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Research Article

AN OVERVIEW ON VARIOUS SUTURING MATERIALS AND SUTURING TECHNIQUES

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A R T I C L E I N F O

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A B S T R A C T

Wound healing is a complicated process during which the tissue repairs itself after injury. This process is often influenced by the number of suture material used, the suture type, the suturing technique, and the quantity of tension on the suture. Suturing is defined as the attachment of incised tissues with needle and thread in order to bind the tissues along and heal. There is a large vary of suture materials for medical purpose and the main varieties embody absorbable and nonabsorbable. The ideal suture is powerful, handles easily, and forms secure knots. It causes less tissue inflammation and doesn't promote infection. A large variety of material is available for suturing incised tissues. Also, foremost to clinical success could be a thorough understanding of the various techniques of surgery, suturing, and the materials presently available to ensure the desired clinical results. This article is an attempt to discuss the suture materials and suturing techniques to help the practitioner acquire optimal wound closure and thereby optimal healing.

INTRODUCTION

Wound healing is a complicated process during which the tissue repairs itself after injury. This process is often influenced by the number of suture material used, the suture type, the suturing technique, and the quantity of tension on the suture. Wound healing is often achieved in one of the following two ways:

- Healing by 1st intention (primary wound healing).
- Healing by 2nd intention (secondary wound healing).

Healing by primary intention: Primary union of a wound in which the incised tissue edges are joined and held until union occurs.

Healing by secondary intention: Wound closure wherein the edges remain separated and the wound heals from the base and sides via the formation of granulation tissue. Thus, in primary (union) healing, edges of wound are approximated by surgical sutures.

Suturing is defined as the attachment of incised tissues with needle and thread in order to bind the tissues along and heal. (Visha MG *et al*, 2019).

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Goals of Suturing

a. Provide an adequate tension of wound closure without dead space but loose enough to obviate tissue ischemia and necrosis.
b. Maintain hemostasis.
c. Permit primary-intention healing.
d. Provide support for tissue margins until they have healed and the support is no longer needed.
e. Reduce postoperative pain.
f. Prevent bone exposure resulting in delayed healing and unnecessary resorption.
g. Permit proper flap position (Cohen ES, 2007).

Ideal Requisites of sutures are

Tensile Strength, Tissue biocompatibility, Low Capillarity, Pliability, Sterilization without deterioration of properties, low cost etc.

Classification of Suture Materials *(Hupp JR, 2015)(Fig.1)*

Based on the degradation of material within the tissues

- Absorbable (lose Tensile Strength < 60 days).
- Non-absorbable (maintain Tensile Strength > 60 days).

Based on the source of materials

- Natural, e.g.: silk
- Synthetic, e.g.: polyglycolic acid
- Metallic, e.g.: stainless steel

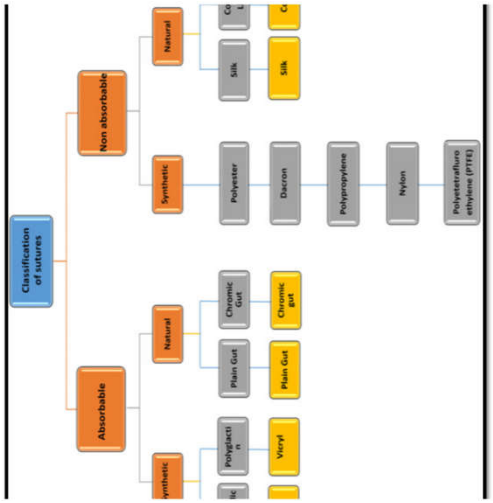

Fig. 1-Classification of Suture Materials

Based on the number of filaments in the suture material

Monofilament: These materials are made of a single strand.

- E.g.: Absorbable: monocryl
- Non-absorbable: polyamide, polyester etc.

Multifilament: Rolled, twisted or braided together to form a uniform strand of thread.

- E.g.: black braided silk.

Pseudo monofilament: E.g.: Catgut

Based on the diameter of the thread in cross section: Suture materials are labelled from 1-0 to 10-0.

According to coating applied on the material

- Coated or Uncoated e.g. Chromic coated etc.
- Dyed or Undyed.

According to tissue reaction

- Reactive
- Not reactive

Absorbable Sutures: *(Koshak HH, 2017)*

- Popular in periodontal and implant surgeries.
- Less postoperative inflammation.
- More patient's comfort.
- Available in two forms natural or synthetic.

