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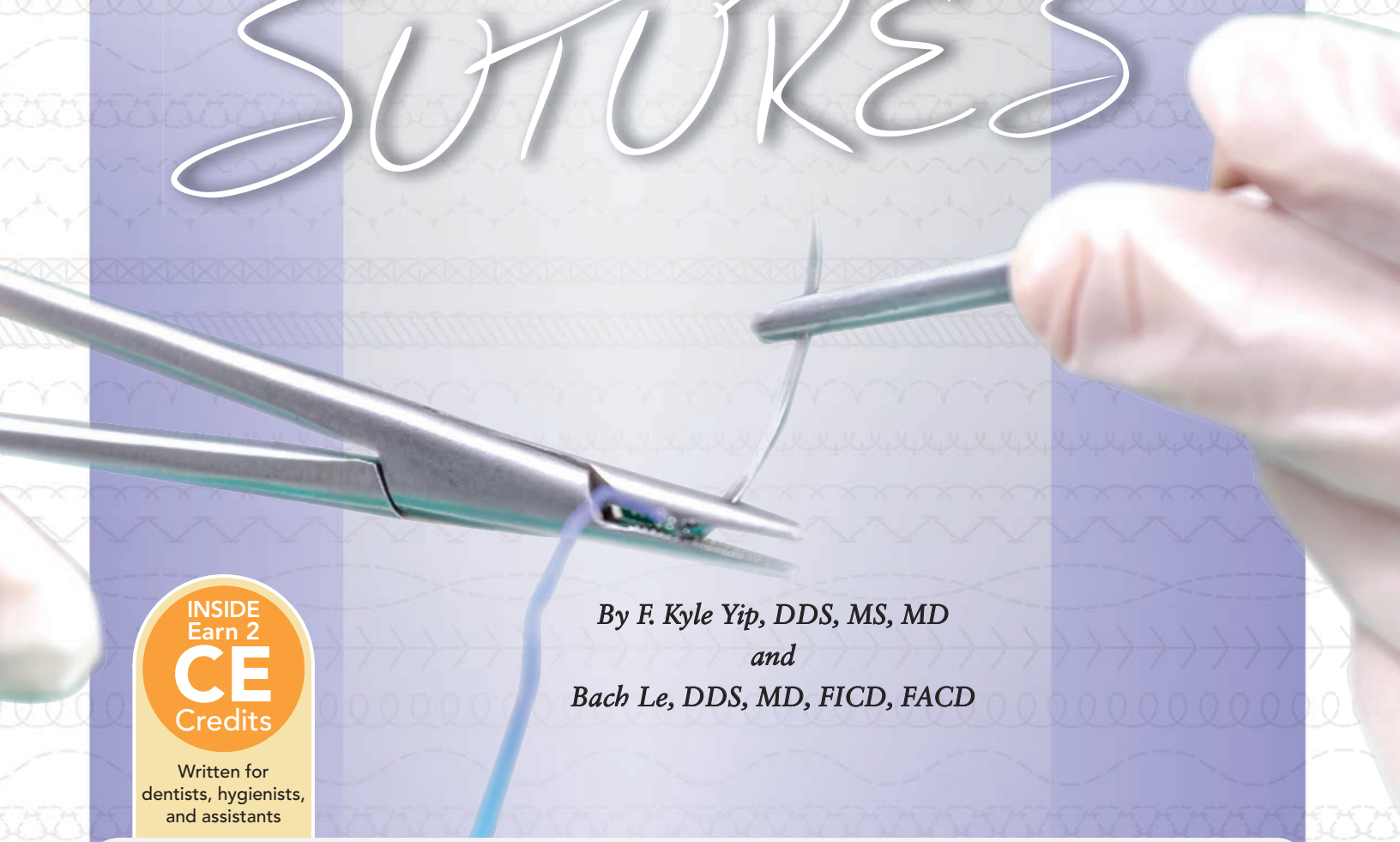
Knowledge for Clinical Practice

A Guide to SUTURES



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and

Bach Le, DDS, MD, FICD, FACD

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Foreword

With more than 19 years of experience in dental implant practice and postgraduate education, I view this suture manual as the ideal guideline for both the recent graduate and the experienced general clinician. This thoughtful suture guideline provides an intelligent, articulate, and clear explanation of specific suture techniques, while also addressing the clinical concerns of the general clinician who is now required to maintain pace with quickly moving trends in general dentistry, as well as proficiently perform periodontal, oral maxillofacial, or implant surgical procedures.

As dentistry continues to evolve and redefine boundaries of dental specialties, a comprehensive perspective is needed to showcase the various procedures associated with dental suturing. Presented here are the required instrumentation, available biomaterials, and appropriate protocols of suturing to perform efficient closure techniques.

Based on decades of in-depth clinical research, the authors of this piece have clearly identified the advantages and disadvantages of each material required for suturing. Specific clinical situations, such as tissue or bone regeneration or implant placement, are identified, while emphasizing the most effective aspects of each material and technique associated with corresponding surgical procedures to achieve the best surgical practices for a maximum surgical outcome.

This suture manual will serve as an everyday consulting suture guideline for any clinician, expanding their surgical closure techniques know-how as they keep this guideline close at hand. Indeed, this is a perfect reference guide to review ideal suturing and closure protocols for the most comprehensive surgical step-by-step suturing guidelines for today's modern clinician.

Every clinician, regardless of his or her dental practice or specialty, education or origin of degree, has the power to make a difference. To be successful for the greater good of their patients' well-being, to become a natural force for good, all that is required is the will to engage with anything and everything you can bring to the table to better serve our patients.

So consequently, we must.

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ABSTRACT

"Suturing" is a fundamental skill in dentistry but can be a very daunting and confusing topic for many dental providers. Gut suture or polytetrafluoroethylene (PTFE)? Square knot or surgeon's knot? Simple interrupted or mattress suture? The abundance of available techniques, materials, and clinical applications can be overwhelming. Fortunately, the vast majority of clinical scenarios can be addressed by understanding basic technique and fundamental concepts. This guide will review wound healing, suture types and materials, and basic and advanced techniques to equip the dental provider with a foundation in wound closure and management.

EDUCATIONAL OBJECTIVES

After completing this article, the reader should be able to:

1. Gain a fundamental understanding of tissue repair and the role of suturing
2. Recognize the various types of suture materials and needles
3. Learn fundamental suture techniques and ergonomics
4. Determine alternative suture techniques and their indications.

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Introduction

The evolution of suturing materials presents the dental practitioner with refinements designed for specific surgical procedures. Such innovations not only facilitate the clinician during closure but also decrease potential postoperative complications to the patient.

The use of thread and needle to repair wounds dates back millennia, with the earliest reports circa 3,000 BC in ancient Egypt. The practice likely dates back much further, as archeological evidence found ligatures in the place of repaired wounds and the presence of eyed needles as far back as 30,000 BC. Modern descriptions of suturing were first made by the physician Sumatra in India circa 500 BC, followed by Hippocrates circa 350 BC. Through the following centuries, a wide variety of materials – silk, linen, cotton, horsehair, animal tendons and intestines, and wire from precious metals – have been applied in operative procedures.

Since that time, techniques and materials have evolved, but most fundamental principles remain unchanged. Nevertheless, proper "suturing" and its application in surgery remain a nebulous and discomforting notion for many dental practitioners.

The primary goal of suturing in dentistry is to manipulate, position, adapt, and stabilize tissues in order to optimize wound healing and minimize complications. Improper technique results in tissue instability that may result in wound dehiscence at wound edges or separation of tissue from the underlying bone. This may lead to complications such as unnecessary scarring, tissue or bone loss, or graft failure.

This text aims to provide the dental practitioner a practical guideline for "suturing," and help lift the mystery clouding everyday clinical scenarios.

