Sutures

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dar žr. sąsiuvinius “topkė ir operacinė chirurgija”

SUTURE MATERIALS

"suture" - any strand of material used to ***ligate (tie) blood vessels*** or ***approximate (sew) tissues***.

no single suture material is used by every surgeon who practices within specialty.

Hypothetical ideal suture:

**All-purpose** **material** - could be used in any surgical procedure (only variables being size and tensile strength).

**Sterile**.

**Nonelectrolytic, noncapillary, nonallergenic, noncarcinogenic**.

**Nonferromagnetic** (titanium is better than steel).

**Easy to handle**.

**Minimally reactive** in tissue, **not predisposed to bacterial growth**.

**Holding securely when knotted** (no fraying or cutting).

**Resistant to shrinking** in tissues.

**Absorbed** with minimal tissue reaction after serving its purpose.

**1. Size & Tensile Strength**

accepted surgical practice is to use *smallest diameter suture that will adequately hold tissue* - minimizes trauma as suture is passed through tissue.

**suture size** is stated numerically (0 – is medium size; smallest size is 11-0; largest size is 6):

as number of 0's increases, strand diameter decreases; e.g. size 5-0, or 00000, is smaller in diameter than size 4-0, or 0000;

large sizes increase with integers (2 is larger than 1).

**knot tensile strength** - force, in pounds, which suture strand can withstand before it breaks when knotted.

accepted rule is that ***suture tensile strength*** need never exceed ***tissue tensile strength***; however, sutures should be at least as strong as normal tissue through which they are being placed; if tissue reduces suture strength over time, relative rates at which suture loses strength and wound gains strength are important.

**Metric measures and u.s.p. suture diameter equivalents**

 

**2. Monofilament vs. Multifilament**

##### Monofilament Sutures

*atsiriša + bijo instrumentų*

made of single strand.

encounter less resistance as they pass through tissue.

resist harboring organisms.

tie down easily, but require more throws when knotting.

suture crushing or crimping can nick or create weak spot in strand → suture breakage.

##### Multifilament (s. Braided) Sutures

*pjauna audinius + infection↑*

consist of several filaments twisted / braided together.

greater tensile strength (per size), pliability, flexibility.

can tear fragile tissues.

can harbor bacteria.

may be coated to help them pass relatively smoothly through tissue and enhance handling characteristics.

**3. Absorbable vs. Nonabsorbable**

##### Absorbable Sutures

*loss tensile strength in < 60 days*; hold wound edges in approximation temporarily, until they have healed sufficiently to withstand normal stress.

types of material:

**natural** absorbable sutures - prepared from collagen of healthy mammals.

**synthetic** absorbable sutures

absorption mechanisms differ:

*natural absorbable sutures* - **digested by body enzymes**.

*synthetic absorbable sutures* - **hydrolyzed** (water gradually penetrates suture filaments, causing breakdown of suture's polymer chain);

lesser degree of tissue reaction!!! (compared to enzymatic action of natural absorbables).

in ***fever, infection, protein deficiency*** suture absorption process↑ → too rapid decline in tensile strength!!!

absorption↑ if suture is placed in body cavity that is moist or filled with fluid.

if sutures become wet during handling, prior to being implanted in tissue, absorption process begins prematurely!

N.B. Do not soak absorbable sutures! Synthetic absorbable sutures must be kept dry.

absorption stages:

**first stage** (first several weeks) - tensile strength diminishes in gradual, almost linear fashion.

**second stage** - loss of suture mass.

strand is eventually completely dissolved, leaving no detectable traces in tissue.

fast absorbing sutures are used for mucosa.

##### Nonabsorbable Sutures

indications:

skin closure (can be easily removed).

temporary prosthesis attachment (i.e. defibrillators, pacemakers, drug delivery mechanisms).

prosthetic heart valves, vascular sutures

hernia repair

patient history of delayed healing (e.g. radiotherapy, steroid therapy).

patient history of reaction to absorbable sutures, keloidal tendency, tissue hypertrophy.

contraindications – biliary and urinary tracts.