Natural Absorbable Sutures: Monofilaments of highly purified collagen, mild to moderate tensile strength, mild inflammatory reaction, and difficult to handle. Should not be used in high acidic environment (reflux bulimia, esophagitis, Sjogren's syndrome, radiation therapy).

Catgut: First absorbable suture material.

- Derived from either serosal layer of cow's intestine (bovine source) or submucosal fibrous layer of sheep intestines.
- Resorption is by enzymatic degradation by proteolytic enzymes and phagocytosis.
- Loses it's tensile strength within 10-15 days and is resorbed by 2-3 months.

Available in two types:

1. ***Plain Gut:*** Becomes stiff and difficult to handle, poor tensile strength, poor knot stability, and high tissue reactivity (Fig. 2).
2. ***Chromic Gut:*** Dyed with chromium salt solution, completely resorbed after 90 days, loses it's tensile strength around 3-4 weeks and less tissue reaction than plain gut (Fig. 3).
3. A new catgut recently introduced by Ethicon (Somerville, N J) is **"fast-absorbing gut"** loses it's tensile strength by 5-7 days and gets resorbed by 2-4 week (Bennett RG, 1998).

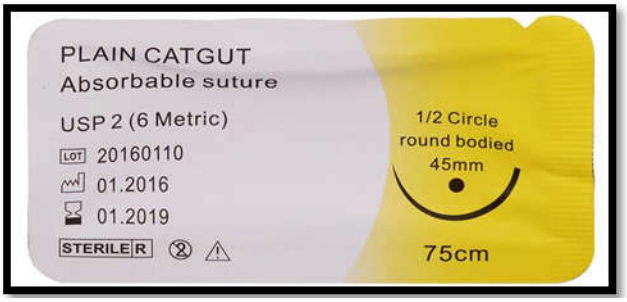

Fig 2 Catgut

Fig 3 Chromic Gut

Non-absorbable Sutures: Nonabsorbable sutures resist enzymatic activity and hydrolysis. Treated for capillarity (the passage of tissue fluid along the strand permitting infection).

More Patient's discomfort.

Available in two forms natural and synthetic.

Natural Non-absorbable Sutures

Silk: It is available as multifilament, Braided form (Fig. 4).

Fig 4 Silk

- Made from the natural protein (fibroin) fiber produced by silkworm larvae.
- High elasticity & good knot security.
- Black dyed for easy visibility.
- Bacteria and fluid collection (Wick effect).
- Silk is also less likely to tear tissue than stiffer materials such as nylon; this makes silk useful as a temporary suture during surgery to retract tissue for greater visibility.
- Used for mucosal closure intra orally.
- Silk swells on implantation.

Synthetic Absorbable Sutures

Braided filaments:

Polyglycolic acid (P.G.A): Introduced in 1970as the first synthetic absorbable suture, polyglycolic acid (Dexon), was initially marketed. It is absorbed by hydrolysis (hydrophobic), good tensile strength (resist muscle pull), bacterial growth inhibition, mild tissue reaction, and resorption rate from 21 to 28 days. PGA is composed of a coating of N-laurin and L-lysine over polyglycolic acid (Brandt MT and Jenkins WS, 2012)(Fig. 5).

Fig 5 Polyglycolic acid

- **Dexon®:** Available as Non-toxic coating or uncoated, violet or undyed.
- It's braided configuration allows easy handling and prevents fraying.

Polyglactin 910 (Vicryl): Coated, available as clear or violet coloured sutures, stronger than Dexon.

- In 1974 Ethicon introduced polyglactin 910 (Vicryl), a synthetic suture that is similar to polyglycolic acid (Dexon) in many respects.
- It is a copolymer of glycolic acid and lactic acids in a ratio of 9:1.(Aderriotis D and Sàndor GK, 1999)

Poliglecaprone 25 (Monocryl-Ethicon): Introduced in 1993.

- Monofilament, is composed of copolymer of glycolide and epsilon-caprolactone.
- It offers high initial tensile strength with good knot handling and absorbs by hydrolysis in 119 days.
- Poliglecaprone 25 has one of the lowest amounts of tissue drag and is the most pliable of all absorbable sutures.

Polydioxanone (PDS II Ethicon): Undyed or violet-colored thread.

- It is a polymer made from paradioxanone.
- First available commercially in 1982.
- It has enhanced flexibility and significantly greater tensile strength than both polyglycolic acid and polyglactin 910(Brandt MT and Jenkins WS, 2012).