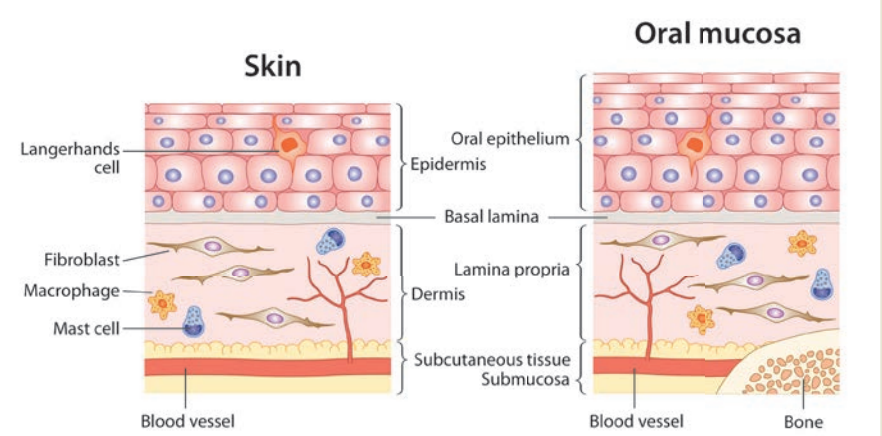


Figure 1. Comparison figure highlighting parallels between skin and oral mucosa

Tissues

An understanding of the tissues being repaired or manipulated is fundamental. In comparison to skin, oral mucosa is known to heal more quickly and with less scarring.[1] On the other hand, mucosa may also exhibit weaker handling characteristics in terms of tensile and pull-through strength. The oral cavity also presents a unique environment compared to skin, with the constant presence of saliva, microbiologic exposure, and constant movement, all providing unique challenges to sutures and wound healing.[2]

Mucosa

The moist mucosal lining of the oral cavity is called the **oral mucosa.** It has three main functions: protection, sensation, and secretion. Oral mucosa is similar to and continuous with skin but carries distinct properties due to the unique functions of the oral cavity.

Like skin, the oral mucosa comprises two main layers: the surface is **oral epithelium** (stratified squamous) and the underlying connective tissue is termed **lamina propria.** These layers are analogous to the epidermis and dermis of the skin (Figure 1).[3] The deeper layers of connective tissue are called **submucosa**, which is comprised

of adipose tissue and salivary glands. In areas where the submucosa is absent, mucosa is in direct apposition with the periosteum of the underlying bone and is referred to in total as mucoperiosteum (masticatory mucosa).

Oral mucosa may be comprised of keratinized or nonkeratinized squamous epithelium. Keratinized mucosa is typically stippled in appearance and is found on the hard palate, gingiva, and dorsal tongue. Nonkeratinized mucosa, on the other hand, is thinner, smoother, and less resilient. Nonkeratinized mucosa is found on the buccal mucosa, vestibule, soft palate, and floor of the mouth.

Keratinized mucosa is significantly more resilient to tearing in comparison to nonkeratinized mucosa. A suture thread is held securely within keratinized mucosa and can withstand a greater degree of tension without pulling through than nonkeratinized mucosa. Notably, keratinized mucosa tends to exhibit almost no scarring during repair and regeneration. An exception can be found when the underlying bone is unhealthy or inadequate, such as with the significant scarring found after cleft palate repair.[4]

Nonkeratinized mucosa, on the other hand, such as with buccal mucosa, is significantly more delicate and prone to tearing. Unlike keratinized mucosa, nonkeratinized mucosa does exhibit scarring, although generally milder than skin.[1]

Wound Healing

Normal Course

Wound healing in humans occurs by two processes: **regeneration** and **repair.** Very few tissues in the human body heal by regeneration, which results in minimal to no scar formation. These tissues include the liver and skeletal muscle, as well as fetal skin wound healing. Instead, most wounds heal by repair and scar formation, which results in bridging of wounded tissue by a collagen-abundant extracellular matrix that is somewhat disorganized. Scars demonstrate several shortcomings compared to normal tissue, including decreased tensile strength, decreased elasticity, and abnormal color match (Figure 2).

Three overlapping phases generally describe the wound healing process, as described here.

Coagulation – Inflammatory Phase

Wound healing begins with hemostasis and activation of the coagulation cascade. A matrix of fibrin, fibronectin, and platelets bridge the wound gap, and signaling factors such as cytokines are released to recruit a cellular inflammatory response. The inflammatory phase is characterized by neutrophil invasion followed by macrophages which populate the wound and peak at three days, with the phase lasting approximately 14 days.

Proliferative Phase

The proliferative phase starts with the formation of granulation tissue in the wound bed and is primarily achieved by angiogenesis and fibroblast influx. These processes begin 48 to 72 hours after injury.

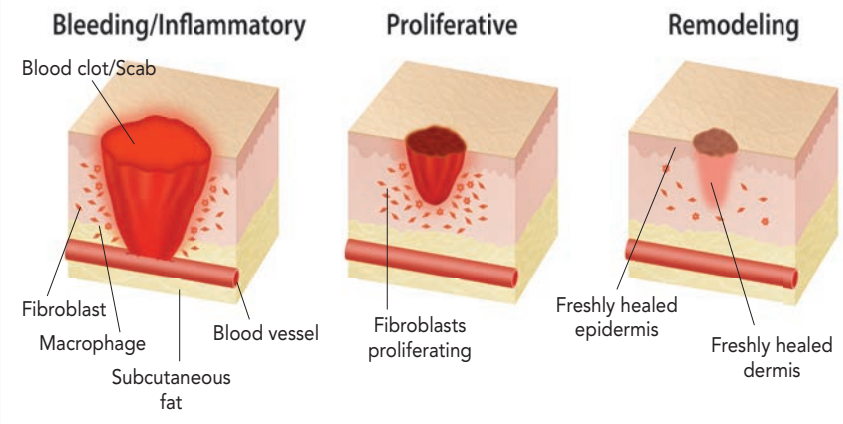


Figure 2. Three stages of wound healing

Endothelial cells are signaled to begin neovascularization of the wound, and fibroblasts are recruited to proliferate and produce a collagen matrix to increase wound strength. This phase lasts approximately 2 to 4 weeks.

The late proliferative phase is characterized by epithelization of the wound bed, followed by contraction of the scar via myofibroblasts.

Remodeling Phase

In the final phase of wound repair, disorganized collagen fibers in the scar are replaced and reorganized in parallel with tension lines, which will increase tensile strength. Final strength is stated to be a maximum of 80% of the original tissue.

This phase takes place several days to weeks after initial injury and can last up to a year.

Surgical Repair

Primary Intention

Healing by primary intention occurs when wound edges are brought together into direct approximation. This minimizes scar formation by intimately apposing wound edges, thus reducing clot formation and bridging by intermediary tissues (Figure 3).

Secondary Intention

Healing by secondary intention occurs when wound edges are not brought together. Granulation tissue bridges the gap between wound edges and epithelializes over time, forming significant scar tissue.

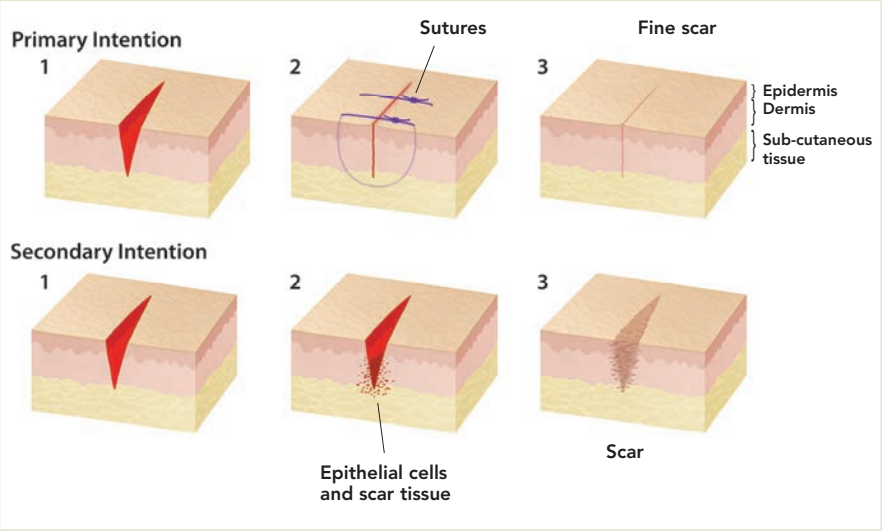


Figure 3. Difference in wound healing between primary and secondary intention closure

Differences in Oral Tissue Healing

The rapid and scarless nature of oral healing has been the subject of several research studies in recent decades. Current theories suggest that the causes are multifactorial.[3] The oral cavity environment, which is constantly moist and bathed in saliva, has been shown to contribute to faster wound healing. Saliva, in particular, has been shown in animal models to contain factors that promote faster wound closure.[2] Also, the genetic expression of oral tissues is unique to that of skin, and various cytokines, such as TGF-b1, are thought to reduce inflammation and resultant scar formation in oral wound healing.[5]

Extraction Socket Healing

The native healing of an extraction socket is another interesting example of privileged oral healing. The extraction socket wound is typically healed by secondary intention, which begins with clot formation, followed by granulation tissue formation and epithelialization. The resultant matured tissue exhibits no apparent residual scar tissue, consistent with regeneration over repair.

