

General Surgery
Surgical Skills Curriculum for Residents

Wound Closure I-Basic Module

Mark A. Mattos, M.D.

Clinical Professor of Surgery, Educational Planner
Department of Surgery
Wayne State University School of Medicine
Detroit, Michigan

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I. CLINICAL GOAL / MODULE RATIONALE

Resident should have the ability to close any type of wound or incision, at any depth, under any degree of tension, with any type of suture, and using one of many wound closure techniques.

The ability to perform a wound closure that is effective, durable, aesthetically pleasing, and resistant to wound infection is a fundamental skill that must be mastered by all surgeons.

This wound closure module provides residents with the knowledge and technical skills to correctly perform a variety of wound closures through discussion, demonstration and utilization of deliberate practice of modern wound closure techniques.

II. COGNITIVE OBJECTIVES

By the end of this training session residents should understand the advantages and disadvantages of performing a

1. Running continuous suture closure.
2. Simple interrupted suture closure.
3. Vertical mattress suture closure.
4. Horizontal mattress suture closure.
5. Running subcuticular suture closure.

By the end of this training session residents should be able to.....

6. Identify the various types of wound closures available
7. Demonstrate the ability to select the appropriate wound closure technique based on the size, character and location of the wound

III. TECHNICAL OBJECTIVES

By the end of this laboratory session residents should be able to successfully.....

1. Perform a simple interrupted closure at surface
2. Perform a continuous suture closure at surface
3. Perform running subcuticular suture closure at surface
4. Perform an interrupted vertical mattress suture closure at surface
5. Perform an interrupted horizontal mattress suture closure at surface
6. Perform a simple interrupted closure at depth
7. Perform a continuous running suture closure at depth

8. Perform an interrupted horizontal mattress suture closure at depth

IV. ASSUMED PRE-EXISTING SKILLS AND KNOWLEDGE

Knowledge and Skills

- Basic knowledge and understanding of skin layer anatomy
- Resident will have been introduced to various instruments and sutures and needles used for wound closure during their 3rd year surgical clerkships and 4th year surgical electives and subinternship rotations.
- Resident will have been introduced to different types of forcep handling and needle driving skills used for wound closures during their 3rd year surgical clerkships and 4th year surgical electives and subinternship rotations.
- Resident will have been introduced to different types of wound closures techniques during their 3rd year surgical clerkships and 4th year surgical electives and subinternship rotations
- Resident will have been introduced to different types of basic knot tying techniques during their 3rd year surgical clerkships and 4th year surgical electives and subinternship rotations.

V. READING and PREPARATION

1. Ethicon Wound Closure Manual (PDF): www.ethicon.com
2. W.L. Gore Pamphlet: Tools of The Trade and Rules of The Road, A Surgical Guide, pp. 287-309. Deitch, E.A., Ed.. Lippincott Williams & Wilkins, 1997. (PDF)
3. Giddings, F.D.. Surgical Knots and Suturing (2nd Edition). Giddings Studio Publishing, Fort Collins: 2002. (PDF)
4. Zuber, T.J.. The Mattress Sutures: Vertical, Horizontal, and Corner Stitch. American Family Physician, Dec 15, 2002; vol 66(12): 2231-2236. (PDF)
5. Usatine RP, Moy RL, Tobinick EL, eds. Suturing Techniques. In: *Skin Surgery*. Mosby: A Practical Guide. St. Louis, Mo; 1998:88-100. (PDF)
6. Usatine RP, Moy RL, Tobinick EL, eds. Elliptical excision. In: *Skin Surgery*. Mosby: A Practical Guide. St. Louis, Mo; 1998:120-36. (PDF)

7. Rohrich RJ, Robinson JB. Wound Healing. In: *Selected Readings in Plastic Surgery* 1999, Volume 9, Number 3. (PDF)
8. Wayne State Department of Surgery Knot Tying Video clips (to be shown during skills module presentation)
9. Video clips demonstrating various knot tying techniques are available by going to You Tube or Google and inputting the subject "Knot Tying Techniques"

Wound Closure Technique Overview

<http://www.uphs.upenn.edu/surgery/Education/facilities/measey/WoundClosureManual.pdf>