Synthetic Non-absorbable Sutures:

Nylon: First introduced in 1940(Bennett RG, 1988).

- It was first synthetic non-absorbable suture material available commercially.
- Available as braided (coated) or nonbraided, mono/multifilament's.
- Ethilon is the trade name for the monofilamentous nylon suture manufactured by Ethicon (Jenkins WS, Brandt MT *et al*, 2002).

Polypropylene: Prolene (polypropylene manufactured by Ethicon) or Surgilene (also polypropylene manufactured by Davis & Geck) is a plastic suture formed by the polymerization of propylene by means of a suitable catalyst.(Sortino F, Lombardo C *et al*, 2008).

- One characteristic unique to polypropylene suture is the extreme smoothness of its surface (Fig. 6).

Fig 6 Polypropylene

Polybutester. A recently introduced special type of polyester suture called polybutester (Novafil) has been marketed by Davis & Geck (Bennett RG, 1988).

- Unique feature is their ability to elongate or stretch with increasing wound edema. When edema subsides, suture resumes original shape; so it is an ideal suturefor lacerations secondary to blunt trauma.
- Tensile strength high and lasts longer.

Polytetrafluoroethylene(PTFE)/Gore–Tex: PTFE is a synthetic microporous monofilament suture that contains approximately 50% air (Fig. 7).

Fig 7 Polytetrafluoroethylene (PTFE)

- Has unique property of sliding upon itself.
- It is of white colour which is highly visible in the surgical field.
- High tensile strength, excellent handling properties, low tissue reaction (nonwicking) but it is very expensive (Koshak HH, 2017).
- In oral surgeries, its use was proposed due to the procedure using membranes made from the same material.

Principles of Suturing

For a good suture to be placed selecting the correct armamentarium, the appropriate suture material, the required needle, and also the type of suturing technique are all essential. It is also important to follow certain principles.(Neelima Anil Malik, 2012)

1. The beak of the needle holder should grasp the needle at the junction of 2/3rd of needle from the tip. Grasping the needle further away will result in bending of the needle when inserting through the tissues. It may also result in breakage of the needle especially a swaged needle as it is weak in that region.
2. When the needle is introduced into the tissues it should enter perpendicular to the tissue surface. Change in this angulation may tear the tissues.
3. After inserting the needle, pull the needle along its curvature to prevent undue damage to the tissues.
4. Needle should pass at a distance of about 2-3 mm from the edges of the flap. This distance should be the same on both wound edges. This principle may be modified in certain instances where the wound edges are at uneven levels.
5. The needle is passed through the free side of the flap first and then through the fixed side.
6. In wound edges of uneven thickness, the needle is first passed through the thinner flap and then through the thicker flap.
7. The needle is to be passed from the deeper flap to the superficial flap.
8. When the needle is passed through the tissues, the depth of penetration should be more than the distance from the wound edges. This brings about wound edge eversion which is required for wound closure.
9. Make sure suturing is not done under tension. The wound edge will necrose or tear under tension. Undermine adequately prior to closure to ensure tension-free wound approximation.
10. Do not strangulate the tissues by unnecessary tightening of the knot as it will result in necrosis and loss of tissue.
11. The knot should be stabilized over one side of the wound and not rest along the edges of the wound as infection may track into the wound.
12. Distance between 2 sutures should be approximately 3-4 mm. It may be placed closer in areas of high muscular activity where movement is likely to cause dislodgement of sutures.

Suturing Techniques

Interrupted Suture Techniques

Simple-loop (Interrupted) suture technique: *(Fig. 8)*

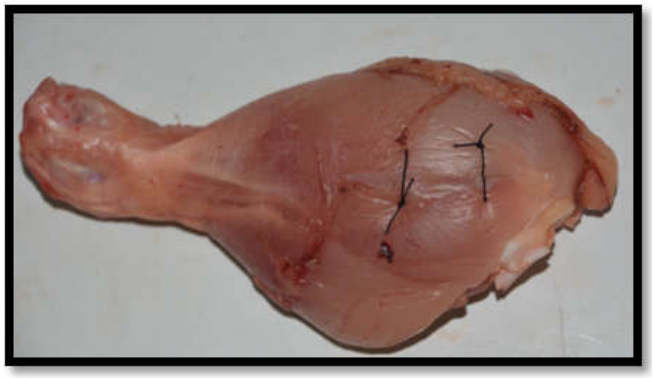

Fig 8 Direct loop & Figure of '8' suture

- The most common type of sutures placed in dentistry is the routine interrupted suture.
- Some surgeons refer to the routine interrupted suture as a ''simple'' suture.