Materials/Instrumentation

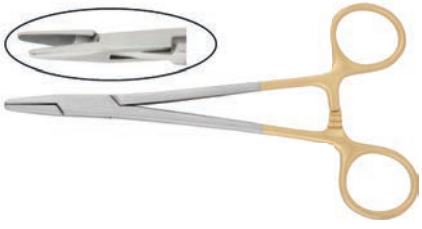
Needle Holder

Needle holders are specialized forceps that utilize a ratcheting mechanism to clamp suture needles securely in place and avoid twisting or movement. The tips or jaws of the needle holder can be smooth or

serrated. Serrated tips are preferable because they are more resistant to needle movement within the jaws, but care must be taken as the serrations can damage the needle with excessive clamping force or can damage the suture if used on the thread.

Needle holders vary widely in size and shape and should be selected to match the needle size and application. A 4" to 6" length is suitable for suturing intraorally. Needle holder tips around 3–5 mm are suitable for the most common needle sizes. Finer tips are sometimes used for very small needle shapes. An antisnare beveling around the box joint of the tips may help prevent catching of the suture in the joint of the needle holder while instrument tying.

Mayo-Hegar and Crile-Wood



The Mayo-Hegar and Crile-Wood needle holders are both ratcheted, finger ring instruments available in a wide range of lengths and used in multiple types of surgical procedures. Typically, 4"–6" in length, fine to medium tip size, and brazed tungsten-carbide tips provide versatility and are recommended for most applications.

Castroviejo

Castroviejo needle holders, which usually come with serrated, brazed tungsten-carbide tips, are a double-spring instrument used for holding small, delicate needles in various microsurgical procedures. Originally designed for ophthalmologic surgery, Castroviejo needle holders are preferred by some clinicians for handling very small needles and fine suture, such as 4-0, 5-0, 6-0, and smaller.

Tissue Pickups

Tissue pickups are forceps specializing in manipulating and holding tissue atraumatically. They are typically used in the nondominant hand to position tissue for needle passage by the dominant hand. Tissue pickups should generally match the needle holder in length to allow proper ergonomics.

Adson Forceps

Short-medium (4.75") length fine-toothed or serrated pickups that allow gentle handling of wound edges.

Gerald Forceps

Medium-long length (7") fine-tooth pickups that allow easier access to the posterior oral cavity and pair with longer needle drivers.

Scissors

Surgical scissors should be sharp to aid in trimming tissue and suture. A slight curve or angle may be useful for accessing cumbersome areas of the oral cavity.

Iris Scissors

Fine scissors with short blades, which were originally developed for ophthalmic surgery, can be curved or straight, in varying lengths from 3"–6".

Kelly and Goldman-Fox Scissors

Straight or curved standard series scissors with one serrated blade used for trimming tissue or cutting suture.

Dean Scissors

Heavier tissue scissors that are angled to allow easier access to the posterior oral cavity.

Castroviejo Scissors

Castroviejo scissors are small, fine, double-spring scissors most

commonly used during periodontal and microsurgeries. These scissors have short, sharp, and slightly curved working ends made for fine resections of soft tissues and trimming wound margins or mucosal grafts.

Suture Thread

Characteristics

Composition – Natural vs Synthetic

Suture material can be naturally derived or synthetically manufactured. Naturally derived materials tend to elicit a greater immune or inflammatory response. Common natural materials include silk, which is spun by silkworms, and gut suture, composed of purified collagen derived from sheep or bovine intestine.

Degradation: Absorbable vs Nonabsorbable. Guidelines for Usage

Suture material that generally maintains its tensile strength over 60 days is considered nonabsorbable. Contrary to common belief, most "nonabsorbable" sutures are not actually permanent but undergo very slow degradation. Silk, for example, loses all of its strength by one year, and is often undetectable at two years.

Naturally derived sutures are absorbed via proteolytic enzymatic degradation and is generally associated with greater tissue inflammation. Synthetic suture material is absorbed via hydrolyzation, which results in a lesser degree of tissue inflammation.

Degradation occurs more rapidly in the oral cavity due to the presence of saliva, which provides constant moisture and enzymatic degradation. Studies have shown there to be a decrease in tensile strength retention time in the presence of saliva compared to manufacturer recommendations, which are likely tested in other environments.[6]

The choice of absorbable vs nonabsorbable sutures is often subject to preference by the clinician. Commonly used nonabsorbable sutures [polytetrafluoroethylene (PTFE), nylon, polyethylene] tend to be monofilament and more hygienic and less reactive than absorbable sutures. Silk, which is braided, is an exception to this and does significantly accumulate plaque and debris.

PTFE Suture

This suture material is ideal for dental bone grafting and implant procedures where a soft monofilament suture is desirable. PTFE suture's monofilament construction reduces bacterial wicking into the surgical site. Unlike most monofilament sutures, the suture thread is soft and avoids the irritation and discomfort normally associated with stiff monofilament suture.

Additionally, they retain a high tensile strength and are readily visible in the mouth. PTFE suture stretches with edema without loosening or breakage and maintains its tensile properties when edema subsides. They can be removed after 2–3 weeks.[7] A significant disadvantage to PTFE suture is cost compared to other materials.

On the other hand, the convenience of absorbable sutures such as chromic gut or polyglactin/polyglycolic acid (PGA) may often outweigh the advantages of nonabsorbable sutures, as many patients are averse to suture removal during follow-up.

Structure – Monofilament vs Multifilament

Suture material can be monofilament or multifilament. Monofilament suture consists of a single strand of material. This results in decreased friction during knot rundown, decreased resistance through tissue, and reduction in debris and bacteria accumulation. However, monofilament sutures tend to be less pliable with more memory, and together with decreased friction, can result in greater knot slippage or failure. The suture ends also tend to be stiffer and more irritating to adjacent tissue, such as the tongue.

Multifilament sutures are typically braided, and may exhibit favorable handling characteristics such as pliability, flexibility, and tensile strength. Increased friction may aid in knot retention. The suture ends are typically softer and more comfortable for patients.

TABLE 1. Commonly Used Suture Materials in the Oral Cavity

	Composition	Filaments	Tissue Reaction	Strength Retention	Handling Notes
Nonabsorbable					
Silk **PrecísPOINT**	Natural (Silkworm)	Multifilament, Braided	Moderate	Gradual degradation	Easy to handle Good knot retention Debris and bacterial accumulation
Polypropylene **PrecísPOINT**	Synthetic	Monofilament	Minimal	No loss	Moderate memory Knot slippage Smooth knot rundown
Nylon **PrecísPOINT**	Synthetic	Monofilament	Minimal	Gradual hydrolysis	High memory Knot slippage Smooth knot rundown
Polytetra-fluoroethylene (**PTFE**)	Synthetic	Monofilament	Minimal	No loss	Easy to handle; pliable Good knot retention Stretches with edema without loosening or breakage and maintains its tensile properties when edema reduces
Absorbable					
Plain Gut **PrecísPOINT**	Natural (Sheep intestine)	Monofilament	Moderate	3–5 days	Easy to handle Good knot retention May be "sticky" during knot rundown
Chromic Gut **PrecísPOINT**	Natural (Sheep intestine)	Monofilament	Mild–Moderate	5–7 days	Easy to handle Good knot retention May be "sticky" during knot rundown
Polyglycolic Acid (PGA) **PrecísPOINT**	Synthetic	Multifilament, Braided	Mild	10–14 days	Easy to handle Good knot retention Mild debris and bacterial accumulation

Disadvantages include poorer handling because of increased friction during knot rundown, increased resistance through tissue, and a greater propensity to harbor debris and bacteria. Some of these disadvantages may be offset by coated sutures.

Size

Suture size is described numerically by the United States Pharmacopeia system (USP), utilizing 0's to denote decreasing size. For example, USP 4-0 is 0000, which is smaller in diameter than USP 3-0, or 000. The most common sizes utilized in the oral cavity are USP 3-0 and 4-0 sutures, followed by 5-0.

