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Advances In Surgical Suture Materials- A Narrative Review

Dr. Shobha. E. S, Dr. Prashant. N. T, Dr.Vinod Rangan,
Anagha. M. D

Abstract:
Surgical sutures helps in the closing and healing of surgical wounds or wounds caused by trauma, by binding tissues together. Because of their ability to promote tissue adhesion and wound closure, absorbable and non-absorbable suture materials are becoming increasingly popular. Dental suturing plays a critical role not just as physical device to approximate apposing tissues, thanks to the introduction of more sophisticated technology in suturing techniques and suturing materials. The article emphasizes some significant advances in surgical suture.
Keywords*: Surgical sutures, wound closure, suture materials, dental suturing*

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I. Introduction:

A "suture" is any strand of material used to ligate blood vessels or approximate tissues. [1]. It also provides tissue boundary support till they heal, removes dead space, and reduces postoperative pain.

The use of sutures in surgeries and injury therapy has proven to be critical and useful. The primary role of suture is to hold opposing tissues together so as to make the surgical or injury wound heal more rapidly with minimal scarring. Many different materials have been used as suture materialstraditionally, some of which are still in use today, such as gold, silver, iron, and steel wires, dried animal intestines, animal hair (for example, horse hair), silk, tree bark, and plant fibres (for example, linen).

Sutures have been proven to be necessary and beneficial in surgeries and wound care. The primary function of sutures is to keep opposing tissues together so that wound healing occurs quickly and scar-free. The first/primary purpose of dental suturing in surgeries is to insert and stabilise surgical flaps so as to allow for optimal healing[2].

The number of tissue layers involved in wound closure, tension across the suture placement depth, the presence of oedema, the anticipated time of suture removal, the need for sufficient strength, and the induction of little to no inflammatory responses have an impact on suture material selection in wound management [3].Sutures core function and efficacy are founded on their physicomechanical qualities, which must be preserved even when changed or coated with bioactive substances and sensors [2].

Knotless barbed sutures, bacteria-fighting sutures, bioactive sutures such as stem cell- and drug-eluting sutures, and smart sutures such as elastic and electronic sutures are some of the current and future advances in suture technology [2].

II. Discussion:

Suture material is an artificial fibre that is used to keep wounds together until collagen, which is synthesised and woven into a stronger scar, can hold them together sufficiently on its own [1].

Suture material selection in wound management is influenced by the number of tissue layers involved in wound closure, tension across the suture placement depth, the presence of oedema, the anticipated time of suture removal, the need for sufficient strength, and the induction of little to no inflammatory reactions [4].

Furthermore, great knot security, ease of knot installation, and the absence of irritating or contagious substances are all desirable characteristics [5, 6, 7].

The important traits and attributes that influence how effectively specific sutures perform are the filament structure, size, degrading property, tensile strength, and surface[8].

Barbed Sutures:

Barbed sutures were invented by John Alcamo in 1956 and were granted a US patent in 1964[3].

Sharp projections or barbs on the surface of the suturematerial aid in the linear adhesion of tissue sutures[9]. The use of barbed sutures in difficult reconstructive surgeries has increased[10].

Knotless barbed sutures had the same tensile strength as smooth sutures on fascial healing in the pig model without causing any negative side effects [11].

Barbed sutures have been used successfully in a wide range of specialities, including general and aesthetic surgery, obstetrics and gynaecology, orthopaedics, urology, and other procedures[12-15].

There is emerging evidence that knotless barbed, self-anchoring suture devices are as safe and well-tolerated for tissue suturing as standard sutures and that their use is associated with faster surgical closure, cheaper costs, and fewer local complications[18].

A recent study found that utilising barbed sutures minimises the chance of destroying gloves[16]. Multifilament barbed sutures with higher mechanical properties are known as "intertwined," and they are ideal for deep wound closures[17].