Uses- These sutures are useful to suture divided papillae, to reapproximate the edges of a flap back into place, and to close the soft tissue after a biopsy.

- Most commonly used in the oral cavity.
- This suture goes through one side of the wound, comes up through the other side of the wound, and is tied in a knot.

Advantages - Speed and above all the ease of applying them.

- Shows esthetic result: if correctly applied, once healing is completed the suture leaves no visible traces.
- It does not bring the surfaces of the flaps into contact, simply approaching the margins of the wound at one or more points.

Disadvantage- It leaves the suture more sensitive to laceration as pressure inside the flaps increase, due to postoperative edema.(Siervo S and Lorenzini L, 2008).

Figure of 8 suture technique:(Fig. 8)

- This is another very commonly used suture technique in dental surgery and is frequently confused with the simple loop.

Indications

- Used when the flaps are not in close apposition as a result of apical flap position or nonscalloped incisions.
- Used in extraction sites/ exodontic surgery.
- Provides protection to socket.
- Adaptation of gingival papilla around adjacent tooth.
- Regenerative periodontal surgery.

Advantages: Rapid closure.

- Main advantage is easier access between the teeth.

Disadvantages: Due to orientation it is difficult to remove.

- Leaves a significant amount of suture threads in socket.

- The major disadvantage being presence of suture between the 2 flaps.

Mattress Suturing Technique

- A mattress means the suture passes through the flap twice.
- Mattress sutures provide precise flap edge placement and control.
- They are less likely to tear through the tissue because the tearing forces are directed over several vectors, depending on whether the sutures are vertical or horizontal mattresses.
- They allow the surgeon to apply downward (inverting) or upward (everting) pressure at the flap edge.
- There are numerous indications for mattress sutures, involving all fields of oral surgery, for example in exodontics, implantology, and periodontics.
- Both inverting and everting sutures are useful in the mouth depending on the desired result.

Types of horizontal & vertical mattress

Internal (Everting)

External (Inverting): By using inverting horizontal or vertical mattress suture the material does not pass under the Incision line, thus minimizing wicking.

Vertical mattress suture: (Fig. 9)

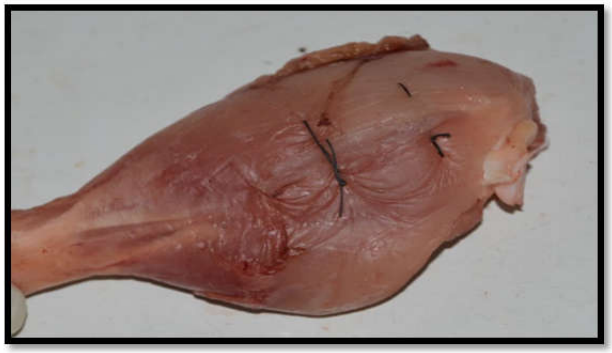

Fig 9 Vertical mattress suture (Inverting and Everting)

Advantages- Runs parallel to the blood supply of the edge of the flap and therefore not interfering with healing.

- For better adaptation and maximum tissue approximation.
- Where healing is expected to be delayed for any reason, it is better to give wound added support by vertical mattress.
- Used to control soft tissue hemorrhage.

Disadvantage: Crosshatching.

There are two main variations on a vertical mattress.

- The **"everting/internal" vertical mattress** are particularly useful in papillae management or papillae preservation technique in anterior areas and in maximizing wound eversion, reducing dead space, and minimizing tension across the wound.
- The **"inverting/external" vertical mattress** is most commonly used in securing periodontal flaps because the bulk of the suture lies on top of the tissue and does not cross under the wound edge.(Moore RL and Hill M, 1996).

Horizontal mattress suture (Fig. 10)

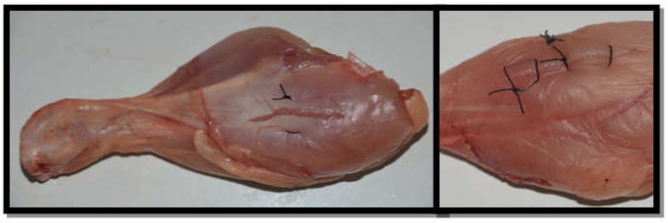

Fig 10 Horizontal mattress suture (Everting and Inverting)

- It produces broad contact of the wound margins.
- Horizontal mattress sutures are used when more precise apposition of wound edges is needed.
- Horizontal sutures have less tendency to tear through tissue.
- "Inverting/External" horizontal mattressis useful in cases of bone grafting to keep the suture material away from the grafted material.
- Horizontal mattress suture used to closely adapt non tension-free tissue around an implant abutment, coupled with simple loop sutures to co-adapt the tension-free flap margins created by the horizontal mattress.