absorbable suturing materials

|  |
| --- |
| **Surgical Gut: plain, chromic, fast absorbing** |
| COLOR | Yellowish-tan (plain) or Brown (chromic); Blue Dyed |
| TYPE | Monofilament |
| MATERIAL | Highly purified collagen (derived from healthy beef / sheep intestines);chromic gut is treated with chromium salt. Packaged in alcohol (must be kept wet); fast absorbing gut is heat-treated. |
| TENSILE STRENGTH RETENTION in vivo | Individual to patient (unpredictable rates of absorption):**plain gut** (> 1 sav) – 7÷10 days (absorption is complete within 70 days)**chromic gut** (2-3 sav) – 10÷21 days (absorption time over 90 days).**fast absorbing** (< 1 sav) – 5÷7 days. |
| ABSORPTION | Proteolytic enzymatic digestive process. |
| TISSUE REACTION | Moderate (plain > chromic) - suture antigenicity! |
| USES | General soft tissue approximation, ligation (incl. ophthalmic procedures).Not for cardiovascular and neurological tissues. Fast absorbing gut only for external sutures! |

the more pure collagen in strand, the less foreign material – the less inflammatory reaction..

don't store surgical gut near heat.

moisten (but never soak!) surgical gut.

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| COATED / uncoated **VICRYL** (POLYGLACTIN 910) |
| TYPES | Braided; Monofilament |
| COLOR | Violet; Undyed (Natural) |
| MATERIAL | Copolymer of lactide and glycolide (± coated with polyglactin 370 and calcium stearate). |
| TENSILE STRENGTH RETENTION in vivo | ≈ 65% remains at 14 days; ≈ 40% remains at 21 days (only 30% for sutures ≤ 7-0). |
| ABSORPTION | by slow hydrolysis (complete in 56-70 days). |
| TISSUE REACTION | Minimal. Dermal or conjunctival sutures remaining in place > 7 days may cause localized irritation (should be removed as indicated). |
| USES | General soft tissue approximation, ligation (incl. ophthalmic procedures).Not for cardiovascular and neurological tissues. |

**VICRYL RAPIDE** is fastest-absorbing synthetic suture (begins to "fall off" in 7-10 days as wound heals - need for suture removal is eliminated).

**Coated VICRYL *Plus* Antibacterial** contains IRGACARE MP (one of purest forms of broad-spectrum antibacterial agent *triclosan*).

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| **MONOCRYL** (POLIGLECAPRONE 25) |
| TYPES | Monofilament |
| COLOR | Undyed (Natural) |
| MATERIAL | Copolymer of glycolide and ε-caprolactone. |
| TENSILE STRENGTH RETENTION in vivo | high initial tensile strength diminishing over 2 weeks: ≈ 50-60% remains at 7 days; ≈ 20-30% remains at 14 days; lost within 3-4 weeks. |
| ABSORPTION | by hydrolysis (complete at 91-119 days). |
| TISSUE REACTION | Slight (virtually inert in tissue) |
| USES | General soft tissue approximation, ligation. Not for cardiovascular, neurological, ophthalmic, microsurgical procedures. |

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| **PDS II** (POLYDIOXANONE) |
| TYPE | Monofilament |
| COLOR | Violet; Blue; Clear |
| MATERIAL | Polyester polymer (p-dioxanone) |
| TENSILE STRENGTH RETENTION in vivo | twice as long as other synthetic absorbable sutures: ≈ 70% remains at 14 days; ≈ 50% - at 28 days; ≈ 25% - at 6 weeks. |
| ABSORPTION | by slow hydrolysis: minimal until ≈ 90th day; complete within 6 months. |
| TISSUE REACTION | Slight |
| USES | All types of soft tissue approximation (not for vascular prostheses and artificial heart valves). |

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| (Polyglyconate) |
| TYPE |  |
| COLOR |  |
| MATERIAL | Copolymer of glycolide and trimethylene carbonate. |
| TENSILE STRENGTH RETENTION in vivo |  |
| ABSORPTION |  |
| TISSUE REACTION |  |
| USES |  |

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| --- |
| (Polyglycolic Acid) |
| TYPE |  |
| COLOR |  |
| MATERIAL | Homopolymer of glycolide |
| TENSILE STRENGTH RETENTION in vivo |  |
| ABSORPTION |  |
| TISSUE REACTION |  |
| USES |  |

nonabsorbable suturing materials

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| **PERMA-HAND** SILK |
| TYPES | Braided |
| COLOR | Black; White |
| MATERIAL | Organic protein (fibroin). |
| TENSILE STRENGTH RETENTION in vivo | Progressive fiber degradation may result in gradual loss of tensile strength (loses most tensile strength in ≈ 1 year; cannot be detected after 2 years). |
| ABSORPTION | Gradual encapsulation by fibrous connective tissue. |
| TISSUE REACTION | Acute inflammatory reaction |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

Surgical Silk - standard of performance (best handling suture material) by which newer synthetic materials are judged!

loses 20% tensile strength when exposed to moisture - should be used dry!

