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A Review: Surgical Thread

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Surgical Thread: History, Classification, Applications, and Innovations in Modern Surgery

Abstract: ***Surgical threads, also known as sutures, are critical tools in modern surgical procedures, enabling wound closure, tissue approximation, and hemostasis. Over the decades, significant advancements have been made in their materials, design, and bio-compatibility. This paper explores the classification, material science, clinical applications, and emerging innovations related to surgical threads. Emphasis is also placed on the comparison between absorbable and non-absorbable sutures, synthetic versus natural materials, and recent trends in antimicrobial and bioactive sutures.Innovations in Modern Surgery Considering availability of a wide variety of suture materials, it's important to know the differences between various sutures before making an informed decision. Suture material's overall performance is influenced by its physical qualities, handling features, and biological factors. The aim of this seminar paper is to give highlights on the biological properties of suture materials. Suturing is not simply about closing a wound; it is a skill that requires finesse and can significantly impact the healing process, reduce complications, and even affect long-term results***
Keywords: suture, hemostasis, Antimicrobial, bioactive, decades.

I. INTRODUCTION

Effective wound closure is important for success of any surgical procedure. An incomplete closure leads to separation of edges, providing a potential pathway for bacterial contamination leading to infection and scarring. Although tissue adhesives and staples are now being used as alternatives, surgical sutures are still the mainstay for a secure wound. **2**

Suture is a general term for all materials used to stitch torn tissues. Sutures can be synthetic or natural and have a monofilament or braided construction. Through the history of mankind, various materials were tried to serve this purpose. Plants such as flax, hemp, and cotton and animal tissues such as hair, tendon, silk, and intestines are some examples. The oldest, known suture was on a mummy in ancient Egypt on 1100 BC, and the first written description on surgical wound suturing belongs to the Indian physician Sushruta in 500 BC .**3**

Sutures and surgery have been tied together since the first operations were performed. Throughout the history of surgery, the variety of materials used to close wounds has included wires of gold, silver, iron, and steel; dried gut; silk; animal hairs; tree bark and other plant fibers; and, more recently, a wide selection of synthetic compositions. Despite the multitude of different procedures performed with a host of different wound closure biomaterials, no study or surgeon has yet identified the perfect suture for all situations.

Suture support for different tissues varies widely, with some tissues requiring support for only a few days, while others may require support for weeks or even months. A short-term need for suture support may be met with the use of absorbable sutures. It eliminates the need for stitch removal and the associated discomfort, while also providing maximum tensile strength during the early healing stages. This review is aimed to present an overview of the available absorbable sutures, classification, their distinguishing characteristics, the suture material properties, benefits, and applications.

II. HISTORY OF SUTURE

Suturing is not a new technique but is a known procedure since ancient era. This is the branch basically evolved for the purpose of wound healing and its management Physicians have been using sutures for at least 4000 years . Archaeological records from ancient Egypt and India show the use of linen, animal sinew, flax, hair, grass, cotton, silk, pig bristles, and animal gut to close wounds. The famed Sushruta is reported to have used suture materials of bark, tendon, hair, and silk as sutures in surgery.5

The first detailed description of a wound suture and the suture materials used in it is described by Sushruta in Sushruta Samhita, written in 500 BCE. Since he was the author of the earliest systematic report, it is assumed that in the case of Egyptian, Babylonian, Greek, and Arab surgeries, all have their origins in India. 5

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The ancient Greek physician Claudius Galen (131–211 CE) was the first to describe the chorda or gut string as a suture material. The surgeon Antyllus (300 CE) performed bone and joint resections, tracheotomies and the first operations on traumatic aneurysms, using chorda material . The use of dried sheep intestine (for ligatures in surgical operations) is advised in Vagbhataratha Kaumudi (700 AD), a commentary by Harikrishna on Astanga Hridaya of Vaghbhata-II . and in similar works . In Europe, Salerno and Rogerio recommended gut strings as suture material, especially for wounds at the large abdominal viscera. Abulcasim (second half of the 10th century), the famous Arab surgeon, produced a detailed description of suture techniques.5