Advantages- It everts mucosal margins, bringing greater areas of raw tissue into contact so used for closing bony deficiencies such as oro-antral fistula or cystic cavities, extraction socket wounds.

Disadvantages: More trouble to insert.

- In addition to the risk of suture marks, horizontal sutures have a high risk of tissue strangulation and wound edge necrosis if tied too tightly.(Moore RL and Hill M, 1996).
  - Horizontal mattresses, vertical mattresses distribute tearing forces in 4 and 2 directions respectively.

The anchored suture

The Anchor suture described by Morris 1965 allows delicate positioning of a single papillae when it is undesirable to tie on to tissue on the lingual or on the adjacent embrasures.(Moore RL and Hill M, 1996).

Used mainly in the mesial or distal wedge procedure.

Advantage: These sutures bring together flap surfaces rather than simple points and help to reposition the flap apically or coronally, close advancement of the flaps and the compression that is applied.

Intrapapillary Suture: This technique is recommended for use only with modified Widman flaps and regeneration procedures in which there is adequate thickness of the papillary tissue. Permit exact tip-to-tip placement of the flaps.

Continuous sutures*:* Continuous sutures are a series of sutures placed without cutting or knot tying between each suture. They can incorporate any of the same suture forms above. Continuous suturing allows for placement of fewer knots and enables the operation to avoid tying knots in areas that are difficult to reach.

Simple continuous / Running: Quick but wound will open totally if the material breaks later.

Advantages: Rapid technique and distributes tension uniformly.

- More water tight closure.
- Only 2 knots with associated tags.

Disadvantage: If cut at one point, suture slackens along the whole length of the wound, which will then open the gap.

Knot Tying

Suture securing is the ability of the knot & the materials to maintain tissue approximation during the healing process. (Thacker JG, Rodeheaver G *et al*, 1975).

Types of knots

1. ***Square knot-*** This suture knot is made by tying two overhand knots, each done in opposite directions. For example, the first loop is made by making a loop over the jaws of the needle holder, and the second knot is subsequently made by forming a loop under the jaws of the needle holder (Fig. 11).

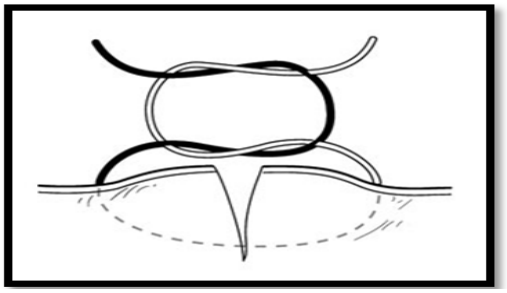

Fig11 Square knot

2. ***Surgeon's knot-*** This knot is used primarily with braided suture material, whether synthetic or natural. The surgeon's knot is a modified square knot in which the first overhand knot is doubled; therefore, two loops of the suture are formed over the jaws of the needle holder and tightened. The last loop is formed under the jaws of the needle holder in a direction opposite from the first loops (Fig. 12).

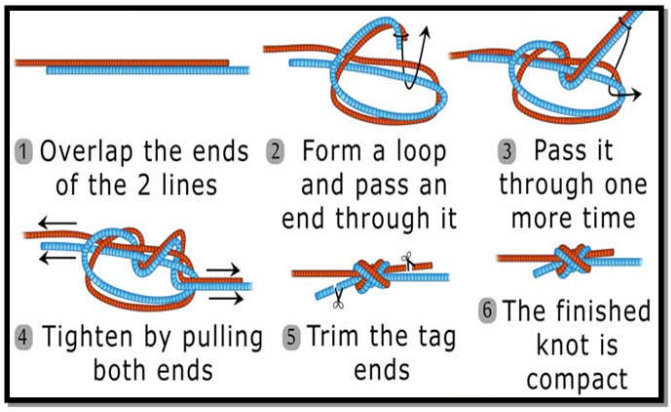

Fig 12 Surgeon's knot

Can be given as 2-1 and 2-2.