Suture Needle

The suture needle is described by its shape and geometry. The critical elements of a needle relate to the shape of the

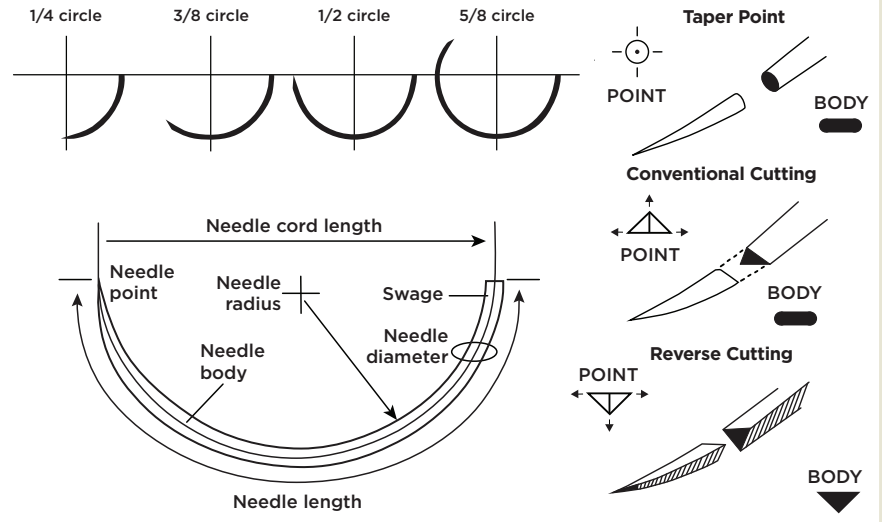


Figure 4. How suture needles are shaped and described, as well as the three most common cutting shapes

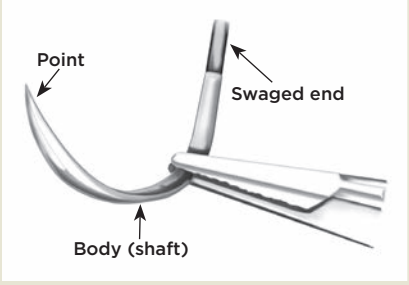


Figure 5. Illustrating where to grasp the needle

cutting element, the size or length of the needle, and its curvature (Figure 4).

Shape

The needle is composed of three regions: the point, body, and swage. The point is the tip-end component of the needle that serves as the cutting element. The body continues the curvature of the needle and may or may not also continue the cutting edges of the point. The swage is the base of the needle, where the suture thread is attached without the need for a needle eye (Figure 5).

Manufacturers have proprietary needle shapes that fall into their respective naming systems, but the overall principles are similar. The following guidelines cover the most typical needle types that are used in dental applications.

Size

Most general-purpose needles for the oral cavity are around 18–20 mm in needle length. For finer or more delicate tissues, needle lengths in the 10–12 mm range may be more appropriate.

Curvature

Needle curvature is described as fractions of a circle with varying radiuses. This can range from 1/8 to 5/8 circle. The most commonly used curvature is a 3/8 needle. A half circle can be useful in confined or deep locations due to its more acute turning radius.

Cutting Surface

Suture needles are classified based on their cross-sectional shape. The most common needle is shaped triangularly in cross section and is referred to as a cutting needle. This provides three cutting surfaces of the needle to pass easily through tissue. A conventional cutting needle orients the apex of the triangle toward the inner curvature of the needle. A reverse cutting needle orients the apex of the triangle toward the outer curvature of the needle. The reverse shape reduces the risk of lacerating the tissue it is being passed through and is the most common shape used in the oral cavity.

Taper needles have a round cross section and no cutting surface beyond the needle point. This results in spreading instead of cutting tissue after penetration. This can be less traumatic, but also results in more difficulty passing through tough tissue such as keratinized mucosa and is best reserved for delicate

tissue such as blood vessels or nonkeratinized mucosa.

Technique

Ergonomics

Suture technique is made challenging by its application in the oral cavity. It is common to overlook basic ergonomics while trying to adapt suture within the confines of the mouth.

The patient's head should be roughly at the elbow height of the operator. The operator may be seated or standing. A right-handed operator should generally be positioned from 7 o'clock to 12 o'clock to allow their dominant hand to remain in front of the patient. The operator should remember to position, turn, and/or tilt the patient's head to allow direct access. The operator's wrists should be in neutral orientation (not flexed or extended) and allow for pronation and supination. Flexion and extension of the wrist may be utilized but doing this for extended periods may indicate that the patient and provider positioning is suboptimal. The conventional grip is the easiest to learn, engaging the fingertip pads and the rings. The middle finger stabilizes the instrument and the index finger is extended for precision (Figure 6).

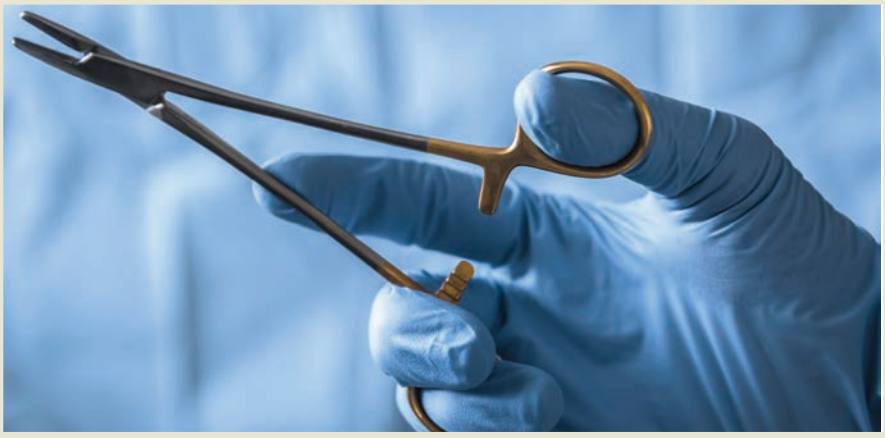


Figure 6. Handling the needle holder. The conventional grip is the easiest to learn, engaging the fingertip pads and the rings. The middle finger stabilizes the instrument and the index finger is extended for precision.

In general, it will be easier and more precise to suture toward oneself. In the case of a running suture, the anchor knot should be placed posteriorly and the suture advanced anteriorly in the mouth.

The same is true for passing a needle through tissue; a right-handed operator will have more control passing the needle from right to left or toward oneself, as opposed to away. This is the "forehand" orientation, as the palm faces the same direction as the needle point. However, this is superseded by the position of the tissues, resulting in the need to "backhand" the suture and pass the needle in the opposite, unnatural direction. An example of this for a right-handed operator is securing a buccal flap on the patient's right mandible. The needle should first be passed from the loose tissue (the buccal flap) and secured to the stable tissue (intact lingual/palatal tissue), regardless of the left–right direction. Practicing this unnatural "backhand" movement is a critical skill to develop.

Basic Principles (Figure 7)

- Load the suture needle toward the end of the needle holder, clamping the ratchet to the first or second notch to avoid excessive force on the needle.
- Do not grasp the suture needle with another instrument, such as a hemostat, as this can damage the needle.
- Grasp the suture needle approximately 1/3 the length of the needle away from the swage end. Grasping the swage can damage the attachment of the suture thread.
- Orient the needle between 60°–90° to the long axis of the needle holder.
- Hold the needle holder using