A. Mesopotamia Civilisation (4000 B.C)

Mesopotamia land between the Tigris and Euphrates River, was the arena of the growth and decay of many civilisations including those known as Sumerian, chakdean, Assyrian and Babylonian. Eight of the fifteen Mesopotamian‟s prescriptions were devoted to how to apply plasters for the treatment of wounds and sores. Other records outlined specific postoperative instructions, for instance, the dressing of operation sites with oil-soaked linen bandages. 6

B. Egyptian Civilisation (3100 B.C)

Edwin Smith Surgical Papyrus which was discovered as a piece of a course book in ancient Egypt is recorded as the oldest surgical document. In 1862 Edwin smith (1822-1906), a pioneer purchased a papyrus found in a grave near Luxor. The 48 cases preserved in the Edwin smith papyrus were arranged systemically from head to foot in order of severity. That document mentioned methods to close the wounds with sutures and preventing the infection for the sutured wound. The oldest and well-preserved suture on the human body was found on a mummy of the 21st Egyptian Dynasty (around 1100 BC). The sutures were on the belly, knee and elbow of the mummy.6

C. Chinese Medicine (2900 B.C)

Fu Hsi, who is said to have reigned about 2000 B.C, is the legendary founder of China first dynasty his most important invention includes yan and Ying concepts. The most famous Chinese surgeon Hua T‟ o was credit for invention of anaesthetic drugs, medicinal baths, hydrotherapy and suturing .6

D. Indian Medicine (2500 B.C)

600 BC its emphasis on the art of surgery. The sushruta describes many difficult The sushruta is lived about operations such as cataract, lithotomy, opening the chest and drain the pus, various kinds of threads and needles were used for closing the wound but when intestine was torn large black ant's were recommended as wound clips. Large black ants should be applied to the margins of the wound so ants firmly beaten the part with their jaw. Sushruta, also used cotton, drawn copper, horse hair as ligatures. 6

E. Medicine Hippocrates (460-377 BC) – (Father of Modern)

Hippocrates was born in Kos, a Greek island of the south eastern. He was the son of Herak lides and belonged to a family of physicians their ancestry of Asclepius, Hippocrates worked mainly in Kos and the nearby coast of Asia Minor (corresponding to present-day Turkey) . He mentioned ivory and bone needle for stitching wound. The name suture for natural or synthetic materials comes from Latin word sutura and this term was first used by Hippocrates in 400 BC. Linen as suture material, used by Hippocrates in fistula operation . 6

F. Galen (129-200 AD)

Galen was born in Pergamum on the Ionic coast of Asia Minor in 129A.D. under Roman jurisdiction. In 400 B.C. Galen, physician to the Roman gladiators, recommended the use of silk and hemp sutures for hemostasis . Galen of Pergamon 150 A.D., gained a reputation by treating and sometimes suturing the severed tendons of gladiators, presumably he was referring to linen or Celtic thread . He continues, in many places under Roman rule 160

The Scottish Society of the History of Medicine can obtain silk, especially in large cities where there are many wealthy women. If there is no such opportunity, choose from the material where you are living, the least putrescible, such as thin catgut which quickly falls from the vessel. This is the first reference to catgut although Galen makes it plain in other passages that it was known to the ancients . Wool used in the operation on the eyelid .6

III. AURELIUS CORNELIUS CELSUS

Roman teacher Aurelius Cornelius celsus (25 BC- 50 BC). Celsus placing a suture ligature for haemostasis. Celsus was first to mentioned a double ligature on blood vessels. Ligature the larger vessels but as for the small ones we catch them with hooks and twist them many times thus closing their mouths . Celsus tells us that sutures were of ancient origin and should be 'soft, and not over twisted, so that they may be easier on the part. Whether he was referring to linen or wool is uncertain. He also described fibulae or small metal clips similar to the Michel clips of today. 6

