Recent Advances in Suturing Material

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To access & cite this article

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INTRODUCTION

Any strand of material used to ligate blood vessels or tissues is referred to as a "suture." Dental suturing's main goal is to position surgical flaps securely to encourage optimal healing that is through primary intention and also support tissue margins while they heal to avoid dead space, and to lessen postoperative discomfort. Inadequate suturing can result in flap skipping, necrosis of bone, pain, and a delayed healing of the wound.

RECENT ADVANCES

In an effort to personalise and enhance the functional outcome of sutures, there has been a recent growth in the development of novel sutures with additional properties, such as those modified with antimicrobial agents, bioactive molecules like DNA, drugs, antibodies, proteins, and silver.

Antimicrobial suture

Polyglactin 910 or PLGA are absorbable, synthetic braided suture suture coated with Triclosan an antimicrobial agent which helps in significant reduction in postoperative pain and capacity to inhibit bacterial colonisation.1 By directly binding to the FabI protein (enoyl-acyl carrier protein reductase), triclosan prevents bacteria from producing fatty acids. It has bacteriostatic activity at low concentrations (0.025 to 1.000 mg/ml) and bactericidal activity at high concentrations (7.5 to 8.0 mg/ml).2

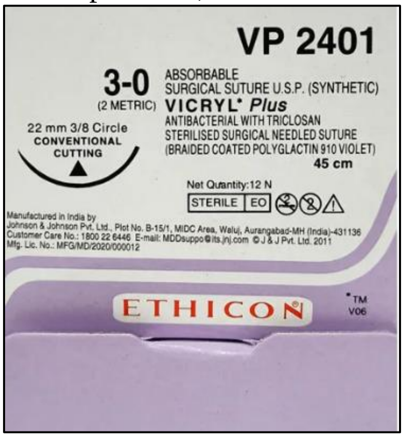
The methods for incorporating antimicrobial compounds on sutures includes Dip coating method, Surface modification, Blending and compounding method.3

Dip-coating, which involves submerging sutures in a solution containing antimicrobials and polymeric coating agents (such as PLGA, PVA, and PLLA) for a predetermined amount of time to allow the coating agents to physically adhere to the sutures. Surface modification and compound immobilisation, in which the suture surface is altered via plasma treatment, radiation, or chemical grafting to introduce a functional group in order to facilitate the formation of covalent bonds that will facilitate the immobilisation of an antimicrobial compound. And blending and compounding, in which antimicrobial agents are combined with suture materials before the antimicrobial suture is synthesised. The electrospinning technique was used in this approach to create very thin fibres (micro or nano scales).3 The most popular technique for incorporating bioactive molecules onto sutures among these is the dip-coating approach because it is less expensive and technically challenging than other methods of drug elution and fabrication and does not alter the mechanical properties of sutures.4

Commercially available Anti-microbial suture

Suture type	Triclosan based suture	Chlorohexidine based suture
Brand name & Manufacturer	VICRYL Plus - Ethicon Inc PDS Plus - Ethicon Inc MONOCRYL Plus - Ethicon Inc Petcryl Plus - Futura Surgicare Pvt Ltd	Trisorb Plus- SamYang Biopharmaceuticals Corp Monosorb Plus- SamYang Biopharmaceuticals Corp Neosorb Plus- SamYang Biopharmaceuticals Corp

The development of antimicrobial sutures has utilised a variety of antimicrobial substances, including antiseptics, natural products, antibiotics, nanoparticles, and biotechnological products.



Antimicrobial suture (Triclosan based)- VICRYL Plus - Ethicon Inc

Source-https://dentalstall.com/shop/ethicon-vicryl-plus-3-0-absorbable-violet-braided-suture-vp-2401/

Antiseptic based suture

Povidone iodine & chlorhexidine are some antiseptic based suture materials. Iodine has been added to sutures either by itself or in combination with other antiseptics, allowing povidone-iodine to work by oxidising reactive molecules on bacterial membranes and deactivating enzymes in the respiratory electron transport system. Thus, preventing the growth of S. aureus and E. coli.5 Chlorhexidine also an antiseptic agent and sutures coated with chlorhexidine exhibit bactericidal activity against S. epidermidis and E. coli.6 Octenidine, an antiseptic, and octenidine coating sutures have antimicrobial effects for up to 9 days. Octenidine interacts with membrane cardiolipin, disrupts the structure of the bilayer, and causes cytoplasmic leakage and effective against Multiple drug resistance bacteria.7

Natural product based material

Several natural products, including grapefruit seed extract, aloe vera, chitosan, turmeric, clove oil, and eugenol, have been investigated for suture coating helps in reducing the bacterial count at the site of suture.8 Also, suture coated with Chitosan has 14 days of antimicrobial effect and inhibit S. aureus and E. coli.9