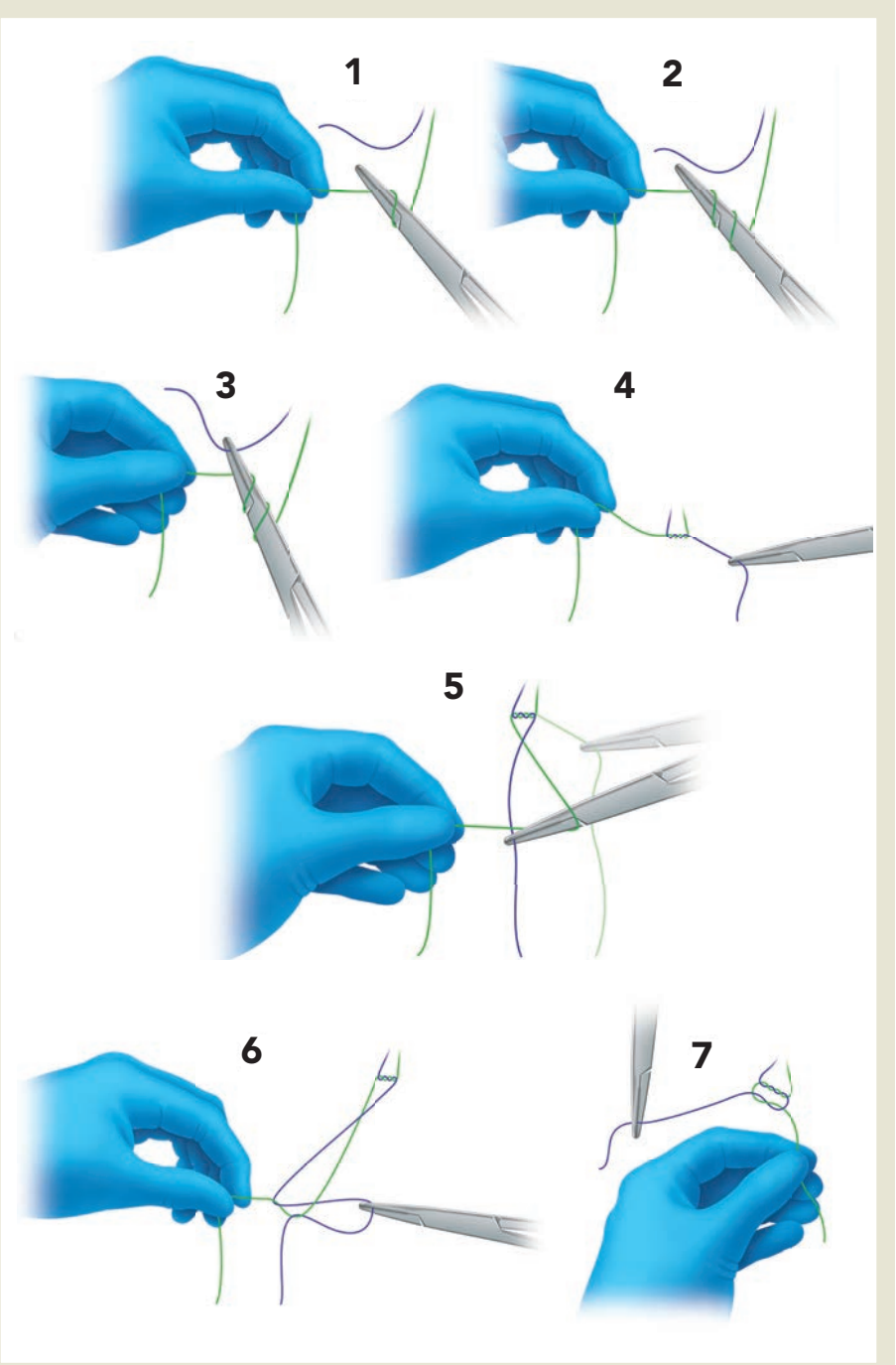


Figure 7. Instrument tie

the thumb and ring finger on the rings, while the middle and index fingers extend down the shaft for control. Even greater control may be achieved by holding only the shaft of the needle holder while passing the suture needle through tissue. The grip is then returned to the rings when the instrument is ready to ratchet and unratchet.

- Suture loose tissue to attached tissue: "From ship to shore."
- Enter the tissue surface approximately 60°–90°, while maintaining a 3-mm boundary from the tissue edge. Tissue forceps may aid in stabilizing and positioning the flap. Take care to handle the flap gently with toothed forceps, as excess force may crush the flap edge.
- Guide the needle through the tissue along the curvature of the needle. This requires a balance of advancement and rotation. Early rotation of the suture needle can result in translation through the flap and tissue laceration.
- When the suture needle point emerges on the other side of the flap, gently grasp the suture needle point end to draw the remaining needle through the tissue, taking care to follow the curvature of the needle.
- Avoid passing the needle through both sides of the wound in one pass. Passing the suture through

each flap individually, in two separate passes, will avoid unnecessary trauma to the first flap while trying to maneuver through the second.
- The position of the needle passing through the second flap should mirror that of the first in depth and exit point to allow similar layers and levels of tissue to be evenly approximated.
- The needle is brought from within the wound into the deep surface of the second flap and exits tissue surface in a similar position to where the suture entered the first flap.
- Take care to pull the suture thread perpendicularly out of the tissue surface as it emerges. A common mistake is to pull the suture thread "up" or "out" of the mouth, which can cause tissue trauma and laceration. Instead, utilize a smooth instrument, such as the closed end of a needle holder, to guide the direction of the thread out of the tissue while pulling on the suture.
- Leave approximately 2–3 cm of the tail end of the suture to reduce waste.
- Hold the suture needle between thumb and index finger in the nondominant hand and reduce any slack in the suture thread by wrapping around the remaining fingers.
- The suture is now ready to "instrument tie" utilizing the needle holder in the dominant hand (Figure 7, #7).
- The following adaptations can be used to accomplish various knots and closure methods (Figure 8).

Knots

Knots (Figures 8 and 9) are used in surgery to secure two ends of a suture thread to form a surgical loop through tissue. A knot is constructed by performing consecutive throws. Each throw is actually a half knot, whereby each suture strand is twisted together to create an intertwined weave.

To instrument tie a knot, each throw involves creating a loop around the instrument with one suture end and pulling the other suture end through the loop. By varying the number of loops created in a throw, and alternating the direction of the loop, different knots can be constructed.

When completing each throw, the suture ends should be pulled tangentially across the wound surface to reduce any gap under the knot, and the direction of each end should be opposite from their origin in order to flatten the knot. Tension should be placed equally on both ends to distribute the weave between both limbs of the suture. An exception is made in the case of the slip knot, as described later.

The knot should be positioned on the buccal aspect of the wound, when possible, to avoid irritation to the tongue.

Square Knot

A square knot consists of two overhand knots (half knots) thrown in opposite directions. The resultant knot is resistant to slippage and is suitable for oral applications.

A loop is formed around the needle holder with the long end of the suture thread. The free end is then grasped with the needle holder and pulled through the loop to the opposite side of the wound. The two ends are then pulled taut in opposing directions, tangential to the wound surface to lay the knot down flat and intimately against the wound. A loop in the opposite direction as the first loop is then formed in the long end of the suture, and the free end is again grasped and pulled through the loop. The ends are again pulled taut in opposing directions, tangential to

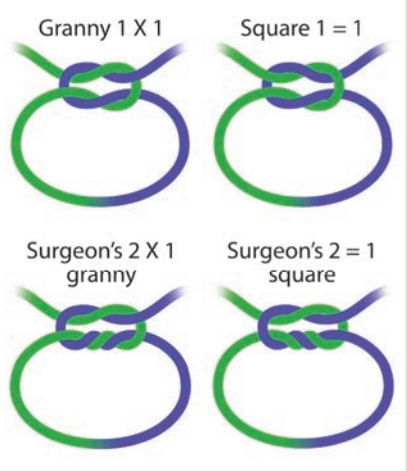


Figure 8. Knots

the wound surface, until the square knot is locked. The suture ends should now be on the same side that they originated.

Granny Knot

A granny knot is very similar to a square knot, in that two overhand knots (half knots) are utilized to construct a binding knot. The difference is that both overhand knots (half knots) are thrown in the same direction. The resultant knot is more prone to slipping than a square knot and offers no advantages. This knot can be mistakenly utilized if the loops on consecutive throws are made around the needle holder in the same direction.

Surgeon's Knot

The surgeon's knot is a modification of the square knot, whereby the first throw is made with a double loop. This increases friction in the half knot and makes the first throw more resistant to slipping before the second throw is placed to lock the knot. The loop in the second throw should be in the opposite direction of the two loops in the first throw, in order to properly square the knot.

Zarzar 2-1-2 Knot

This is a secure, slip-safe modified surgeon's knot, where the first throw is made clockwise with a double loop. This increases friction in the half knot and makes the first throw more resistant to slipping before the second throw is placed to lock the knot. The single loop in the second throw should be counter-clockwise-opposite direction of the two loops in the first throw, in order to properly square the knot. Then, make a third throw with a clockwise double loop to deadlock the final knot.

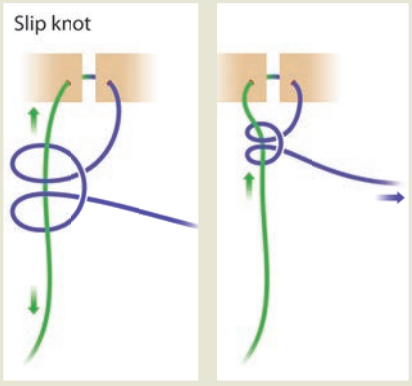


Figure 9. Slip knot. Tension pulled tangentially to "flatten" the knot.

Slip Knot

In the context of surgery, a slip knot is not a distinct entity, but a modification in the procedure of the above knots in order to allow a sliding rundown of the knot complex along the suture thread. This technique can be useful when placing knots in a confined space, such as the back of the mouth, or when tying knots "under tension" to bring wound edges together. These situations tend to form "air knots," because the manipulation of the suture thread (in the case of a difficult access) or tension from the wound edges causes the first throw to become partially loosened prior to locking the knot with the second throw. As a result, a gap between the knot complex and the tissue surface is left, and the suture loop is loose within the tissue.