Suture materials have been used or proposed for millennia. Plant-based (cotton, flax, and hemp) and animal-based sutures were used (tendons, hair, muscle strips and nerves, arteries, catgut, and silk) to start with. Surgical suture use was first recorded in ancient Egypt about 3000BC, and the earliest documented suture use was discovered in a mummy around 1100BC. A thorough detail about the suture materials used on different types of wounds was written by Sushruta, an Indian sage and physician, in 500BC.Suture procedures were described by Hippocrates, the Greek father of medicine, as well as by Roman Aulus Cornelius Celsus later. Galen, a Roman physician from the second century, presented the mechanism of gut sutures. By 10th century, Abulcasis devised the catgut suture and the surgical needle.The collection of sheep intestines was necessary to make the catgut suture, which was created in the same manner as strings for guitars, violins, and tennis racquets. 7

IV. TYPES OR CLASSIFICATION OF SUTURES

Suture material can be classified by numerous different characteristics. For practical purposes, the 6 categories of suture classification believed to best assist surgeons in choosing the proper suture material for their surgeries are:

1) Suture size
2) Tensile strength
3) Absorbable versus nonabsorbable
4) Multifilament versus monofilament
5) Stiffness and flexibility
6) Smooth versus barbed 8

Sutures are, in general, categorized according to the type of material (natural or synthetic), the lifetime of the material in the body (absorbable or nonabsorbable), and the form in which they were made (braided, twisted, and monofilament) . Suture manufacturing comes under the regulatory control of the Food and Drug Administration (FDA) because sutures are classified as medical devices. 9

The three classes of sutures are collagen, synthetic absorbable, and nonabsorbable. They are as follows:

Class I – Silk or synthetic fibers of monofilament, twisted, or braided construction.

Class II – Cotton or linen fibers or coated natural or synthetic fibers in which the coating contributes to suture thickness without adding strength.

Class III – Metal wire of monofilament or multifilament construction.

V. PROPERTIES OF SUTURE MATERIALS

A. Tensile Strength

Tensile strength is the measured force, in pounds, that the suture will withstand before it breaks.12,13 Suture material should have, and maintain, adequate tensile strength for its specified purpose.12

B. Absorption

Tissue absorption is a suture characteristic distinct from the rate of tensile strength loss. A suture may display rapid loss of tensile strength yet be absorbed slowly.14 An absorbable suture is defined as a suture that undergoes degradation and absorption in tissues. A nonabsorbable suture maintains its tensile strength and is resistant to absorption. However, most foreign materials will eventually undergo some degree of degradation over time. The rate of absorption is especially pertinent to late suture complications, such as the development of sinus tracts and granulomas.15 Absorbable sutures are generally used for buried sutures that approximate deep tissues.16 Nonabsorbable sutures are most commonly used externally in the skin and will eventually be removed, or for wounds in deeper structures that require prolonged support.16 Factors that delay wound healing are many and include, but are not limited to, diabetes, corticosteroid therapy, malnutrition, stress, and systemic disease. Such factors significantly influence suture choice, and with an increased risk of delayed healing, a nonabsorbable external closure would likely be chosen over an absorbable suture.

C. Cross-Sectional Diameter

Suture diameter designations are specified in descending sequence (ie, 1-0 is larger than 11-0). When selecting suture size, the finest gauge commensurate with the natural strength of the tissue is recommended.13 The number and diameter of sutures used to close a wound should be the minimum necessary for coaptation of the edges.

D. Coefficient of Friction

The coefficient of friction pertains to how easily a suture passes through tissue.14

E. Knot Security

Knot strength is calculated by determining the force necessary to cause a knot to slip.14,17 The least reliable part of any suture is the knot.13 Knot security is the quality of a suture that allows it to be tied securely with a minimum number of throws per knot.12 Greater knot strength minimizes the risk of wound dehiscence. A knot stays tied because of the friction produced by one part of the knot acting on another, which relates to the coefficient of friction of the suture material. A suture with a high coefficient of friction has good knot security but tends to abrade and drag through tissue.18 A knot should hold securely without fraying or cutting. For safety, a knot should have at least 3 throws with 3-mm long ends. Smooth surfaces decrease knot security and must be compensated for with extra throws.