<http://www.aafp.org/afp/2002/1215/p2231.html>

<http://www.uptodate.com/contents/closure-of-skin-wounds-with-sutures>

: <http://emedicine.medscape.com/article/1836438-overview>

Simple Interrupted and Running Continuous Suture Closure

<http://www.youtube.com/watch?v=Vw6UH0RUX2o&list=PLB0F7E9E7EEA647C2>

<http://www.youtube.com/watch?v=Y2i8prclQlk>

<http://www.youtube.com/watch?v=57pu6Ol9U7g>

Running Subcuticular Suture Closure

<http://www.youtube.com/watch?v=l-CkCsZVKHg&list=PLB0F7E9E7EEA647C2>

<http://www.youtube.com/watch?v=vlfauSVRnS8>

http://www.youtube.com/watch?v=YJ8UexCzR_I

Vertical Mattress Suture Closure

<http://www.youtube.com/watch?v=824FhFUJ6wc&list=PLB0F7E9E7EEA647C2>

<http://www.youtube.com/watch?v=qNcM6D9OK0s>

<http://www.youtube.com/watch?v=UV-j1zxckXA>

Horizontal Mattress Suture Closure

<http://www.youtube.com/watch?v=Svcau54Svyg>

<http://www.youtube.com/watch?v=9DdaooEXshk>

VI. DESCRIPTION OF TASK(S) AND PROCEDURE(S)

1) Introduction and Overview

- a. In this surgical skills session, the residents will review the objectives and understand the rationale behind the module objectives. If a faculty instructor is present the instructor will review with resident/fellow.
- b. The residents/fellows will familiarize him/herself with the wound closure models to be used for this module. If a faculty instructor is present the instructor will provide an expert overview of the instruments and wound closure models used in the performance of the various wound closure techniques within this module.
- c. Using the wound closure models, the faculty instructor will then demonstrate all of the necessary technical skills and wound closure techniques required to complete this module.

2) Work Station

- a. **Residents are expected to have reviewed the module syllabus prior to performance of the skill tasks in this module.**
- b. Residents are expected to have reviewed all of the references provided in Section 4 prior to the simulator training session.
- c. The module will utilize a variety of animate (e.g. pigs feet, pig bellies) and/or inanimate (foam suture pads) wound closure models.
- d. The module will utilize those surgical instruments, sutures and needles typically used in the closure of wounds and incisions in human subjects.

3) Skill Tasks

- a. Selection of correct surgical instruments used for wound closures
- b. Selection of appropriate size and type of sutures and needles
- c. Selection of appropriate wound closure technique
- d. Performance of various wound closure techniques

4) General Principles of Wound Closures

- a. For best cosmetic and technical results follow Langer's lines when suturing (especially important on the face).
- b. Best cosmetic results may be achieved when incisions are made parallel to the direction of the tissue fibers.
- c. Do not crush the skin in the forceps as this leads to ischemia and increased rates of infection and wound dehiscence.
- d. The swage of the needle is prone to bending and breaking so always load body of needle at tip of jaws, 1/2 to 1/3 of way from swage and at 90 degree angle (Fig 1)



a. *Figure 1: How to load the needle on the needle driver*

- e. The needle tip should enter the tissues perpendicular to the skin (Needle enters tissues at 90° angle) without skiving the skin.
- f. Follow the curve of the needle and do not force penetration of the tissue.
- g. Forced penetration causes micro tissue tears which adversely affect wound healing.
- h. Do not pull needle out of tissue with forceps as this shears tissue as well, utilize the needle holder to grasp the needle, rotate your wrist, and follow the natural curve out of the tissue.
- i. Never lift tissue with the needle as it risks breaking the needle tip off.
- j. If the needle bends, stop sewing, tie the suture, and get a new needle as needles that have been bent back into position are weaker and more prone to breakage.
- k. Match placement of the needle on one side with the placement of the needle on the other side.
- l. Take smaller "bites" of equal tissue depth to give precise approximation and larger bites of equal tissue depth to provide strength
- m. Evert skin edges as this gives the best cosmetic result and decreases wound infection rates – remember the skin is edematous when you put it together but once the swelling goes away the wound will lay nicely if eversion is done correctly at closure.
- n. Uneven closure as a result of too little or too great advancement of the suture can result in rippling or dimpling of the suture.
- o. Take similar, appropriate sized bites, and similar placement of the needle.
- p. Sutures placed too close to the wound edge can result in the sutures being pulled through the wound edge. This results in separation of the wound edges leading to an increased infection risk.
- q. Sutures placed too far away from the wound edges may fail to achieve eversion of the wound edges upon closure.

