

**Wayne State University
Department of Surgery**

**Knot Tying Module
Syllabus**

Knot Tying Module

I. CLINICAL GOAL / MODULE RATIONALE

Resident should have the ability to perform any kind of knot, at any depth, under any degree of tension, using all types of suture, and with either hand.

IIa. COGNITIVE OBJECTIVES

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

1. Understand the value of square knots in surgical procedures.
2. Understand the value of being able to use an instrument to tie square knots.
3. Understand the benefit of being proficient at being able to tie two-handed square knots.
4. Understand the benefit of being proficient at being able to tie one-handed square knots
5. Understand the handling differences between monofilament suture vs. braided suture when tying square knots.
6. Understand the minimum number of square knots necessary to prevent unraveling of the knots and to safely secure the tissue being tied or ligated.
7. Understand the difference between a square knot and a surgeon's knot. Know why and when a surgeon's knot is required.
8. Understand the importance of maintaining tension on the suture while tying knots.
9. Understand the value of being able to tie square knots without excessive 'pulling' tension on delicate tissue.
10. Understand the value of using the 'slip knot' technique when tying knots under moderate or severe tension.

IIb. TECHNICAL SKILLS OBJECTIVES

By the end of this laboratory session participants should.....

- 1) Tie a series of instrument-tied square knots at surface level.
- 2) Tie a series of two-handed square knots at surface level and at depth.
- 3) Tie a series of one-handed square knots at surface level and at depth.
- 4) Tie a series of two-handed square knots under no tension and with tension.
- 5) Tie a series of one-handed square knots under no tension and with tension.
- 6) Tie a series of two-handed square knots on delicate tissue.
- 7) Tie a series of one-handed square knots on delicate tissue.
- 8) Tie a surgeon's knot at surface level.
- 9) Tie a surgeon's knot + a series of two-handed square knots under tension.
- 10) Tie a two-handed slip knot at surface level and at depth.
- 11) Tie a one-handed slip knot at surface level and at depth

II. ASSUMPTIONS OF PRE-TRAINING SURGICAL SKILLS AND KNOWLEDGE

- Basic knot tying training during 3rd year Surgery Clerkship
- Basic knot tying training during 4th year sub-internship elective

III. SUGGESTED READINGS, REFERENCES and PREPARATION

1. Surgical Knots and Suture Techniques, 2nd Edition, 2002. Giddings, FD. Giddings Studio Publishing, Fort Collins, Colorado. (PDF)
2. Covidien Surgical Knot Tying Manual, 3rd Edition, 2008-2009. Edlich RF, Long WB, Eds., Norwalk, CT. (PDF)
3. Ethicon Knot Tying Manual, 2005. Ethicon, Inc., Somerville, NJ. (PDF)
4. Ethicon Wound Closure Manual, 2007. Dunn, DL., Phillips, J., Eds., Ethicon Inc., Somerville, NJ. (PDF)
5. Ethicon website: www.ethicon.com
6. Syneture website: www.syneture.com
7. Covidien website: www.covidien.com
8. Handbook on Knot Tying and Surgical Skills: Tools of The Trade and Rules of The Road, A Surgical Guide, pp. 287-309. Deitch, E.A., Ed... Lippincott Williams & Wilkins, 1997. (PDF)
9. Video clips demonstrating various knot tying techniques are available by going to You Tube or Google and inputting the subject "Knot Tying Techniques"
10. Video clips demonstrating various knot tying techniques are available at <http://hsc.unm.edu/som/surgery/students/knottying.shtml>
11. ©Sim*Vivo, LLC.: Sim*Suture Training Guide www.sim-vivo.com
12. Wayne State Department of Surgery Knot Tying Video clips (to be shown during skills module presentation)