F. Elasticity

Elasticity is the ability of a material to return to its original length after stretching.14 High elasticity will allow the suture to stretch with wound edema but return to its original length and form once swelling has subsided. A high degree of elasticity provides obvious clinical advantages, because highly elastic suture material is less likely to cut through the skin with swelling and effectively approximates wound edges throughout the healing process.

G. Plasticity

Plasticity is defined as the capacity of a suture to be permanently molded or altered.14 Plasticity refers to the ability of a suture to stretch with wound edema without return to its original form once swelling subsides. Thus, sutures that are highly plastic may become too loose when swelling decreases and fail to correctly appose wound edges.

H. Memory

Memory is the capacity of a suture to assume a stable linear configuration after removal from packaging and after stretching. Memory is the capacity of a suture to remain free of curling and other contortions that may interfere with surgical handling and use. Sutures with significant memory are not pliable, which makes them difficult to work with, and significant memory necessitates additional knots.19 (Nylon has significant memory, whereas Gore-Tex suture has no memory).

I. Handling

Several factors impact on how a suture handles including elasticity, plasticity, and memory. The material should handle comfortably and naturally. The hallmark of silk is its exceptional handling characteristics (workability) and ease of knot tying, setting the standard with which all other material is compared.

J. Tissue Reactivity

All suture materials are foreign to human tissue and may elicit a tissue reaction, such as an inflammatory response, that interferes with wound healing and increases the risk of infection. 13The duration and severity of the tissue response depends on the type and quantity of suture material used along with its configuration.An ideal suture stimulates minimal tissue reaction and does not create a situation favorable to bacterial growth. Suture material should be nonelectrolytic, noncapillary, nonallergenic, and noncarcinogenic.

K. Origin

Suture material may be either natural or synthetic; natural fibers (eg, surgical gut and silk) cause a more intense inflammatory reaction than synthetic material (eg, polypropylene).

L. Ease of Removal

For wounds from which suture removal may be painful or difficult and support is only needed for a short time period, rapidly absorbable sutures are indicated.

M. Color

Sutures are available in dyed and undyed material. A dyed material provides easy visualization when the sutures are removed. If suture removal is not planned, undyed material can be used to avoid unsightly show through the skin

VI. CURRENTLY USED SUTURE MATERIALS

Catgut, now called plain gut, is prepared from beef in United States and sheep or goats in India and Pakistan. Chromic gut is a modification aimed to extend the time the suture retains its strength in the body, by treating the catgut sutures with chromium salts to cross-link the collagen molecules. New synthetic absorbable polymers like polyglycolic acid and polylactic acid were developed.14,15 Synthetic suture materials were named according to the corporation, materials, or scientists who formulated them. Mersilene is a combination of Dr George Merson's name, and Terylene, a common European trade name for polyester. Ethiflex suture, is a polyester suture that had a flexible polytetrafluoroethylene coating placed to improve its handling properties. Ethibond is the trade name for a polyester suture with a coating that is tightly bonded to the suture made by Ethicon, Inc (Somerville, NJ, USA). Early braided polyester sutures were taken over by nylon suture due to better handling.21,22

VII. INNOVATIONS

in recent years, there has been a rapid growth in the development of novel sutures that possess improved qualities and desirable features, aimed at enhancing the functional efficacy of sutures.