- r. Do not waste suture, pull your suture through leaving a 2-3 cm “tail” on which to tie to when performing an instrument tie.
- s. Ensure your knots have appropriate tension.
- t. Too little tension can result in wound separation which results in increased risk of infection.
- u. Too much tension can result in tissue strangulation, ischemia and skin necrosis which leads to infection and wound dehiscence.
- v. Leave an appropriate length of tail when using monofilament suture due to it having “memory”. Monofilament suture will have a tendency to unravel if the tail is too short and if the appropriate number of square knots (n=6) are not tied and secured tight and flat against each other.

VII. MODULE INSTRUCTION, NARRATIVE DESCRIPTION, SKILL DESCRIPTION and TRAINING METHOD

1) Introduction and General Principles

- The faculty instructor will review the modules cognitive and technical objectives and goals with you.
- The instructor will then demonstrate to you the technical skills being taught in the module.
- To enhance your education and shorten your learning curves it is expected that you will have reviewed most if not all of the references provided in Section V.
- The overall goal of wound closure is to produce an atraumatically co-apted closed wound under no tension. This is best achieved by accurately placing the needle through the skin in a perpendicular fashion. Care is taken to minimize or avoid excessive upward tension on the suture and tissue. This avoids damage to the tissue that occurs as a result of the suture being pulled through the tissue. It is important for the suture to provide firm tension rather than tight tension at the skin edges to avoid strangulation of the tissues.
- The five types of external suture closures (continuous running suture stitch, simple interrupted suture stitch, running subcuticular suture stitch, vertical mattress suture stitch and horizontal mattress suture stitch have common technical requirements necessary for their success. Needle entry must be perpendicular to the skin and the curve of the needle must be followed to prevent upward force (and damage) of the needle to overlying tissue. It is critically important to minimize the number of times the skin is grasped with the forceps. This preventable technical error in many instances is the primary culprit for ischemic damage to the skin edges and eventual breakdown of the suture repair. Sutures should be spaced evenly along the entire length of the wound with equal “bites” taken on each side of the wound edge. It is absolutely paramount that the skin edges are everted and that moderate tension is used to approximate the skin edges. The suture closure is completed and secured with six instrument tied square knots. Residents should perform a minimum of four suture stitch closures with both braided

and monofilament suture if time permits. Residents should observe the differences in the handling qualities of the two types of sutures when performing each of the four suture closures.

- You will be assigned a surgical foam suture pad and a professional skin suture pad to participate in and complete this module.
- Students will use a pair of forceps with teeth, needle holder, suture scissors, 3-0/ 4-0 nylon or prolene sutures, and 4-0/5-0 vicryl sutures for this module..
- You are expected to complete and become proficient at all of the technical skills tasks described within this module.

2) Running Continuous Suture Stitch

- Running continuous sutures are a series of stitches performed with a single strand of suture. A running suture can be placed rapidly. The strength of a running suture is derived from the fact that tension is distributed evenly along the entire length of the suture strand. A continuous running suture leaves less foreign body material in the wound. Using a monofilament suture is preferred in the presence of an infection.
- When performing a running stitch one must be careful as there is a greater potential for mal-approximation of the wound edges as compared to an interrupted stitch. The weakness of a running suture is that if a section of the suture strand breaks the wound edges are at risk for separating along the entire length of the wound. Each stitch should be equidistant from the wound edge and evenly placed.
- When performing a continuous running suture stitch closure it is important for the surgical assistant to maintain adequate tension on the suture strand as he assists the surgeon in performing the closure in order to ensure that the skin edges remain everted and closely approximated. Failure to do so will result in a loose wound closure resulting in separation of the skin edges, loss of eversion of skin edges, and compromise of wound strength and integrity.

3) Simple Interrupted Suture Stitch

- Interrupted sutures use a number of suture strands to close a wound or incision. Each strand is tied and cut after placement. Eversion of the wound edges is desirable.
- When performing this stitch the wrist should be pronated so that the needle is inserted in an equivalent depth to the skin placement. When the stitch is tied, the edges will be everted. This type of closure provides a more secure closure, because if one suture breaks, the other sutures will hold the wound edges in approximation. Interrupted sutures are also used if a wound is infected, because microorganisms may be less likely to travel along a series of interrupted stitches. One drawback of using interrupted sutures to close a wound is the longer period of time it takes to close the wound as compared to closing a wound with a continuous running sutures or skin staples.
- When performing a simple interrupted suture stitch closure it is beneficial to avoid tying the square knots directly over the skin edges. Gently bring the first knot over to one side of the skin edge and tie the remaining knots in this

location. This maneuver will ensure that the proper amount of tension is placed to the suture closure and the skin edges remain everted and adequately approximated.

