Absorbable sutures in general surgery – review, available materials, and optimum choices

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ABSTRACT: Sutures are the most versatile materials used in surgery. Despite recent technological advances and availability of novel materials such as tissue cements, it appears that surgical sutures will continue to be used for many years to come. The objective of this study was to provide an overview of the most common absorbable sutures used in general surgery. The appropriate suture choice for a particular procedure is of key importance for the success of that procedure.

KEYWORDS: Absorbable sutures, Polydioxanone, Poliglecaprone, Polyglactin

INTRODUCTION

Appropriate suture choice for a particular procedure is a prerequisite for the success of that procedure. Sutures inappropriate for a particular organ may have tragic consequences for patients, as shown by Allan Oldfather Whipple in 1934 [1]. Whipple used catgut as the suturing material in his first ampulla of Vater resection surgeries. However, anastomotic dehiscence leading to patient’s death was observed on the second day after the procedure as the suture had been degraded by the pancreatic juice enzymes. After five months, Wipple replaced catgut with silk sutures and thus defined a new standard for this procedure at the time [2,3].

HISTORICAL PERSPECTIVE

Needles with a small orifice for threading sewing materials were known as early as 50,000 years BC. About 20,000 years BC, bone was the standard needle material [4]. It is very likely that such needles were threaded with sutures for stitching wounds as a number of preserved skulls from the Neolithic period featured signs of trepanation. This procedure was often successful since healing took place after trepanation, and the wounds must have been closed in some way [4].

According to Sushruta, surgical sutures used to be made of hair, flax, or hemp fibers. Interestingly, Sushruta also described materials used by surgeons in training who mastered stitching techniques; among others, these included melons and animal hides [4].

Around 150 AD, Galen of Pergamum became renowned for his ability to heal tendon ruptures in gladiators, thus offering them a chance for a quick comeback to the arena. His work, titled “De Methodo Medendi”, mentions for the first time catgut – a suturing material made of sheep’s or goat’s bowels.

Traditional sutures, mainly made of flax, were also used by Avicenna (980-1037).

The 19th century was an era of catgut. Catgut is a biodegradable fiber characterized by good mechanical properties.

In 1868, Joseph Lister made the first attempt to use sutures coated with an antibacterial agent. Two types of fibers were used to that end, one was obtained from bovine peritoneum and the other was made of traditional catgut. Both types of sutures were coated with an antiseptic phenol solution.

With time, the use of catgut became less and less popular due to the increasing availability of synthetic absorbable sutures. First absorbable synthetic sutures were developed in the US in 1962, and the Dexon suture was introduced into the market in the late 1960s [4]. The Dexon material continued to be improved, and new generations of the suture were introduced [33]. Currently, other synthetic sutures are available, such as Vicryl or PDS, that are characterized by better tissue tone retention properties.

GENERAL CHARACTERISTICS OF SUTURES

Sutures are either absorbable or non-absorbable. Most sutures are manufactured as atraumatic sutures. Some are manufactured as conventional threads for attachment to surgical needles (ligatures). Basic suture characteristics are provided on packages. Suture thickness should match the type of anastomosis to be performed.

Sutures are available in a variety of sizes, and different sizes are used for various applications. Two types of gauges are used to indicate the suture thickness: 1) the metric gauge (in tenths of a millimeter), and 2) the surgical gauge (Tab. I).

The metric gauge, accepted in the European and US Pharmacopoeia, defines suture thickness in tenths of a millimeter. The surgical gauge is used more commonly in the clinical setting.
This material was first used in surgery in 1993. The sutures are made of glycolide and ε-caprolactone copolymer, and are a synthetic equivalent of catgut that causes no tissue reactions. The formula of the polymer is (C\(_2\)H\(_2\)O\(_2\))\(_m\)(C\(_6\)H\(_10\)O\(_2\))\(_m\). Polyglecaprone 25 was found to be non-antigenic and apyrogenic.

It is a biodegradable polymer belonging to aliphatic polyesters obtained from caprolactone in a ring-opening polymerization process. In the human body, it undergoes degradation due to hydrolysis of the ester bonds [8].

The retention period is 21–28 days.

The retention profile, as expressed by approximate percentage of initial retention strength, is as follows [46,48]:

- 75% after 14 days
- 50% after 21 days

The absorption rate is 56–70 days [5,7].