IV. ANATOMICAL CONSIDERATION

None

V. DESCRIPTION OF LABORATORY MODULE

1) Introduction and Overview

- The faculty instructor will review the cognitive and technical objectives and provide the rationale for the module.
- The faculty instructor will familiarize the students with instruments and tools used to perform this module.
- Students are divided into 2 groups of six (1:6 faculty to student ration)
- Students are asked to have reviewed the references provided in Section III prior to the module training session.
- Text and Web-based resources are made available for the training session.
- The faculty instructor will demonstrate all of the technical skill tasks required of the students to complete this module
- Video performance of each knot tying skill task will be provided.
- Faculty will provide expert demonstration of each of the knot tying skill tasks.
- Students will practice the knot tying techniques listed below in a step-wise orderly fashion starting with basic knot tying exercises, progressing to intermediate and advanced knot tying skills as satisfactory improvement is achieved.
- Performing knot tying skills in an orderly step-wise fashion enables the faculty proctor can better teach and evaluate the knot tying skills of the student.
- Students can compare their knot tying performances against the proficiency standards listed in Section XIII as a way to measure their technical knot tying skill.

2) Work Stations and Skill Tasks

There are 3 basic knot tying skill stations for the residents to use during the skills training module. They are list below.

Basic Knot Tying Skill Station

- Surgical Foam Suture Pad
 - Instrument-tied square knots at surface
 - Two-handed square knots at surface
 - Surgeon's knot + two-handed square knots at surface
- W.L. Gore, Ethicon, Sim*Vivo Suture and Knot Tying Boards
 - Two-handed square knots at surface, tension
 - Surgeon's knot + two-handed square knots at surface, tension
- Surgical Foam Suture Pad
 - One-handed square knots at surface
 - Two-handed slip knots at surface
 - One-handed slip knots at surface

Intermediate Knot Tying Skill Station

- W.L. Gore, Ethicon, Sim*Vivo Suture and Knot Tying Boards
 - Two-handed square knots at 2" depth
 - One-handed square knots at 2" depth
- 4" Knot Tying Cylinder
 - Two-handed slip knot + square knots to hooks, suture pad and penrose drain
 - One-handed slip knot + square knots to hooks, suture pad and penrose drain

Advanced Knot Tying Skill Station

- 6" Knot Tying Cylinder
 - Two-handed slip knot + square knots to hooks, suture pad and penrose drain
 - One-handed slip knot + square knots to hooks, suture pad and penrose drain
- 8" Knot Tying Cylinder
 - Two-handed slip knot + two-handed square knots to hooks, suture pad and penrose drain
 - One-handed slip knot + one-handed square knots to hooks, suture pad and penrose drain
- 4" Knot Tying Cylinder
 - One-handed slip-knot + square knots to penrose drain with needle driver in needle driving hand
- 6" Knot Tying Cylinder
 - One-handed slip-knot + square knots to penrose drain with needle driver in needle driving hand
- 8" Knot Tying Cylinder
 - One-handed slip-knot + square knots to penrose drain with needle driver in needle driving hand

3) Performance evaluation

- Student performance for this module will be assessed using any or all of the following three skill assessment metrics:
 - 1) Procedural Skill Task Checklist
 - 2) Task Completion Time
 - 3) Global Rating Scale.