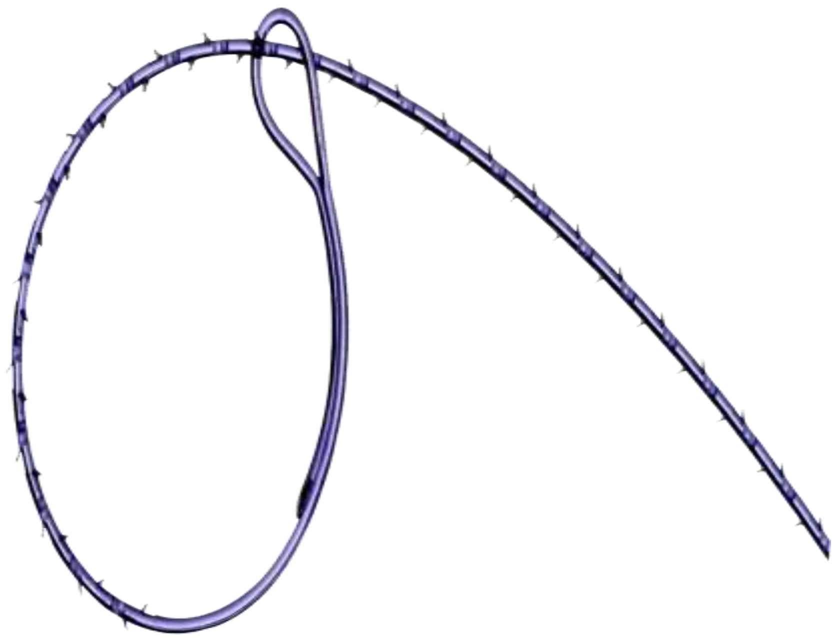

Fig 1- Barbes sutures; Courtesy:Dolphin sutures

Antibacterial sutures: Infections caused by bacterial adhesion and growth on device or implant surfaces are a serious problem during reconstructive surgeries and the usage of implanted biomedical equipment[19,20].

These antimicrobial sutures reduce complications and postoperative infections. Diacetyl chitin sutures are absorbable and used when the epithelium and connective tissues are involved in the short-term healing of wounds. Bacterial adherence to the sutures may be avoided by applying controlled etching and oxidative plasma treatment, resulting in antibacterial sutures that are both inexpensive and have desirable qualities.[21,22]

Fig 3- Antibacterial sutures; Courtesy: Medical design&Outsourcing
Fig 4-Plus Antibacterial suture for SSI prevention; Courtesy: J & J Meditech

III. Drug eluting suture:

Depending on the therapeutic agent utilised, drug-eluting sutures may reduce postoperative problems such as surgical site infections and expedite wound healing[23].

It can also lessen the need for additional medications, some of which may be less effective or more difficult to get at the site of therapy after systemic distribution. Slow-release medications can be therapeutically useful locally for an extended length of time without passing the hazardous threshold in the systemic circulation. Several techniques are used to create drug-eluting sutures, including electrospinning, grafting, and dip coating the suture surface[8].

Tetracycline-coated silk sutures were more effective against S. aureus and E. coli, and antimicrobial efficacy increased with drug concentration[24]. Coating braided silk sutures with levofloxacin hydrochloride and poly (-caprolactone) yielded results comparable to tetracycline, with greater susceptibility to E. coli than S. aureus and tolerable in-vitro cytotoxicity of porcine endothelium cells[23].

In tissue engineering and regenerative medicine, biodegradable scaffolds are frequently utilised as a carrier to transplant and develop stem cells into diverse tissues[25]. Sutures impregnated with growth factors or stem cells might be utilised to mimic the dispersion of these biological components to the correct location[26,27].

Sutures with bioactive coatings offer excellent tensile and degradability qualities, enabling fast tissue regeneration upon insertion. The fundamental goal of stem-cell-seeded sutures is to increase the number of cells in the wounded region, which speeds up tissue regeneration and repair[27]. The mechanical healing of tendons was made possible by a bioactive suture created by planting pluripotent stem cells onto a braided suture material[28].

A novel stem cell-seeded biological suture material has been developed for use in cardiac surgery and tissue. Quantum dot nanoparticles were placed into the human mesenchymal stem cell-seeded suture material to detect the seeded cells inside the myocardium[30]. A tracheal anastomosis suture manufactured from adipose-derived stem cells (ASCs) decreased local acute inflammation in another study[29].

Sutures injected with growth hormones and/or stem cells can replace scaffolds in tissue engineering and regenerative medicine. The clinical benefits of utilising sutures as a carrier in cell therapy have advanced due to improved mechanical performance of the heart, tendon repair, tracheal anastomosis, and wound healing with fast recovery and tissue regeneration in a short period[8]. It is possible to increase the therapeutic application of shape-memory alloy (Nitinol) nanocoated metallic sutures modified with stem cells[30,31].