Polyglecaprone 25 sutures are manufactured synthetically as absorbable, braided, and monofilament sutures.

Polyglecaprone 25 sutures are used for bringing together and/or ligating soft tissues when absorbable suture stitching is required.

### Polyglyactin 910

The full name of this material is poly(glycolide-co-L-lactide) [5]. This polyester material is used for production of absorbable stitching materials (sutures) and absorbable meshes used, for instance, for hernia repair.

Owing to its biodegradability and biocompatibility, polyglactin 910 has been registered by the FDA (Food and Drug Administration) for use in therapeutic applications. In the course of its synthesis, monomeric fragments, comprised of glycolic acid or lactic acid, are joined by ester bonds, which results in an aliphatic polyester as the final product. The empirical formula of Polyglactin 910 is C\(_2\)H\(_2\)O\(_2\))\(_m\)(C\(_3\)H\(_4\)O\(_2\))\(_n\). Polyglactin 910 undergoes degradation due to hydrolysis of the ester bonds [6].

The retention period of Polyglactin 910 sutures is 28–35 days [46,48].

The retention profile, as expressed by approximate percentage of initial retention strength, is as follows [5,7]:

- 75% after 14 days
- 50% after 21 days

The absorption rate is 56–70 days [5,7].

Polyglactin 910 sutures are used for bringing together and/or ligating soft tissues, including in eye surgery, for connecting peripheral nerves, as well as for microsurgical procedures on blood vessels with diameters smaller than 2 mm. Polyglactin 910 sutures are widely used in gastrointestinal tract surgeries.

### Polydioxanone

This material was first used in surgery in 1982. Polydioxanone sutures are used when absorbable materials are indicated. Due to their longer strength retention, polydioxanone sutures are indicated for the management of slower-healing wounds and tissues. These monofilament sutures are made of the poly(p-dioxanone) polyester. The empirical formula of the polymer is C\(_4\)H\(_6\)O\(_3\) [5,7].

## Characteristics of Absorbable Materials

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Polydioxanone is a polymer made of recurring sets of ether and ester groups (Figure 3). The synthesis of polydioxanone requires heat and catalysis using zinc compounds. Polydioxanone sutures undergo biodegradation via hydrolysis, and the degradation metabolites are excreted mainly in urine [9].

Effective retention period is up to 90 days [5,7].

The retention profile, as expressed by approximate percentages of initial retention strength, is as follows:

- 70% – 14 days
- 50% – 28 days
- 25% – 42 days

Polydioxanone suture absorption rate is in the range of 180 to 210 days.

Polydioxanone sutures are used for bringing together soft tissues. The sutures may be used in gastrointestinal tract surgery (e.g. for intestinal anastomoses), pediatric cardiovascular surgery, microsurgery, and eye surgery.

**SUMMARY**

The currently available wide selection of sutures and surgical procedures that surgeons can take advantage is based on observations and hundreds of procedures performed worldwide over the centuries. The development of suturing techniques is closely related to the scientific progress. Until several decades ago, the most common suture material was catgut, known for centuries [4]. Today, it has been replaced by newer materials, such as genetically engineered sutures produced by recombinant E.coli strains (MIT Boston, USA, 2007) or sutures made by transgenic spiders [10]. Novel types of sutures are being developed. For instance, there are absorbable sutures made of magnesium alloys [11,12,13] that have not yet been introduced for wider use.

Choosing appropriate sutures is often based on the surgeon’s experience, preference, or economic aspects. The manufacturers provide information regarding the retention strengths of individual products; this parameter is often decisive for the choice of suture during surgical procedures. Appropriate suture choice for a particular procedure is of key importance for the success of that procedure. No studies that might help to optimize this choice have been conducted in recent years. There is a lack of studies on the dynamics of strength profiles in various environments. Elucidation of microstructures as well as Fourier-transformed infrared (FT-IR) spectra of the most common materials presented above, following exposure to different biological environments, might markedly contribute to optimization of suture choices. Novel materials are also important, such as absorbable zinc/magnesium sutures that may find use in surgery in the future. It seems very important to broaden the scope of research to include objective studies of these materials, particularly in in vitro settings.

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