**VI. MODULE INSTRUCTION, NARRATIVE DESCRIPTION
SKILL DESCRIPTION and TRAINING METHOD**

1) Introduction, General Principles and Practical Tips of Knot Tying

- The overall goal of any knot tying skill is to efficiently and effectively produce a series of stable square knots of sufficient strength to securely ligate a structure or approximate the edges of a wound or incision.
- The proper performance and application of these techniques results in safer faster surgery, less wastage of costly surgical materials, decreased operating room time, and improved patient care.
- When practicing, always use a thick string or suture first to determine if you are placing your knots correctly.
- The student should be able breakdown each type of knot into its individual component steps, master them, and then practice each step until they can move through the sequence of steps smoothly.
- Always start with a crossed suture if you can. By doing so, initiating a knot is easier, avoids crossing your hands and does not obstruct yours or the assistants view.
- Students will perform all knots using monofilament or braided suture.
- The half-hitch is the first basic throw of the surgeon in creating a square, hybrid or granny knot. This is also referred to as a *simple knot*. A half-hitch is formed when the suture material is looped and one end is completely twisted around the other end.
- For a knot of any kind to be performed, placement of two half-hitches is required.
- The square knot is the basic knot used in surgery. In this knot, two half-hitches are placed in opposite directions (mirror images of each other). This knot once tied cannot be loosened, and is the most secure knot used in surgery. A square knot can tie two-handed, one-handed, or with an instrument.
- The hybrid knot is an intermediate type knot; not quite square knot but not granny knot either. This knot is generally secure. It is performed by alternating the direction of the half-hitches using the thumb and index finger as when performing a square knot, but in this instance the hands do not rotate 180° to form a square knot. In essence, it is a 'psuedosquare' knot.
- The granny knot is performed by placing two half-hitches in the same direction. This knot lacks security, is unstable, and will loosen with excess tension or motion.
- The surgeon's knot is performed when two twists are placed in the same direction in the first half-hitch (known as surgeon's half-hitch or throw, which is then followed by a second half-hitch (basic single throw) in the opposite direction to produce a secure squared surgeon's knot. When two surgeon's half-hitches are throw in opposite directions this is known as a double-double square knot.
- The slip knot is performed primarily when two half-hitches are thrown in the same direction and vertical tension is applied to one suture strand (similar to a granny knot except horizontal directed tension is applied for a granny knot). Similarly, a square knot can sometimes be secondarily converted into a slip knot

by applying pressure on one end of the suture. A slip knot can be tied two-handed, one-handed, or with an instrument.

- Placement of all final (end) knots is done with the suture strands in a horizontal direction to ensure proper sitting of the knot.
- Knots should be as small as possible to prevent an excessive amount of tissue reaction or minimize foreign body reaction.
- Avoid “sawing” or contact friction of the suture strands as this can weaken the integrity of the suture.
- Avoid excessive tension to suture during tying as this may break the suture and cut through tissue.
- Suture should approximate tissue, not strangulate
- Tie only the proper number of knots. Extra knots do not add to the strength of a properly tied knot. Bulk is not better!
- Avoid damage to suture material when handling. Avoid crimping or crushing of the suture strands.
- Students should be prepared to change stance or position in the OR in order to place a knot securely and flat. Do not be an immobile surgeon!
- Students will receive specific feedback at each step of the specific knot tying skill so that they will not acquire poor technical habits which will need to be corrected at a later time in their training. Once the students can perform all of the component parts of the knot tying skill in the appropriate sequence, they will be allowed to practice the skill until they can move through the sequence of steps smoothly.
- Step-by-step description with pictures detailing the specific hand and finger movements for each hand are described in the Ethicon, Syneture, W.L. Gore and Giddings knot tying manuals (distributed to as PDFs).
- Residents are recommended to review the available Department of Surgery and web-based videos clips on Google and YouTube show how each of the knots briefly described below are performed.

2) **Instrument Tied Square Knot**

- Instrument-tied knots are best used for wound closure or when one or both of ends of the suture are too short to be effectively tied with one or two hands. An easy set of rules to remember when tying this knot are as follows: 1) Try to keep the needle holder parallel to the wound, 2) Always role the long suture strand over the needle holder toward the short end and tighten the knot in the opposite direction by pulling away from the short end of the suture, 3) Keep free suture tail about 2 to 3 cm in length.
- The skill is practiced on the surgical foam suture pad or with a pig’s foot. Use both braided and monofilament sutures. When performing this technique with a monofilament suture, caution is urged to avoid repeated grasping of the main body of the suture with the needle driver as this may lead to breaking of the suture, and to avoid excessive bending of the suture as this may result in cracking and weakening of the suture.

- The benefits of instrument-tied square knots are suture conservation and speed. If performed properly, one can tie up to 10 instrument-tied square knots using an 18 inch suture. This compares to only 1-3 two- or one-handed-tied knots with the same length of suture.
- It is important for the residents to breakdown this entire knot tying skill into its component parts and have them master each of the parts before practicing the entire skill start to finish.