N.B. keep silk dry!

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| **SURGICAL STAINLESS STEEL** |
| TYPES | Monofilament; Multifilament |
| COLOR | Silver metallic |
| MATERIAL | 316L stainless steel (low carbon, iron-chromium-nickel-molybdenumalloy) - compatibility with stainless steel implants and prostheses. |
| TENSILE STRENGTH RETENTION in vivo | Indefinite. |
| ABSORPTION | Nonabsorbable. |
| TISSUE REACTION | Minimal acute inflammatory reaction. |
| USES | Abdominal wound closure, hernia repair, sternal closure, orthopaedic procedures. |
| disadvantage | difficulty in handling (cutting, pulling, tearing of patient's tissue; fragmentation; barbing; kinking; easily tear surgical gloves). |
| contraindication | Prosthesis of another alloy (unfavorable electrolytic reaction may occur). |

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| don't bend stainless steel wire!most suture materials have some inherent degree of elasticity (will "give" to accommodate postoperative swelling); stainless steel, if tied too tightly, will cut like knife as tissue swells or as tension is placed upon suture line!many surgeons refer to wire size by **Brown & Sharpe (B & S) gauge** of 40 (smallest diameter) to 18 (largest diameter); ETHICON labels surgical stainless steel with both B & S and U.S.P. diameter size classifications. |  |

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| **ETHILON** NYLON  |
| TYPES | Monofilament, braided |
| COLOR | Black; Undyed (Clear) |
| MATERIAL | Long-chain aliphatic polymers nylon 6 or nylon 6,6. |
| TENSILE STRENGTH RETENTION in vivo | Gradual loss (progressive hydrolysis) ≈ 15-20% per year |
| ABSORPTION | Gradual encapsulation by fibrous connective tissue. |
| TISSUE REACTION | Extremely low tissue reactivity (minimal acute inflammatory reaction) |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

monofilament nylon sutures have tendency to return to original straight state ("**memory**") - more throws in knot are required to securely hold monofilament nylon sutures.

H: draw nylon a few times between gloved fingers to remove packaging "memory".

***wet monofilament nylon*** is more pliable and easier to handle than dry nylon (ETHILON sutures are pre-moistened or "pliabilized" for use in cosmetic plastic surgery).

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| **NUROLON** NYLON |
| TYPES | Braided |
| COLOR | Black; Green; Undyed (Clear) |
| MATERIAL | Long-chain aliphatic polymers nylon 6 or nylon 6,6. |
| TENSILE STRENGTH RETENTION in vivo | Gradual loss (progressive hydrolysis) ≈ 15-20% per year. |
| ABSORPTION | Gradual encapsulation by fibrous connective tissue. |
| TISSUE REACTION | Minimal acute inflammatory reaction |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

looks, feels, and handles like silk; however, NUROLON has more strength and less tissue reaction than silk.

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| **MERSILENE** POLYESTER FIBER |
| TYPES | Braided |
| COLOR | Green; White |
| MATERIAL | Polyester (polyethylene terephthalate). |
| TENSILE STRENGTH RETENTION in vivo | No significant change - last indefinitely in the body! |
| ABSORPTION | Gradual encapsulation by fibrous connective tissue. |
| TISSUE REACTION | Minimal acute inflammatory reaction. |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

first synthetic braided suture shown to ***last indefinitely in body***!

do not weaken when wetted prior to use!

among the most acceptable for vascular synthetic prostheses.

uncoated - higher friction when passed through tissue.

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| **ETHIBOND** EXTRA POLYESTER FIBER |
| TYPES | Braided |
| COLOR | Green; White |
| MATERIAL | Polyester (polyethylene terephthalate) coated with polybutilate (lubricant), i.e. coated MERSILENE |
| TENSILE STRENGTH RETENTION in vivo | No significant change - last indefinitely in the body! |
| ABSORPTION | Gradual encapsulation by fibrous connective tissue. |
| TISSUE REACTION | Minimal acute inflammatory reaction |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

used primarily in *cardiovascular surgery* (incl. placement of prosthetic materials).

ETHIBOND sutures are also available attached to TEFLON or polyester felt ***pledgets*** (serve as "buttress" beneath sutures to prevent tearing of friable tissue) - used routinely in valve surgery.