In order to convert any of the above knots into a slip knot, differential tension is used between the two suture ends during rundown of the looped suture half knots. The author's typical preference is to first place tension on the free end of the suture to keep this limb straight. The loop from the long end of the suture is then slid down to the wound surface. A second loop is then made, and the free end is grasped and brought through the loop. Prior to placing tension on the long end of the suture to run down the loop, the free end is again placed into tension to straighten the limb. This results in two consecutive loops of the long limb around the straight free limb. The loops are then slid down the free end to tighten the knot. A third throw is then utilized with a loop throw in the opposite direction of the second loop, and the two suture ends are pulled simultaneously to flatten and square the knot. The resultant knot is a slip knot at the base topped by a square knot to secure the knot complex.

In the cases of mobile tissue being sutured to fixed tissue, an additional benefit is provided by placing prioritized tension on the free limb during a slip knot. Because the free limb originates from the mobile tissue (the needle passes through this tissue first and leaves the

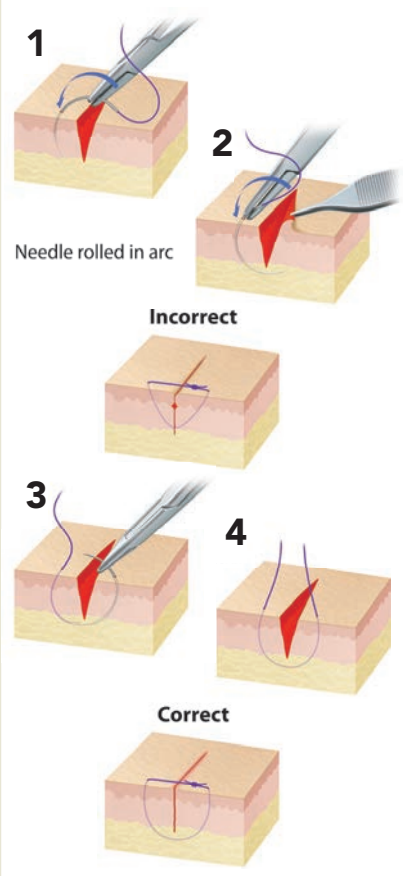


Figure 10. When possible, wound edges should be everted to reduce scar formation. To accomplish this, the needle should enter tissue at 90° or greater. An acute angle will result in inversion of wound edges and greater scar formation.

free end behind), prioritized tension on this limb serves to advance the mobile tissue across the wound gap and intimately adapts it to the fixed side. This technique significantly decreases the occurrence of widened wound gaps and tissue irregularity or scars (Figure 10).

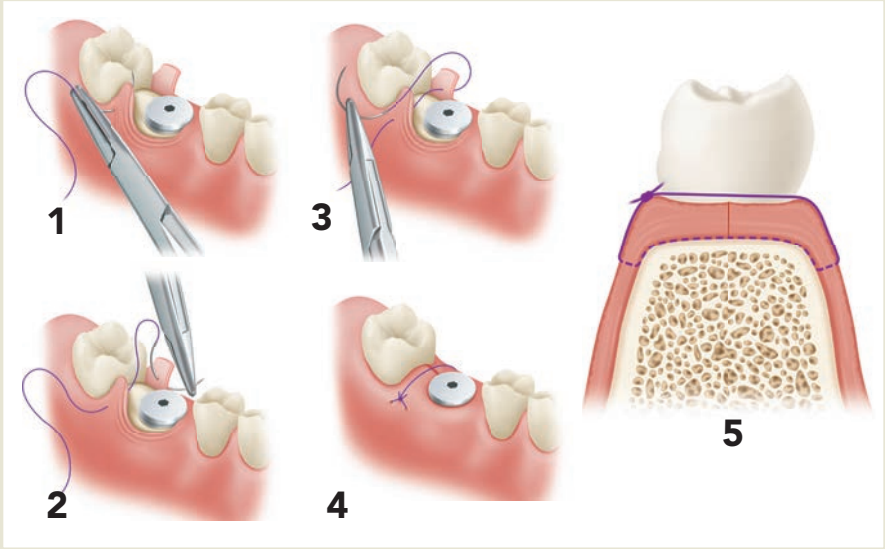


Figure 11. First set of suture variations: Simple interrupted loop

Interrupted Sutures

Simple Interrupted Loop

This is the mainstay and workhorse of closure techniques. The two sides of a wound are captured into a single loop. The needle is passed 3 mm from the wound edge through the first flap. Forceps can be used to secure and position or evert the flap. The needle is then passed through the second flap in a similar position to the first, starting from within the wound and exiting superficially. The appropriate knot for the given suture material is then tied down.

The simple interrupted loop suture allows precise control of the wound margins, intimate adaptation, and requires the least amount of available tissue to be placed securely (Figure 11).

Suggested applications: Most scenarios. Any direct adaptation of wound edges (e.g., crestal incision over ridge, vertical release). Advancing flap over guided bone regeneration (GBR) with slip knot technique. Securing papilla interdentally.

Figure-of-8 Suture, Also Known As Crisscross

The figure-of-8 suture utilizes four points of tissue contact and creates a crossing of the suture thread over the wound. This is particularly useful when suturing over an open socket, as both mesial and distal papilla can be secured with one stitch. The crossing of the suture material over the socket can also help to contain graft material or adjuncts such as gelfoam (Figure 12). The figure-of-8 suture may also aid in suturing together tissue with poor pull-through strength, such as muscle,

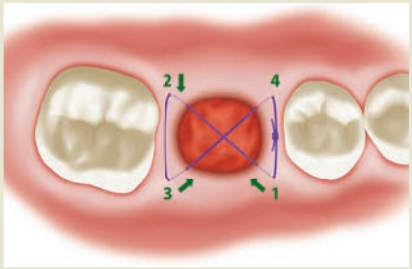


Figure 12. Second variant: Figure-of-8 suture utilizing extraction socket as example.

due to the distribution of force over two points of contact on either side instead of one.

For an extraction, the needle is passed 3 mm from the wound edge through the base of the papilla of the buccal flap. The needle is then advanced across the wound diagonally to the opposite corner before entering the deep side of the distal lingual papilla, and then exits superficially at the base of the lingual papilla. The suture needle is then brought over the wound margin to repeat the process on the buccal flap again, now at the distal papilla. The needle is then passed over the wound, crossing over the initial path of the suture thread, and punctured through the lingual aspect of the mesial papilla. At this point, the tail end of the suture and the long end are on the buccal and lingual surfaces of the mesial papilla, and the figure-of-8 suture can be tightened and tied down with the appropriate knot for the suture material.

The sequence of the figure-of-8 suture can also be altered to pass the suture needle on the same end, for example, on the mesial papilla first, before crossing over the wound to the distal papilla. The resultant knot is tied over the wound; however, the risk of developing an air knot is increased with the use of a longer suture thread.

Suggested Applications: Suturing tissue adjacent to open extraction socket, securing graft material and barrier within an extraction socket.

Mattress Sutures

Like the figure-of-8 suture, mattress sutures utilize four points of anchor, two on each side, to increase the resistance of the tissue to pull-through of the knot. This allows greater amounts of tension to be resisted by the suture complex and tissue. Unlike the figure-of-8 suture, the mattress sutures form a continuous loop without crossing of the suture thread.