Nano particle based suture

Non-resorbable polyamide suture (nylon suture) coated with Poly-(diallyldimethylammonium chloride) (PADMAC) with silver nano particle capped to it used as an antimicrobial agent that helps in inhibiting S. aureus and E. coli. The negatively charged silver nano particle binds to the positively charged PDMAC, reducing bacterial adhesion to the sutural surface.10

Antibiotic based suture

Sodium hydroxide and Sulfamethoxazole trimethoprim11, Gentamicin and Silver12, Ciprofloxacin coating using blending approach to the Polycarolactone suture (PCL) produced antimicrobial activity against S. aureus & E. coli for 5 days13

Drug eluting suture

Sutures have undergone changes over time that have enhanced tissue integrity, the immune system's response, and the healing process. Antibiotics, anaesthetics, anti-inflammatory drugs, or analgesics can be delivered directly and effectively into the wound area by the suture. These sutures are typically referred to as drug delivery sutures or drug eluting sutures. Utilizing controlled release systems to produce high drug concentrations at the wound area is the main goal of using sutures.14

Drug-eluting sutures are generated using a variety of techniques, such as electrospinning,15 grafting,16 or coating the suture surface with a dip method.17

The difficulty in creating a drug-eluting suture is obtaining the necessary drug concentration and potency without affecting the mechanical properties. This is possible by enhancing polymer degradation and controlled drug release strategies.

The antimicrobial efficacy increased with drug concentration in braided silk sutures coated18 with Tetracycline or a combination of levofloxacin hydrochloride and poly (e-caprolactone), which are more effective against E. coli than S. aureus.19 Also, suture coated with vancomycin grafted onto polypropylene sutures (non-absorbable suture) showed a long-term release of drug.20 Levofloxacin-loaded Poly-(L-lactic acid) and polyethylene glycol sutures helps in sustainable release of drug and used in ocular surgery.21

PLGA based sutures are electrospun by bupivacaine (local anaesthetic drug). These electrospun drug-eluting suture significantly increased drug diffusion into the tissues at the incision site. The drug concentration loaded on the suture material directly correlated with the drug-release kinetics. This drug-eluting suture was said to be clinically helpful because it provided 7–10 days of postoperative analgesia.22 On absorbable suture surface, polyethyleneimine coated with dexamethasone and poly (lactic-co-glycolic acid) particles demonstrated controlled drug release for 4 weeks without affecting the mechanical properties of the suture material.23

Stem cell seeded suture

Stem cells seeded suture’s main goal is to increase the number of cells at the injured area in order to facilitate tissue regeneration and repair.24 Biological components such as growth factor or stem cell coated in the sutures helps in delivering these growth factors in the desired site.25

Recently, in comparison to the traditional method (injection), the mesenchymal stem cell-seeded biological suture loaded with quantum dot nanoparticles was able to deliver stem cells to the heart more effectively. This led to less fibrosis and improved mechanical function of the heart.26 Also, a bioactive suture made by seeding pluripotent stem cells and also by bone marrow-derived mesenchymal stem cells onto a braided suture material aided in the mechanical repair of tendons.27

Thus, in tissue engineering and regenerative medicine, sutures infused with growth factors and/or stem cells can take the place of scaffolds. Sutures have advanced the clinical benefits of cell therapy with improved heart mechanical function, tendon repair, tracheal anastomosis, and wound healing with quick recovery and tissue regeneration in a short amount of time.

Smart sutures

Shape memory suture

Shape-memory polymers have the ability to return from an altered state to their original state in response to external energy stimulation such as heat, light, solution, magnetic, or electric field.28 Smart sutures have a strong mechanical property that allows them to form a self-tightening knot for efficient wound closure. Commonly used shape memory sutures are Barbed suture derived from shape memory polymers and widely used in cardiovascular, orthopaedic, obstetrics surgery, and so forth, reducing the complexity of knotting in confined spaces, especially in minimally invasive surgery.29

Elastic sutures

The use of non-elastic sutures may result in tissue necrosis and delayed wound healing. To avoid such complications elastic sutures were introduced and developed from polyurethane. Thermoplastic polyurethane elastic sutures are commonly used in practical and safe for midline laparotomy wound closure thus avoiding complications like a burst abdomen after abdominal surgery.30

Electronic suture

For monitoring wounds, electronic sutures are thin, flexible silicone that contains sensors such as a gold microheater along with two silicone and platinum nanomembrane temperature sensors integrated on polymer or silk strips. These microheaters assist in maintaining the ideal temperature to promote the healing process as well as in determining the presence of infections. Additionally, the flexibility makes threading into surgical needles with significant pull strength and placing a knot.31

CONCLUSION

Surgical sutures are an important medical device in wound management, and recent advancements have increased their applicability and efficacy. Suture's primary function and efficacy are dependent on their physicomechanical properties, which must be preserved while they are modified or coated with bioactive agents and sensors. In addition to improved handling and desired modifications, it should be noncarcinogenic, nontoxic, free of allergens, and most importantly, it should not elicit any adverse response in host tissues.

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