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| **PROLENE** POLYPROPYLENE |
| TYPES | Monofilament |
| COLOR | Clear; Blue |
| MATERIAL | Isostatic crystalline stereoisomer of polypropylene. |
| TENSILE STRENGTH RETENTION in vivo | Not subject to degradation by tissue enzymes. |
| ABSORPTION | Nonabsorbable. |
| TISSUE REACTION | Extremely inert in tissue (minimal acute inflammatory reaction) |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

unaffected by moisture.

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| **PRONOVA** Poly(hexafluoropropylene-VDF) |
| TYPE | Monofilament |
| COLOR | Blue |
| MATERIAL | Polymer blend of poly(vinylidene fluoride) and poly(vinylidene fluoride-cohexafluoropropylene) |
| TENSILE STRENGTH RETENTION in vivo | Not subject to degradation by tissue enzymes. |
| ABSORPTION | Nonabsorbable. |
| TISSUE REACTION | Extremely inert in tissue (minimal acute inflammatory reaction) |
| USES | General soft tissue approximation, ligation (incl. cardiovascular, ophthalmic, neurological procedures). |

COMMON SUTURING TECHNIQUES

žr. sąs. TOPKĖ 164-168 psl.!

Ligatures

***Ligature (s. tie)*** - suture tied around vessel to occlude lumen:

to effect hemostasis

to prevent leakage.

Two primary types of ligatures:

**Free tie** or **freehand ligature**

**Stick tie, suture ligature,** or **transfixion suture** - suture is attached to needle which is used to anchor strand before occluding deep or large vessel.

Primary Suture Line

- holds wound edges in approximation during healing by first intention.

**Continuous (s. Running) Sutures**

**advantages**:

can be placed rapidly.

tension is distributed evenly.

better water-tightness.

less foreign body mass in wound (than interrupted sutures).

**disadvantages**:

risk of tissue strangulation (!)

instrument damage could disrupt entire line of continuous suture.

can transmit infection along entire length of strand.

**Interrupted Sutures** - use number of strands & knots (more time-consuming).

**advantages**:

more secure closure (if one suture breaks, remaining sutures will hold wound).

better vascular supply.

preferred (esp. monofilaments) in infected wounds, because microorganisms may be less likely to travel along series of interrupted stitches.

**Types** of interrupted and continuous sutures:

*simple sutures* (“over and over”).

*complex sutures* - vertical mattress, horizontal mattress, running locked suture.

**Buried Sutures** are placed completely under epidermal skin layer and knot is “buried” in subcutis (not removed postoperatively).

**Purse-string Sutures** are continuous sutures placed around lumen and tightened like drawstring to invert opening; examples:

appendix stump

bowel (to secure intestinal stapling device)

organ prior to tube insertion (e.g. aorta - to hold cannulation tube in place).

**Subcuticular (s. Intradermal) Sutures** - continuous horizontal mattress sutures placed in subcutaneous tissue parallel to wound.

**advantages**:

leaves no “suture marks”.

no need to remove suture (if absorbable material is used) – esp. important in pediatric cases.

used only in ***clean*** wounds.

Secondary Suture Line

eliminate ***dead space***, and prevent ***fluid accumulation*** in wound.

support wounds for healing by ***second intention***.

N.B. if secondary sutures are used in cases of *non-healing*, they should be placed in ***opposite fashion*** from primary sutures (i.e. interrupted if primary sutures were continuous, continuous if primary sutures were interrupted)!

reinforce and support ***primary suture line*** (called **retention sutures**) in abdomen - placed 2 inches from each wound edge - tension exerted lateral to primary suture line contributes to tensile strength of wound.

**nonabsorbable** suture material of *heavy sizes* (0 to 5) - not for strength, but because larger sizes are less likely to cut through tissue when sudden rise in intra-abdominal pressure occurs (from vomiting, coughing, straining, or distention).

use material with **needles swaged on each end** (double-armed) - placed from wound inside toward outside skin (to avoid pulling potentially contaminated epithelial cells through entire abdominal wall).

to prevent suture material from cutting, one end of retention suture may be threaded through short length of **plastic / rubber tubing**.

should be ***removed*** as soon as danger of sudden increases in intra-abdominal pressure is over (usually 2-6 weeks, but patient's condition is most important controlling factor).

dar žr. sąs. TOPKĖ 288, 473 psl.!

N.B. retention sutures provide strong reinforcement, but also cause more postoperative pain than does layered closure!