The fields of tissue engineering, regenerative medicine, and minimally invasive surgery all stand to greatly benefit from these innovations.23

A. Silver Nanoparticles Treated Sutures

Silver nanoparticles treated sutures are sutures that have been coated or impregnated with silver nanoparticles. The use of silver in wound care has been known for centuries due to its antimicrobial properties. Currently, medical devices such as wound dressings for burn injuries and urinary catheters incorporate the use of silver nanoparticles.24

B. Drug Eluting Sutures

The new era of surgical sutures is represented by drugeluting sutures that not only serve their mechanical purpose but also release medication in the surrounding area after they are implanted.17

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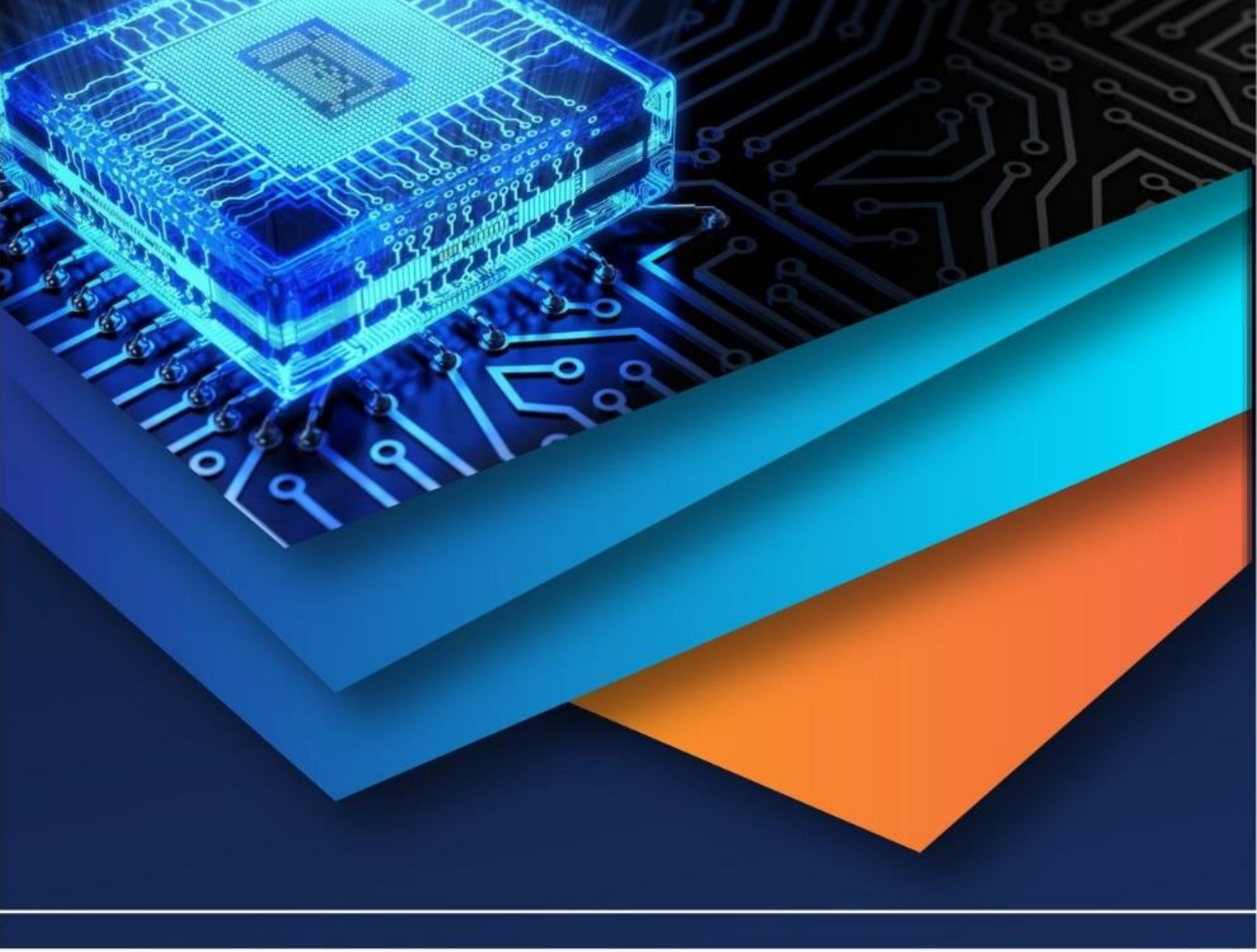

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