Vertical Mattress

The anchor points of the suture will be oriented vertically, or perpendicular, to the wound edge. The deep aspect of the suture loop will be placed first. The needle is placed through the first flap approximately 5 mm from the wound margin. This will allow room later for the superficial aspect of the suture loop to exit with adequate residual

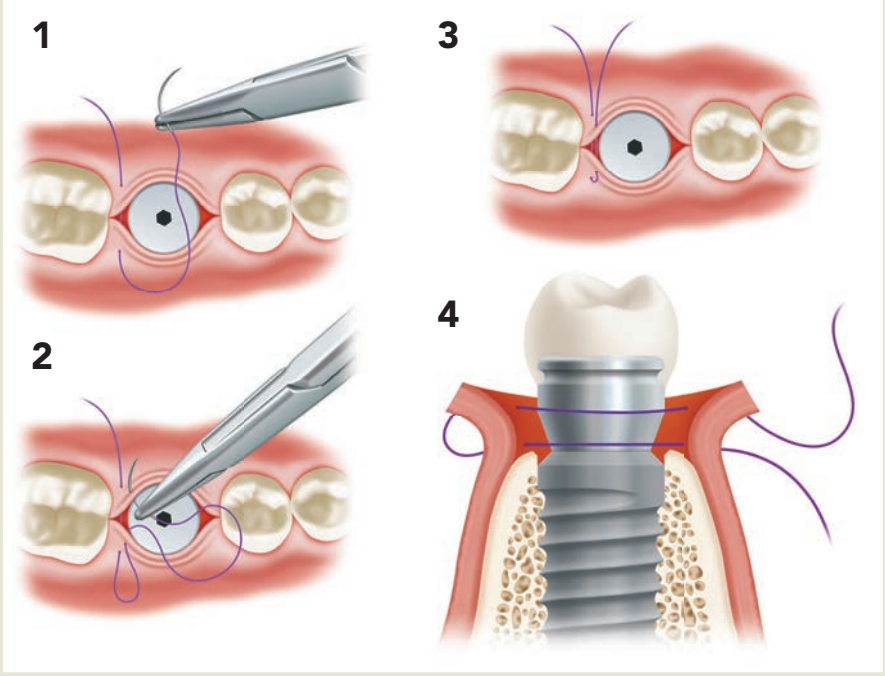


Figure 13. Vertical mattress

tissue between the entry point and the wound margin. The suture needle is brought across the wound to the opposing flap and passed through the flap from the deep aspect to exit superficially 5 mm from the wound edge. The needle direction is then reversed, and the same flap is re-entered from the superficial aspect 3 mm from the wound edge and 2 mm from the previous exit. The suture needle is now brought back across the wound and enters the first flap from the deep aspect to exit superficially 3 mm from the wound edge and 2 mm from the first entry point. The loop is now ready to be tied. Slack is then removed from the suture and a 2–3 cm tail is left at the free end in order to instrument tie the appropriate knot (Figure 13).

Suggested applications: Utilize where additional strength is needed. For example, advancing flaps under tension around implant healing abutments, closure of crestal incision over GBR at an edentulous space, closure of crestal incision over vertical grafting.

Horizontal

The anchor points of the suture will be oriented horizontally, or parallel, to the wound edge. The suture loop will intimately adapt the tissue closed within the loop and result in watertight closure. Care must be taken not to strangulate the tissue and disrupt the blood supply to the wound margin (Figure 14).

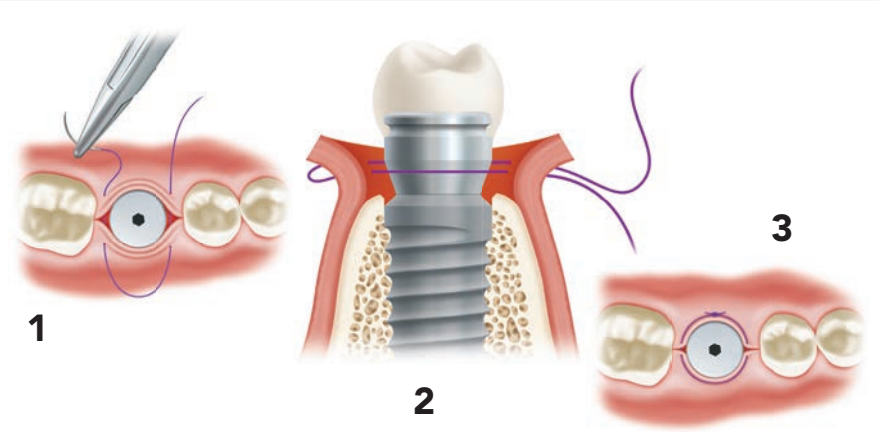


Figure 14. Horizontal mattress

The needle is placed through the first flap approximately 3 mm from the wound margin. The suture needle is brought straight across the wound to the opposing flap and passed through the flap from the deep aspect to exit superficially 3 mm from the wound edge. The needle direction is then reversed, and the same flap is re-entered at the distance from the wound margin, but 5–8 mm away from the exit point. The needle is brought straight across the wound and is passed through the deep aspect of the first flap to exit a similar distance away from the suture origin as on the opposing flap. The loop is now ready to be tied. Slack is then removed from the suture and a 2–3 cm tail is left at the free end in order to instrument tie the appropriate knot.

Suggested applications: Watertight closure needed such as closure of crestal incision at site of vertical grafting, or aid with hemostasis such as an area of tongue biopsy.

Independent Sling Suture

The independent sling suture is a specialized suture that allows a single flap to be secured without engaging an opposing flap, but instead uses a tooth or dental implant as an anchor. This is useful in situations where the opposing tissue may not be of sufficient quality to hold suture, or if it is in an inaccessible or significantly different position from the flap. This is often the case when trying to secure a buccal flap by suturing papilla interdentally, as the interproximal contact point and crestal position may make capturing the lingual papilla on the second pass very difficult without lacerating the tissue (Figure 15).

Suggested applications: Buccal flap adjacent to dentate ridge.

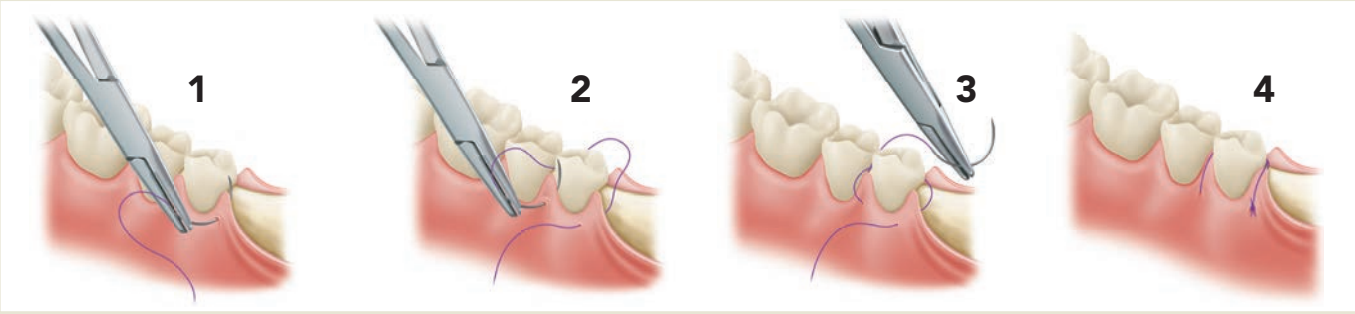


Figure 15. Independent sling suture

Buccal Flap Example

The buccal flap is entered at the base of the papilla, approximately 3 mm from the gingival margin. Once through the flap, the suture needle is then passed through the embrasure space without needing to engage tissue. On the lingual/palatal aspect, the suture is brought around the crown and through the adjacent embrasure space and exited buccally. The suture needle now passes through the buccal flap from the deep aspect, exiting facially at the base of the papilla. The suture needle is now brought back through the same embrasure space without needing to engage lingual/palatal tissue, and the suture thread retraces its path around the lingual/palatal aspect of the crown and is brought back through the original embrasure. The suture ends can now be tied to complete the loop, and the buccal flap is suspended against the crown.

Continuous Sutures

Continuous sutures may be indicated to efficiently close a large wound without needing to tie several individual knots. Continuous suture may also provide an increased watertight seal compared to individual knots that are separated. The main disadvantage of a continuous suture is that failure in any part of the suture will result in failure of the entire length of the suture complex.

Continuous Running

The continuous running suture is started in the same fashion as a simple interrupted loop (Figure 16). The suture needle is passed through the more mobile flap 3 mm from the margin, and a similar 3-mm bite is taken from the deep to superficial at the opposite flap. The loop is completed with the appropriate knot for the suture material. The free end of the suture can now be trimmed to 3–5 mm to avoid interference. The long end of the suture is now retracted by the assistant to prevent interference in the surgical field. The one-third rule is useful here, whereby the assistant places gentle tension up and away from the field on one-third of the remaining suture, allowing the operator two-thirds of the suture to work with. The closure is advanced along the wound by taking the next bite 3–5 mm from the anchor point, again beginning with the same flap. The needle is passed through the opposing flap, and the assistant releases tension on the suture. The operator can then pull the slack through the suture thread to close that aspect of the wound. The assistant again takes one-third of the remaining suture thread and maintains the same amount of tension that the operator has established when passing the suture thread. The closure is again advanced in a similar amount, and the process is continued until the entire wound has been traversed. Once the end has been reached, a modification is utilized in order to tie down the end of the suture complex. The operator does not pull through all of the remaining slack. Instead, approximately 2–3 cm