Stitch Placement

equal tissue "bites" should be taken on each side of wound.

needle should be inserted 1-3 centimeters from wound edge.

*distance from suture to suture* should be approximately equal to *distance from wound edge to suture*.

most tissues heal when edges are held in **apposition**; in some instances, tissues should be either **inverted** (e.g. gastrointestinal anastomosis) or **everted** (e.g. vascular anastomosis).

Continuous suture Interrupted sutures žr. sąs. TOPKĖ 164-168 psl.!

**To invert tissue**

Lembert Lembert

Cushing Halsted

Connell Purse-string

**To evert tissue**

Horizontal mattress Horizontal mattress

Knots

Knot types:

**Standard (s. square) knot** – overhand throw, then underhand throw.

N.B. it is strongest knot!!!

*braided* sutures need 3-4 throws, *monofilament* sutures – 6-8 throws.

additional throws are necessary in:

thicker suture materials

continuous sutures

coated braided sutures

**Surgeon’s knot** (double-overhand throw → standard knot)

indicated when there is ***tension on suture***.

**Granny knot** - overhand throw-overhand throw (creates slip knot which can be cinched down to appropriate tightness) → standard knots.

when tying knot allow space for *postoperative edema*.

avoid *instrument damage* to suture material during instrument ties (monofilaments are especially sensitive!); except when grasping free suture end during instrument tie.

approximate - ***do not strangulate***!

**knot is weakest part of suture** - siūlas paprastai nutrūksta ties mazgu!

do not hesitate to *change stance or position* in relation to patient in order to place knot securely and flat.

***extra throws*** do not add strength to properly tied knot, only to its bulk!

*seesaw motion* (one strand saws down over other until knot is formed) may weaken suture material → may break when next throw is made, or worse, in postoperative period;

if two suture ends are pulled in opposite directions with uniform rate and tension, knot will be tied more securely!

N.B. same knot tied in *two-handed fashion* has significantly more strength than one tied *one-handedly*!

Knotting Monofilament Sutures

relatively **low coefficient of friction**

N.B. more friction results in more secure knot!

monofilament ***nylon*** suture is the most likely to slip!

PROLENE exhibits small degree of plasticity - if it is tied carefully, flattening occurs where strands cross which helps to lock polypropylene knots.

another drawback is **memory** (tendency not to lay flat, but to return to given shape set by material's extrusion process or suture's packaging).

Knotting Multifilament Sutures

used when knot security is critical - high coefficient of friction (knots do not tend to slip)!

easier to handle than monofilament sutures.

Cutting Suture Ends

make sure both *tips of scissors* are visible to avoid inadvertently cutting tissue.

to ensure that actual knot is not cut, *twist or angle scissor blades* prior to cutting.

ends of ***surgical gut*** are left relatively long (≈ 6 mm)\*, ***other materials*** are cut closer to knot (≈ 3 mm) - to decrease tissue reaction.

\*sudrėkusio ketguto mazgo patikimumas krenta drastiškai (vs. kitų siūlų)

Suture Removal

N.B. sutures should be removed "...before epithelium has migrated into deeper parts of dermis; to prevent scar widening, wound edges may be taped...."

N.B. key to success is ***early suture removal*** before epithelialization of suture track occurs and before contamination is converted into infection.

aseptic technique.

cleanse area with **antiseptic** (*hydrogen peroxide* can be used to remove dried serum encrusted around sutures).

pick up one suture end with thumb forceps, and **cut** as close to skin as possible where suture enters skin.

gently **pull** suture strand out through side opposite knot with forceps.

N.B. to *prevent infection*, suture should be removed without pulling any portion that has been outside skin back through skin.