Granny's knot-The slipknot is similar to a square knot in that it is made with two overhand knots, but both knots are made in the same direction. With a needle holder, one overhand knot is made so that the loop forms over the jaws of the needle holder and is then tightened. A second overhand knot is then made so that the loop goes in the same direction over the needle holder and is tightened (Fig. 13).

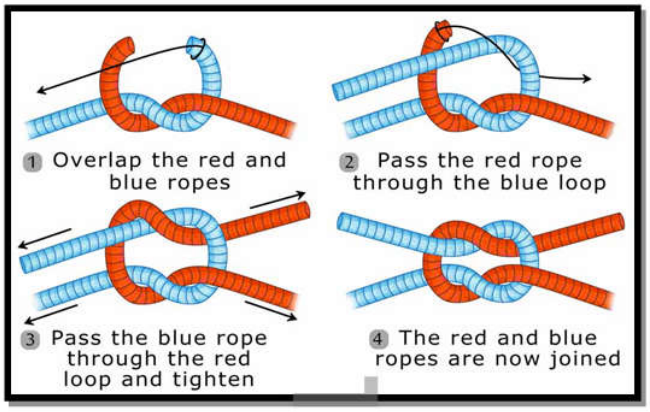

Fig 13 Granny's knot

Recent and Emerging Trends*:* Newer suture materials and design have expanded the range of biomedical applications of sutures. The recent advancements and emerging trends such as sutures with bioactive molecules (drugs, antimicrobials, and stem cells) and smart sutures in suture technology have immense potential in clinical/surgical applications involving specialized procedures and wound management.

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

- ***Antimicrobial agent coated sutures:*** Triclosan-coated absorbable suture materials with antimicrobial properties were commercially launched to overcome or prevent postoperative infections. Triclosan is an antimicrobial agent that is commercially used in several products such as soaps, deodorants, shower gels and toothpastes due of its antimicrobial efficacy with low toxicity to humans. In vivo studies on triclosan-coated sutures exhibited significant inhibition of bacterial colonies on its surface near the infected site without compromising the mechanical property of the suture. Similarly, poliglecaprone 25 suture with triclosan (Monocryl Plus, Ethicon) exhibited good antibacterial efficacy post-implantation in animal models.(Storch ML *et al*, 2004)
- ***Silver nanoparticles treated sutures:*** Silver nanoparticles (AgNPs) are considered to be best candidates for coating polymeric medical devices to enhance their antimicrobial profile. The mechanism of action for silver's antibacterial effect involves generation of reactive oxygen species, which directly affects DNA and cell membrane of microorganisms. In recent time, AgNPs treated surgical sutures to prevent bacterial adhesion on their surface has gained interest to enhance infection free wound closure on incision site.
- ***Drug-eluting sutures:*** Depending on the type of therapeutic agent used, drug eluting sutures can alleviate postoperative complications such as surgical site infections and expedite wound healing.(Chen X *et al*, 2015) It also can reduce the need for supplemental drugs which can have decreased potency or availability at the site of the procedure following a systemic administration. Tetracycline-coated silk suture exhibited greater antimicrobial activity against E. coli than S.

aureus and the antimicrobial efficacy increased with drug concentration.

- ***Stem cells seeded sutures:*** Biodegradable scaffolds are widely used in tissue engineering and regenerative medicine as a carrier to transplant and differentiate stem cells to various tissues. Recent studies revealed that sutures coated with growth factors or stem cells could be used as a mode of delivery for these biological components to the desired site. The primary objective of stem cells seeded suture is to increase the number of these cells at the injured site to accelerate the tissue regeneration and repair.

Smart Sutures

- ***Shape-memory and elastic sutures:*** Development of smart sutures from shape memory polymers can replace the conventional sutures through self-tightening knots for deep wound closures by reducing the complexity for surgeons, especially during key-hole surgeries. Shape-memory polymers (SMPs) are capable to revert from deformed state (temporary shape) to original state (permanent) by external stimulation of energy such as heat, light, solution, magnetic, or electric field.(Lendlein A, Kelch S, 2002).
- ***Electronic sutures:*** Electronic sutures with the capability to monitor, sense, and actuate typical biological responses in the body would be very useful in improving localized tissue health monitoring.

CONCLUSION

Management of soft tissue is the supreme priority for a surgeon in any of the extra & intra-oral surgical or invasive surgical procedures to achieve highest functional & esthetic results. Closure and healing of wound is affected by the initial tissue injury which is basically caused by needle bite and consequent suture passage. Surface characteristics of the suture, needle selection and coating on the suture materials selected for wound closure are significant factors that must be considered by the surgeon.

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