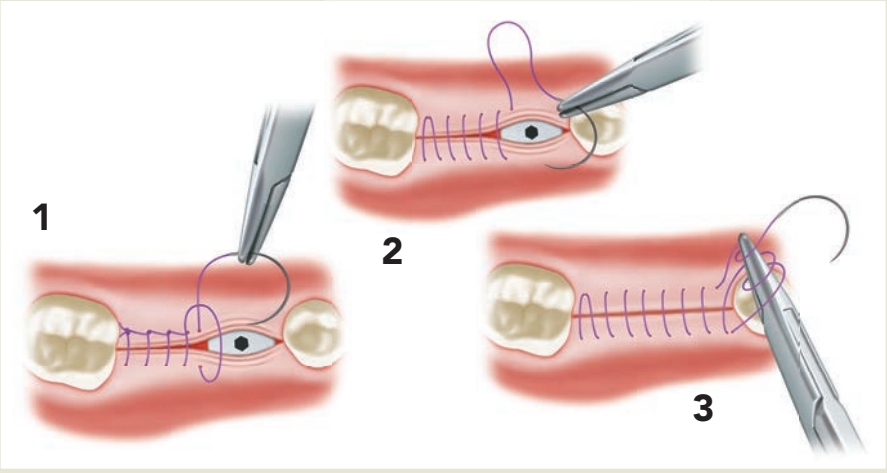


Figure 16. Continuous running suture

of suture is maintained loose prior to the final bite of tissue. This will form a small half loop of suture thread, which is then grasped with one jaw of the needle holder through the half loop. The jaws are not yet closed. The long end of the suture is then placed into tension against the half loop partially held by the needle holder, in order to remove any slack and to even out the suture around the needle holder. The needle holder is then removed from the half loop, and the instrument tying process begins. A loop is formed around the needle holder and the residual half loop functions as the free end of the suture complex. The needle holder engages the half loop with open jaws, and gentle tension centers the jaws within the half loop. The jaws are then closed to grasp the half loop, and the first throw is then cinched down. Subsequent throws alternate in direction to square and flatten the knot complex.

Suggested applications: Full-arch extractions with alveoloplasty and redundant tissue.

Locking Variant

Some providers utilize a "locking" variant of the continuous running suture. This technique begins and ends in similar fashion to the continuous running suture but adds a twist of the suture thread against itself between each successive anchor when the suture is being advanced. This is accomplished by engaging the previous loop of suture after the second bite is completed, prior to placing tension to close the wound at that anchor point. The suture is then advanced to the next anchor point.

This technique has not shown to provide significant clinical benefit. Disadvantages include introducing a point of friction and potential failure at every locking point along the suture complex. It is also difficult to evenly distribute or adjust tension along the suture line prior to knot tying.

Conclusion

Good, fundamental suture technique is the key to optimal and predictable healing. Advanced techniques are available but are often optional. Most scenarios can be managed with a proper, basic technique and a sound understanding of wound healing. A clinician's skills and technique are enhanced with quality surgical instruments as they can minimize the learning-curve challenges, driving surgical success.

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7. Partners in Synergy. Interactive Lecture and Discussion Between Drs. Michael A. Pikos and Maurice A. Salama. June 20-22, 2019.

CE Quiz

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1. **What is the most common needle curvature utilized in dental procedures?**
   a. 1/4 circle
   b. 1/2 circle
   c. 3/4 circle
   d. 5/8 circle

2. **What is the most common needle shape utilized in dental procedures?**
   a. Taper or round
   b. Square
   c. Cutting
   d. Reverse cutting

3. **A monofilament suture harbors more bacteria and debris than a polyfilament suture.**
   a. True
   b. False

4. **Nonabsorbable sutures may degrade over time.**
   a. True
   b. False

5. **Synthetic sutures degrade from naturally occurring enzymes.**
   a. True
   b. False

6. **The most common suture sizes utilized in dental procedures are _____.**
   a. 2-0
   b. 3-0
   c. 4-0
   d. b and c
   e. all of the above

7. **Scar tissue has _____ tensile strength compared to normal tissue.**
   a. greater
   b. lesser
   c. equivalent

8. **Instrument tying a surgeon's knot is composed of _____.**
   a. two loops followed by another loop in the same direction
   b. two loops followed by another loop in the opposite direction
   c. a single loop followed by two loops in the same direction
   d. a single loop followed by two loops in the opposite direction

9. **Instrument tying a square knot is composed of _____.**
   a. a single loop followed by another loop in the same direction
   b. a single loop followed by another loop in the opposite direction
   c. two loops followed by two loops in the same direction
   d. two loops followed by two loops in the opposite direction

10. **A granny knot is different from a surgeon's knot because _____.**
    a. both half-knots are in the same direction
    b. the granny knot has an increased risk of slipping
    c. both a and b are true
    d. both a and b are false

11. **Gut suture is derived from _____.**
    a. cat muscle
    b. cow intestine
    c. dog fur
    d. synthetic polymers

12. **Chromic gut suture is treated to _____.**
    a. absorb faster than plain gut suture
    b. absorb slower than plain gut suture
    c. decrease inflammation and has no effect on absorption time

13. **Which of the following materials is naturally derived?**
    a. Polypropylene
    b. Polyglycolic acid
    c. Polytetrafluoroethylene
    d. Silk
    e. Nylon

14. **The most common suture technique is the _____.**
    a. horizontal mattress suture
    b. vertical mattress suture
    c. running continuous suture
    d. simple interrupted loop suture
    e. sling suture

15. **A ringed needle holder instrument should be held with the rings controlled by the _____.**
    a. thumb and index finger
    b. thumb and middle finger
    c. thumb and ring finger
    d. thumb and little finger

16. Most wounds in the human body heal by _____.
a. regeneration
b. repair

17. Wounds that heal by repair heal with less scar formation than regeneration.
a. True
b. False

18. All oral mucosa is _____.
a. keratinized
b. nonkeratinized
c. epithelialized
d. none of the above

19. The needle holder should typically grasp the needle _____.
a. as far toward the thread as possible, on the swage end
b. 1/3 away from the swage end
c. 1/2 the needle length
d. at a 45-degree angle

20. The most appropriate suture technique to hold socket graft materials is _____.
a. vertical mattress
b. simple interrupted loop
c. figure of 8
d. independent sling suture

21. Absorbable sutures cause more tissue inflammation than nonabsorbable sutures.
a. True
b. False

22. Which of the following is the smallest diameter suture?
a. 0
b. 2-0
c. 3-0
d. 4-0
e. 5-0

23. Which of the following may be disadvantages of monofilament sutures?
a. They are typically more prone to slippage due to less friction
b. The suture ends may be more irritating as they are stiffer
c. They may have more memory and result in less knot stability
d. all of the above

24. Which of the following are advantages of monofilament sutures?
a. They are easier to slide down knots due to less friction
b. They are more hygienic than multifilament or braided sutures
c. They pass through tissue more easily
d. all of the above

25. Which instrument is recommended for grasping a suture needle while passing suture through tissue?
a. Adson forceps
b. Gerald forceps
c. Kelly hemostatic forceps
d. Crile-Wood needle holder

26. Oral mucosa heals ____ compared to skin.
a. faster
b. slower
c. at the same rate

27. Oral mucosa heals with ____ compared to skin.
a. less scarring
b. more scarring
c. similar scarring

28. Which of the following may contribute to privileged healing of oral mucosa?
a. Moist environment
b. Compounds within saliva that promote healing
c. TGF-b1 within oral tissues
d. all of the above

29. Goals of suturing tissue may include _____.
a. manipulating, repositioning, and stabilizing tissue
b. achieving hemostasis
c. reducing scar tissue
d. stabilizing graft tissues or materials
e. all of the above

30. All oral wounds require suturing for optimal healing.
a. True
b. False

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- Gain a fundamental understanding of tissue repair and the role of suturing
- Recognize the various types of suture materials and needle types
- Learn fundamental suture techniques and ergonomics
- Determine alternative suture techniques and their indications.

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2. Usefulness of content ..... ① ② ③ ④ ⑤
3. Benefit to your clinical practice..... ① ② ③ ④ ⑤
4. Usefulness of the references..... ① ② ③ ④ ⑤
5. Quality of written presentation..... ① ② ③ ④ ⑤
6. Quality of illustrations ..... ① ② ③ ④ ⑤
7. Clarity of quiz questions ..... ① ② ③ ④ ⑤
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QUIZ ANSWERS

Fill in the circle of the appropriate answer that corresponds to the question on previous pages.

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ

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If you have any questions, please email *Dental Learning* at questions@dentallearning.net or call 888-724-5230.

PLEASE PHOTOCOPY ANSWER SHEET FOR ADDITIONAL PARTICIPANTS.

Notes

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