**Plastic Surgery Guidelines for Sutures & Day of Removal by Body Area:**

| **Body Region** | **Percutaneous** | **Deep (Dermal)** | **Days\*** |
| --- | --- | --- | --- |
| Scalp | 4-0/5-0 Monofilament | 3-0/4-0 Polyglecaprone, polydioxanone | 6-8 |
| Ear | 6-0 Monofilament | -- | 10-14 |
| Eyelid | 6-0/7-0 Monofilament | -- | 3-4 |
| Nose, Eyebrow | 5-0/6-0 Monofilament | 5-0 Polyglecaprone, polydioxanone | 3-5 |
| Lip, Others face parts | 6-0/7-0 Monofilament | 5-0 Polyglecaprone, polydioxanone | 3-4 |
| Oral mucosa | 5-0 Absorbable | -- | -- |
| Chest / abdomen | 4-0/5-0 Monofilament | 3-0 Polyglecaprone, polydioxanone | 8-10 |
| Back, Extremities | 4-0/5-0 Monofilament | 4-0 Polyglecaprone, polydioxanone | 12-14 |
| Hand | 5-0 Monofilament | 5-0 Polyglecaprone, polydioxanone | 10-14 |
| Over joints | 4-0/5-0 Monofilament | 4-0 Polyglecaprone, polydioxanone | 14 |
| Foot / sole | 3-0/4-0 Monofilament | 4-0 Polyglecaprone, polydioxanone | 12-14 |
| Penis | 5-0/6-0 Monofilament | -- | 8-10 |
| Retention sutures |  |  | 2-6 weeks |

\*sutures may be removed *earlier* if wound can be reinforced with Steri Strips;

sutures should be held *longer* in cases of delayed wound healing.

General rule - **regain of preinjury (100%) tissue strength**:

 at 20 days – 20%

 at 40 days – 40%

 at 90 days – 60%

 at 1 year – 70%.

wound will never regain 100% tensile strength

Suture Selection By Procedure

Suture selection tips:

**When wound reaches maximal strength, sutures are no longer needed**:

slow-healing tissues (skin, fascia, tendons) → nonabsorbable or long-lasting absorbable suture.

fast-healing tissues (stomach, colon, bladder) → absorbable sutures.

**Foreign bodies may convert contamination into infection** – in contaminated wounds use monofilament or absorbable sutures.

**If cosmetic results are important**:

*prolonged apposition* of tissues + *avoidance of irritants* will produce best results.

use smallest inert monofilament suture (nylon, polypropylene).

avoid skin sutures alone; close subcuticularly whenever possible.

use ***sterile skin closure strips*** to secure close skin edges apposition.

**Foreign bodies in presence of high crystalloid concentrations may cause stone precipitation** - use absorbable sutures in urinary & biliary tracts.

**Suture size**:

use *finest size* suture commensurate with natural tissue strength.

use *retention sutures* to reinforce primary sutures.

Gastrointestinal Tract

anastomosis leakage is principle problem!

sutures should *not be tied too tightly* (esp. stomach and intestine – have rich blood supply and may become edematous and hardened).

suture is placed through submucosa, into muscularis and through serosa.

N.B. **submucosa** provides strength in gastrointestinal tract! do not penetrate **mucosa**!

*continuous* suture provides tighter seal (but if continuous suture breaks, entire line may separate!).

many surgeons prefer ***double layer*** closure (second layer of interrupted sutures through serosa).

Stomach heals surprisingly quickly (has peak rate of collagen synthesis at 5 days, attains maximum strength within 14-21 days).

absorbable sutures are usually acceptable (VICRYL > PROLENE).

Small intestine heals very rapidly (maximal strength in ≈ 14 days).

when using ***inverted*** closure, minimize tissue cuff which protrudes into small sized intestinal lumen (to avoid obstruction).

*absorbable* sutures are preferred (will not permanently limit lumen diameter); *nonabsorbable* suture may be used in serosal layer for added assurance.

Colon heals at rate similar to that of stomach and small intestine.

sigmoid is ≈ twice as strong as cecum - but both sections heal at the same rate!

both absorbable and nonabsorbable sutures may be used (absorbable sutures - once absorbed, leave no channel for microbial migration!).

high rate of collagen synthesis is maintained for prolonged period (over 120 days).

Rectum heals **very slowly**!

large bite of muscle should be included in anastomosis.

sutures should be tied carefully - to avoid cutting through tissues.

*monofilament* sutures reduce bacterial proliferation.

Biliary Tract heals rapidly.

foreign body may precipitate **formation of “stones”** – use *finest monofilament absorbable* suture.

Parenchymatous Organs (spleen, liver, kidney) - lacerations heal rapidly.

severed large vessels must be ligated before attempting to close defect.

composed chiefly of cells with *little connective tissue* for support – try to coapt outer **fibrous capsule** of torn tissue.

little tension is placed on suture line and only small size sutures need to be used.

if tissue cannot be approximated, ***tack omentum piece*** over defect.

Closing Abdomen

***Closure technique*** may be more important than type of ***suture material***!

**Repair any mesentery defects** (to prevent possible hernia) - running or interrupted technique (VICRYL or surgical gut).

Consider **retention sutures**! – žr. aukščiau!!!