4) Running Subcuticular Suture Stitch

- Running subcuticular sutures may be employed fairly rapidly with good cosmetic result with a little practice and attention to detail. The sutures for this stitch are placed in the dermis beneath the epithelial layer. Continuous subcuticular sutures are placed in a line parallel to the wound.
- This technique involves taking short, lateral stitches in the dermis without traversing the epidermis along the full length of the wound. When placing a stitch to the opposite skin edge, backstepping a bit (1/4 the distance of the last stitch) will help ensure a cosmetic closure. This stitch can be started and finished using either an external or an internal knot technique.
- When the intent is to start and finish this stitch with internal knots a 4-0 vicryl suture is typically used. Since the knots are internally placed there is no suture to be removed postoperatively.
- If an external knot is desired at the origin and termination of the wound closure then a 4-0 or 5-0 nylon or prolene suture can be used. Typically the external ends of the suture can be fixed with either a small lead shot or steri-strips. This type of stitch should not be removed for 10-14 days.
- If the closure is longer than 7-8cm the suture may break during the attempt to at its removal. In this case, it is recommended to bring the nylon or prolene suture out of the wound at its midpoint so the suture can be cut into two pieces therefore ermitting easier removal of shorter single suture strands from each end of the wound.

5) Vertical and Horizontal Mattress Suture Stitches

- Vertical and Horizontal mattress suture stitches are interrupted suture stitches whose chief advantage is the strength of their closure. Each stitch enters into the wound twice and is inserted deep into the tissue.
- Vertical mattress suture closures are especially useful when eversion of skin edges is also important. They have been particularly helpful in the closure of amputation wounds to the lower extremity.
- Both of these stitches tend to increase the risk of ischemia to the skin edges when excessive tight tension is used to complete the stitch. So when performing these two stitches it is important to use only firm tension in order to avoid the risk of tissue strangulation and subsequent ischemia.
- Performance of a successful vertical mattress suture stitch closure ensures that the strength of the wound closure is more than adequate and superior to that of a continuous running or simple interrupted suture stitch closure or to that of a wound closure using skin staples.
- To ensure consistent eversion of the wound edges it is important that the suture “bites” taken on each side of the wound are of

- equal distance and depth from the wound edges. It is also important to place the inner “bites” no more than 3mm-5mm away from the wound edges to achieve optimal approximation of the wound edges.
- Horizontal mattress suture stitch closure is best performed when the horizontal suture “bites” are not wider than 5mm-10mm apart. This prevents the bunching up of excess tissue and minimizes the risk of strangulation to the incorporated tissue and skin edges.

VIII. COMMON ERRORS and/or PREVENTION STRATEGIES

Suture Tension

- Too much tension on the closure can cause necrosis of the skin edges
- Too much upward tension on the suture can result in the suture pulling out of the tissue
- Too little tension will cause the wound edges not to evert appropriately, cause separation of tissue, and may increase the infection risk
- Have first assistant maintain adequate tension throughout closure to ensure proper approximation of wound edges

Needle and Suture Placement

- Placing needle through skin at $< 90^\circ$ results in skiving of tissue and increases risk of needle pulling through tissue resulting in damage to area
- Placing needle too close to the wound or skin edge may result in the suture pulling through the tissue and loss of skin edge approximation
- Placing needle too far away from skin or wound edge results in ‘bunching up’ or ‘dimpling’ of skin edges resulting poor approximation of skin edges
- Placing sutures too close to each other may result in ischemia of the wound or skin edge
- Placing sutures too far apart may result in an increased risk of wound or skin edge separation, loss of eversion and compromise of wound strength and integrity
- Always strive for needle placement at 90° through tissue
- Always strive for equidistant and equal depth of needle placement to ensure good approximation of the wound or skin edges and ensure eversion of the edges
- Placing “*far-far*” stitches too close to the skin edge will result in loss of strength of the stitch
- Placing “*far-far*” stitches too far from the skin edge will result in ‘bunching up’ or ‘dimpling’ of skin edges resulting poor alignment of the skin edges of skin edges.

