adherence to tissue that is ideal for a subcuticular intradermal [29,30]. It has good plasticity and minimal tissue reactivity [28]. When swelling occurs, suture will stitch to accommodate the wound and when it recedes, the suture will remain loose [29,30].

Braided Polyesters (Mersilene/Dacron)
It can be formed as nylon by condensation polymerisation and it is manufactured to provide the high tensile strength, low tissue reactivity, improved handling & knot stability. Mersilene and Dacron are the uncoated braided polyester which has a rough surface, produce drag when pulled through tissue. Ethibond is the coated polyester. These polyesters are not commonly used nowadays because of the cost & coating susceptibility to cracking after knots are tied [29,30].

Polybutester
The newest non- absorbable suture, which is the thermoplastic copolymer composed of butylene terephthalate and polytetramethylene ether glycol. These are the monofilamentous, stronger, less stiff & has low coefficient of friction than nylon or polypropylene. It has the capacity to stretch 50% of it's length at loads of only 25% of it's knot breaking level. Good elasticity & flexibility are the unique features. Also reduces the potential for suture marks, induce little inflammatory response [29,30].

Principles of Suturing
- The needle should be approximately one-third the distance from eye and two- third from the patient.
- The needle should enter the tissues perpendicular to tissue surface.
- The needle should be passed through tissue along it's curvature.
- The suture should be passed at an equal depth & distance or the bite from incision on both sides.
- The bite should be 2- 3 mm from wound margin of the flap.
- The needle always passes from movable to fixed tissue ,from thinner to thicker tissue and from deeper to superficial tissue.
- Tissue must never be closed under tension. The suture should be tied Only to appropriate the tissue not to blanch or strangulate the tissue.
- Each suture must be placed 3- 4mm apart.
- When the length of the tissue on one side of wound is longer than the other, suturing it would result in "dog ear formation".

In order to eliminate this, the excessive tissue should be undermined, an incision at approximately 30 degrees to the original incision is detected at the weakened tissue. The extra tissue is pulled over the incision, the appropriate amount is excited & wound is closed [30].

Indications and Contraindications
Surgical Gut
Indications: Rapidly healing mucosa
Contraindications: Not used when prolonged approximation of tissue under stress is required [29,30].

Linen
Indications
Superficial vessels, mucosal surfaces (without stress)
Contraindications
Cannot be used for suturing under tension.

Surgical Silk
Indications
Mucosal Surfaces
Contraindications
Cardiovascular Surgery

Coated Vicryl
Indications
Subepithelial mucosal surfaces
Contraindications

Should not used when prolonged approximation of tissue under stress is required.

PDS(Polydioxanone)
Indications
Absorbable suture with extended wound support
Contraindications
Should not used when prolonged approximation of tissue under stress is required.

Nylon
Indications
Skin Closure, Mucosal Surfaces, Cardiovascular Surgery, Plastic Surgery, General Surgery.
Contraindications
None

Polypropylene
Indications
General plastic surgery, cardiovascular surgery, skin surgery.
Contraindications
none.

Surgical Steel
Indications
Abdominal wall, skin closure, sternal closure, tendon repair, orthopaedic surgery and neurosurgery.
Contraindications
Should not be used with prosthesis of another alloy.

Collagen
Indications
Ophthalmic Surgery
Contraindications
Rapidly Healing Mucosa.

Suture Removal
Suture removal is done to secure edges of the wound and body parts together from healed wounds without damaging the newly formed wounds. Removal of suture should be atraumatic and clean as possible.[30] Mostly, skin sutures are removed between the interval of 7 to 14 days and the mucosal sutures removed within 5 to 7 days [29]. The recommended timing of suture removal varies between 3 to 14 days which is depend on several factors like wound location, co-morbidity, and sign of early wound complication [34].

Recent Advancements in Suture Materials
In recent times, there has been a surge in the advancement of sutures, introducing additional features like modifications with antimicrobial agents, bioactive molecules such as DNA, drugs, antibodies, proteins, growth factors, and silver. Following years of research, the US Food and Drug Administration approved the first antibacterial suture, Vicryl Plus (triclosan-coated polyglactin 910 suture), in 2002 to mitigate the risk of surgical site infections (SSI). Triclosan coating, initially applied to Vicryl Plus, has been extended to other suture materials to combat bacterial adhesion and prevent or reduce SSI. Bioactive sutures exhibit therapeutic potential in specific procedures, expediting the healing process [35]. Emerging suture technologies include

1. Drug – eluting sutures
2. Stem cell-seeded sutures
3. Antimicrobial Sutures – Utilizing chitin, a natural polysaccharide endowed with antimicrobial qualities, proves to be highly efficient in expediting wound healing and safeguarding against infections. A newly formulated absorbable suture, based on diacetyl chitin, maintained 63% of its initial strength within a span of 14 days. Notably, complete absorption of the material occurred after 42 days, exhibiting enhanced wound break strength and swift tissue regeneration at the incision site in rats, comparable to Vicryl Plus VR.
4. Smart Sutures

These advancements hold great importance in the fields of tissue engineering, regenerative medicine, and minimally invasive surgery [35].

Conclusion
Suture material selection in both the medical and dental fields involves a careful consideration of factors such as absorbability, material composition, size, strength, biocompatibility, and cost. Ultimately, the choice of suture material depends on the specific requirements of the procedure and the practitioner's preferences. Understanding the differences and similarities between suture materials in these fields is crucial for ensuring successful wound closure and patient well-being.

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