IV. Smart sutures:

Shape memory sutures:

Shape memory polymers have been developed into smart sutures that may replace standard sutures for deep wound closures by self-tightening knots, simplifying surgery for doctors, especially when performing keyhole procedures. When subjected to external energy stimuli such as heat, light, a solution, a magnetic field, or an electric field, shape memory polymers (SMPs) can recover to their original condition after being distorted[32].

By combining strong mechanical properties with extraordinary flexibility and pliability, smart sutures create a self-tightening knot for fast wound closure. Reduced knotting difficulties in confined areas, particularly in minimally invasive surgery, broadens their usefulness in cardiovascular, orthopaedic, obstetrics, and other surgical specialities [33].

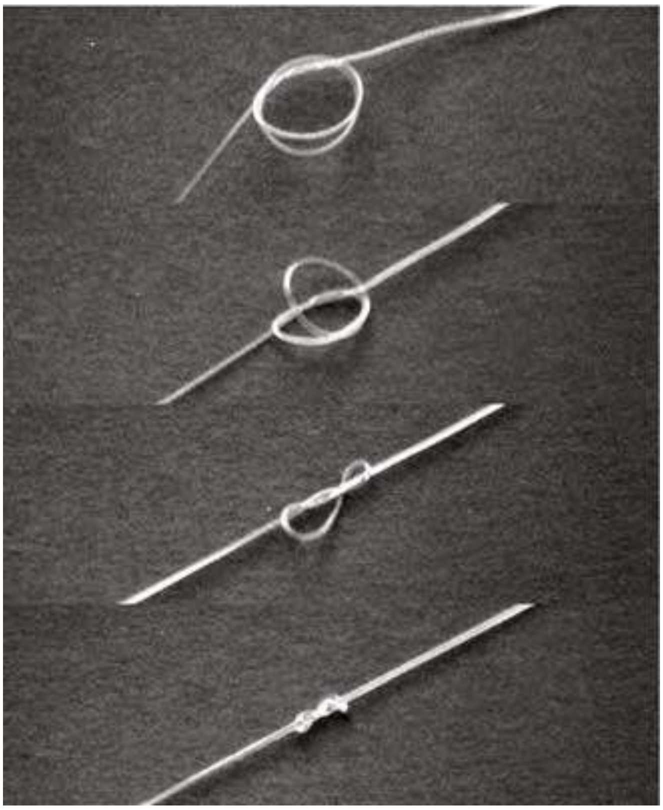

Fig 4: Shape memory sutures; Courtesy: Science

Elastic sutures:

During the early postoperative period, the insertion of nonelastic sutures may result in tissue necrosis, slacking of the sutures, failure of wound healing, and pulling out of tissues, particularly during coughs. To minimise post-operative complications such as a ruptured abdomen after abdominal surgery, newly created thermoplastic polyurethane elastic sutures for midline laparotomy wound closure are practical and safe. The elastic suture material significantly elevated the collagen I/III ratio and the number of inflammatory cells[34].

Shape-memory polymers with self-tightening knots and improved elasticity and tensile strength obtained from polyurethane sutures will see a rise in clinical applications[35].

Electronic sutures:

Electronic sutures that can track, detect, and activate typical body responses may be extremely useful for improving localised tissue health monitoring[8].

Smart electronic sutures with ultrathin, and flexible silicon sensors implanted in polymer or silk strips for wound monitoring (one millimetre wide and three millimetres thick)[39]. Electronic sutures that use microheaters at the wound site can help maintain the right temperature to aid in the healing process and accurately monitor higher temperatures that can be used to evaluate infection status[36].

As minimally invasive surgery and advancements in suture technology gain traction, electronic sutures with additional sensors to monitor pH, wound exudates, bacteria, oxygen, and enzymes, as well as a temperature monitoring system, can help with accurate monitoring and improved healing of acute and chronic wounds[37,38].

The tension threshold during the surgeon's pulling force used to seal the incision site in diverse tissues can also be established using force sensors coupled with feedback control tools in sutures. As a consequence, abnormally high or low tensions in sutures at wound closure sites may be regulated and adjusted, reducing the negative effects of tension-medicated sutures on wound healing[39].

V. Conclusion:

With recent developments, surgical sutures usefulness and efficacy as a medical device in wound treatment have increased. After dental surgery, excellent soft tissue recovery is possible if the fundamental guidelines are followed. The importance of aesthetics in reducing postoperative infections and problems following surgery cannot be overstated. When using different suturing procedures, delicately manipulating soft tissue can ensure excellent tissue healing and a high level of aesthetic outcome.

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