- Placing “*far-far*” *stitches* too shallow may result in failure to close dead space and lead to development of fluid collection.
- Placing “*near-near*” *stitches* through skin at $< 90^\circ$ results in skiving of tissue and increases risk of needle pulling through tissue resulting in damage to area
- Placing “*near-near*” *stitches* too far from skin edges will result in inversion of skin edges and result in poor approximation.
- Placing “*near-near*” *stitches* too close skin edges will result in needle pulling through tissue resulting in damage to the skin edge and loss of edge approximation

Wound or Skin Edge Approximation

- Failure to evert the edges can lead to poor wound healing and increased infection risk
- Always strive for equidistant placement of suture bites and equal depth of needle placement to ensure good approximation of the wound or skin edges and ensure eversion of the edges

Forceps Placement

- Grasping the skin edge with a non-toothed forceps can result in a crush-related ischemic injury to the wound or skin edges
- Multiple unnecessary grasps of the wound or skin edge with a toothed or non-toothed forcep will result in traumatic injury to the wound or skin edge
- Avoid multiple forcep grasps of the skin edge to ensure viability of the wound or skin edge
- Single accurately placed forcep grasps of the skin edge will ensure efficient and safe completion of the wound or skin closure

Knot Placement

- Non-squared knots (granny or hybrid knots) are not acceptable knot tying techniques and will not provide for a stable wound or skin closure
- Performing less than six square knots when using monofilament suture will increase the risk of the knots unraveling and eventual separation of the wound or skin incision
- Leaving too short a tail upon cutting the suture after tying the knots can result in the suture unraveling. Always leave at least 5mm suture tail.
- Always throw six square knots when tying with monofilament making sure that each of the knots are secured tightly and lie flat upon each other

IX. EXPERT PERFORMANCE DEMONSTRATION

- Video demonstrations available
- Live faculty demonstration available

X. EQUIPMENT REQUIREMENTS and MATERIALS NEEDED

- Foam suture pad, or Pig's foot, Synthetic skin
- #15 blade scalpel
- 5 inch - 7 inch needle holder
- Adson or tissue forceps with teeth
- 3-0 monofilament nylon suture / other nonabsorbable monofilament suture
- 3-0 vicryl suture / or other braided suture
- Suture scissors

XI. SUGGESTED TIME LENGTH

Wound Closure Skills Tasks (n=5) 2 Hours

XII. DOCUMENTATION OF COMPETENCY/PROFICIENCY

1. Review syllabus and Wound Closure I-Basic exam for this module.
2. Following the formal teaching session will be expected to practice and engage in a self-improvement program known as **“Deliberate Practice”** for each of the knot tying skill tasks in the module.
3. Deliberate practice is defined by the following content items:
 - The performance of a well-defined skill task
 - A task of appropriate individual difficulty
 - Use of faculty and simulator-based informative feedback
 - Accurate identification of errors
 - Implementation of error correction
 - Unlimited repetitive skill task performance
 - Defined session time
4. You are being asked to become proficient at performing at 5 basic wound closure techniques. You will be graded by one or more assessment tools as listed at the end of Section V and in the table below (*Procedural Skills Task Checklist, Task Completion Time, and Global Rating Scale*).
5. We recommend that the resident perform as many repetitions as necessary for each basic wound closure skill task in order to achieve proficiency (defined as achieving a score of >80% of the procedural skill task steps, >

80% global rating scale score and performance of the skill task within the recommended time limit).

6. The table below lists the guidelines for attainment of proficiency and serves as a guide for the residents to measure their wound closure skill set.
7. Residents should use their pre-test as a guide to the performance of each of the 5 basic wound closure techniques.
8. When the resident achieves the performance requirements described above in this section, he or she can request to be re-tested for proficiency in the performance of the 5 wound closure techniques listed below by a faculty proctor. The resident must achieve proficiency for all 5 wound closure techniques to be considered proficient at basic wound closure.

Wound Closure I-Basic Skill Tasks	Skill Task Checklist Score	Global Rating Scale Score	Skill Task Completion Time (minutes)
1) Continuous Running Stitch Closure	≥ 8	≥ 24	< 5
2) Simple Interrupted Stitch Closure	≥ 7	≥ 24	< 5
3) Vertical Mattress Stitch Closure	≥ 9	≥ 24	< 5
4) Horizontal Mattress Stitch Closure	≥ 8	≥ 24	< 5
5) Running Subcuticular Stitch Closure (internal knot, braided suture)	≥ 8	≥ 24	< 5
6) Running Subcuticular Stitch Closure (external knot, monofilament suture)	≥ 7	≥ 16	< 5