Peritoneum heals quickly.

*continuous* *absorbable* suture is usually preferred.

some believe that peritoneum does not require suturing, while others disagree.

Fascia (main supportive structure).

regains 40% of its original strength in 2 months (may take ≥ 1 year to regain maximum strength).

N.B. ***full original strength is never regained***!

moderate size **nonabsorbable** suture may be used;

**absorbable suture with longer lasting tensile strength** (e.g. PDS II) may also provide adequate support.

N.B. PDS II is especially well-suited for younger, healthy patients.

occasionally, **synthetic graft** (with nonabsorbable sutures) may be used when fascia is absent or weak.

use interrupted technique.

in absence of infection / gross contamination, may choose either monofilament or multifilament;

in presence of infection, ***monofilament*** *absorbable* (PDS II) or *inert nonabsorbable* (stainless steel or PROLENE) sutures may be used.

N.B. both stainless steel and PROLENE sutures may be *detectable under skin* of thin patients.

H: knots should be buried in fascia instead of in subcutaneous space.

anatomic location & type of incision will influence how many layers of fascia will be sutured:

**posterior fascial layer** is always closed.

**anterior fascial layer** may also require suturing.

Muscle does not tolerate suturing well; abdominal muscles may be:

**cut** – muscle needs to be sutured.

**split** or **retracted** (toward its nerve supply) – preferable (avoids interfering with blood and nerve supply) - muscle does not need to be sutured (fascia is sutured).

Mass closure techniques are becoming most popular.

**Smead-Jones far-and-near technique** (strong and rapid) - interrupted single layer closure through both layers of abdominal wall fascia, abdominal muscles, peritoneum, and anterior fascial layer;

sutures resemble "figure of eight" when placed.

absorbable PDS II or VICRYL sutures are used.

Subcutaneous fat does not tolerate suturing well.

Some surgeons question placing sutures - ***little tensile strength***.

Others believe it is necessary ***to prevent dead space*** (esp. in obese patients) – use absorbable sutures (esp. VICRYL).

Subcuticular tissue - continuous short lateral stitches beneath epithelial layer (to minimize scar evidence later); either absorbable or nonabsorbable sutures may be used.

sutures must not be placed too close to epidermal surface to reduce extrusion.

after this layer is closed, skin edges may be approximated with **skin closure tapes** in addition to subcuticular sutures (to give best results).

Skin

very tough - *very sharp needle* is essential to minimize tissue trauma.

continuous or **interrupted** (preferred – to reduce cross-contamination across entire suture line).

**monofilament nonabsorbable** suture.

N.B. surgical gut produces tremendous tissue reaction; however, *fast absorbing surgical gut* tends to be less reactive due to its accelerated absorption profile.

skin edges should be *everted*.

skin regains tensile strength slowly! However, surgeons remove sutures in 3-10 days (wound regained only ≈ 5-10% of its strength!) - because most of stress is absorbed by fascia.

basal epithelial cells move down suture track; when suture is removed, epithelial cells track remains; eventually, it may disappear, but some may remain and form keratin.

punctate scar (seen as "railroad track" or "crosshatch" appearance) is rare if skin sutures are not placed with excessive tension and are removed by 7th postoperative day.

Sutures for drains

**A. Organ** drainage:

drain is secured to ***wall of organ*** being drained with absorbable sutures.

minimize distance between organ and abdominal wall - sutures to tack organ being drained to ***peritoneum and fascia***.

in ***skin*** - either two sutures at 12 and 6 o'clock positions, or four sutures at 12, 3, 6, and 9 o'clock positions - secured with temporary loops;

when drain is no longer needed, skin sutures may be easily removed to remove drain; opening can be left open (to permit additional drainage until it closes naturally).

**B. Peritoneal cavity** drainage (through stab wound) – tube is anchored to skin with 1-2 nonabsorbable sutures.

Ophthalmic surgery

good blood supply; but cornea is avascular!

cornea epithelialization occurs rapidly, but full thickness cornea wounds heal slowly (sutures should remain for 21 days).

muscle recession (suturing muscle to sclera) only requires sutures for 7 days (if longer may produce granulomas to sclera).

suture material:

**silk** was preferred, but may irritate cornea (necessitating premature suture removal).

fine **absorbable** sutures are currently used (VICRYL!).

Upper alimentary tract procedures (down to cardiac sphincter) - potentially contaminated area.

**oral cavity & pharynx** (heal quickly) - fine size absorbable sutures; in buccal mucosa surgeons may prefer monofilament nonabsorbable suture (less severe tissue reaction).

**esophagus** (avoid mucosa penetration).

Respiratory tract surgery

N.B. bronchial stump heals slowly, and sometimes not at all!

usually achieved with mechanical devices.

avoid absorbable sutures - may permit secondary leakage as they lose strength; avoid monofilament nylon suture - potential for knot loosening.

Cardiovascular surgery - lasting strength and leak-proof anastomoses are essential!

most surgeons prefer **synthetic nonabsorbable** sutures.

**steel** **wire** sutures are used on sternum (unless it is fragile, osteoporotic → very heavy VICIRYL sutures).

Vessel anastomoses - *excessive tissue reaction* may lead to decreased lumen or thrombus formation.

inert **synthetics** (nylon, polyester, polypropylene) are materials of choice.

**continuous** sutures provide leak-proof closure in large vessel anastomoses; interrupted monofilament sutures are used for microvascular anastomoses.

Urinary tract surgery ≈ biliary tract.

transitional cell epithelium migrates over denuded surfaces quickly.

regain wound strength rapidly and are essentially healed by 21 days.

Bladder wall regains 100% of its original tensile strength within 14 days!!!

closure must be leak-proof.

**absorbable** sutures as rule! (nonabsorbable sutures incite formation of calculi) - MONOCRYL, PDS II, coated VICRYL, chromic gut.

Female genital tract (potentially contaminated area + work within very restricted field).

Tendon surgery

tendons heal slowly! (fibroblasts immigrate from peritendinous tissue) → **scar** tissue → replacement with **new tendon fibers**.

*striated tissue nature* makes suturing difficult.

close apposition must be maintained to achieve good functional results (esp. in extensors!).

suture material - inert & strong.

tendon ends can separate due to muscle pull! - sutures with great degree of elasticity should be avoided; suitable suture material:

surgical steel

polyester

polypropylene

nylon.

suture should cause least possible interference with:

tendon surface (gliding mechanism).

blood supply.

|  |  |
| --- | --- |
| prevent suture slippage – use **figure-of-eight** and other types of suturing.many surgeons use **Bunnell Technique, s. pull-out suture** (suture is brought out through skin and fastened over polypropylene button → suture is withdrawn when its function is no longer necessary).in *periosteum* (heals fairly rapidly!) virtually any suture may be used satisfactorily. |  |

Alternatives to sutures

Surgical Staples

fast.

least inflammatory reaction.

skin edge adaptation is more difficult – scar may be more visible!

especially useful in scalp wounds.

contraindicated – on face.

Sterile Adhesive Skin Tapes (“Steri Strips”)

lowest infection rates!

use in areas with *very little skin tension*.

skin must be dry, not hairy, not oily.

prepare skin with **benzoin tincture** (avoid on wound – toxic to tissues!).

Topical skin adhesives

- indicated on ***low tension wounds*** (skin edges lie close together without significant tension).

**Butylcyanoacrylate** – forms opaque and brittle bond.

**2-octyl cyanoacrylate** (DERMABOND, FDA approved in 1998) - forms transparent & flexible bond!

in ≤ 3 minutes, DERMABOND provides strength of healed tissue at 7 days.

can be used in conjunction with, but not in place of, deep dermal sutures.

patient can shower right away without fear of compromising incision.

as wound heals, DERMABOND will gradually slough off (generally in 5-10 days).

contraindications:

any evidence of active infection or gangrene.

mucosal surfaces or across mucocutaneous junctions (e.g. lips, oral cavity).

skin that is regularly exposed to body fluids

skin with dense hair (e.g. scalp).

wounds subject to significant static or dynamic tensions (unless deep sutures, immobilization, or both are also used).

application:

wound edges must be tightly apposed (with gloved fingers or forceps) so that ***adhesive is not placed into wound***.

position patient so that wound surface is parallel to floor, taking special care that any runoff does not flow in direction of vital structures such as eye.

apply 3 thin layers of adhesive, waiting ≈ 30 seconds between layers.

maintain manual approximation of wound edges for ≈ 60 sec after final layer.

full apposition strength is expected to be achieved in 2.5 minutes after final layer is applied (top layer may remain tacky for ≈ 5 minutes).

apply dry bandage.

*Panaudota literatūra*:

Sabiston Textbook of Surgery 2001, ETHICON educational material, NMS Surgery, Emergency Medicine