3) Two-handed Square Knot (Reef Knot or Flat Knot)

- This is the primary knot used in surgery. This knot is composed of two half-hitches (ei. simple knots) thrown in opposite directions (i.e., mirror images of each other) and secured with horizontal directed tension.
- The two-handed square knot is the best method to use when the closure requires *firm and continuous pressure* during the process of tying.
- Always start with a crossed suture. In right-handed tying, the long or fixed segment of the suture is held in the left hand, whereas the right hand holds the short or free end of the suture and does most of the maneuvering by holding, letting go, and regrabbing the suture.
- Residents will receive specific feedback at each step of the specific knot tying skill so that they will not acquire poor technical habits which will need to be corrected at a later time in their training. Once the residents can perform all of the component parts of the knot tying skill in the appropriate sequence, they will be allowed to practice the skill until they can move through the sequence of steps smoothly.
- Step-by-step description with pictures detailing the specific hand and finger movements for each hand are described in the Ethicon, Syneture, W.L. Gore and Giddings knot tying manuals (distributed to as PDFs).
- Residents are recommended to review the available Department of Surgery and web-based videos clips showing how the two-handed square knot is performed.

4) One-handed Square Knot (Reef Knot or Flat Knot)

- All maneuvering with this knot, including releasing and regrasping of the suture, is done with one hand while the other hand holds the long strand of the suture taut.
- The one-handed square knot can be performed more quickly than a two-handed knot. When tying one-handed knots using a suture tie only, square knots are secured using both index fingers. When the surgeon is tying with a suture and needle often the needle driver remains attached to the needle. In this scenario, only one index finger is used to position each half-hitch and secure the knots, thus keeping the needle and needle driver out of the wound.
- This knot has the advantage that it can be used in deep cavities.

5) **Surgeon's Knot (Friction Knot)**

- This knot is used to secure knots on wounds that will be under times of excessive wound stress and tension.
- The surgeon's knot is created by producing two primary turns of the same direction in the first half hitch loop and then placing the second half hitch in the opposite direction so that a square surgeon's knot results.
- Placement of a surgeon's half-hitch as the initial knot allows the second half hitch knot to be placed without having to maintain tension on the suture.
- The primary disadvantage of this knot is that it is bulky, difficult to tighten, and in the hands of inexperienced operator's results in increased breakage of the suture while tying.
- This knot should not be performed when tying at depth as it is difficult to maintain its configuration.

6) **Slip Knot**

- This knot is used to secure knots at depth and for those wound closures that are under excessive stress and tension.
- This knot is created by two half-hitches thrown in the same direction with vertical tension placed to the hand holding the suture. This temporarily locks or fixes the knots to the tissue under tension until a third half-hitch is thrown in the opposite direction producing a square knot and permanently securing the wound or incision edges together.
- Following this initial slip knot-square knot, the appropriate number of square knots is then produced as recommended for the specific suture used.

7) **Tying at Depth**

- Once the residents have become proficient with tying two-handed and one-handed square and slip knots at surface level, they must become proficient at tying at depth.
- Two different techniques are used to tie at depth depending on whether or not the surgeon uses a suture tie or suture and needle when tying knots.
- When using a suture tie, the surgeon slides knots down to the target tissue using both hands and alternating index fingers.
- When using a suture and needle, the surgeon slides knots down to the target tissue using only the index finger on the hand not holding the suture and needle.

8) **Granny Knot**

- This knot is not recommended under any circumstances and is not intentionally used in surgery.
- It can be converted to a *slip knot* if one of the suture strands is pulled and placed on vertical tension.
- Granny knots are to be avoided at all times.

VII. COMMON ERRORS and/or PREVENTION STRATEGIES

▪ Two Handed Knot Tying at Surface – 4 major errors

- *Excessive motion involving the right hand.* The instructor will emphasize that the majority of work for this knot is done with the left hand. The right hand is used primarily to manipulate the rope or suture material. If the student persists in this error the instructor will ask the resident to use only his right hand while he uses his left hand to cooperatively aid the student in tying the knot. This simple teaching method helps the student understand the secondary role of the right hand in tying this knot. The instructor should emphasize that excessive use of the right hand slows the performance of the completion of this skill.

- *Dropping the suture or failure to maintain tension on the suture.* Initial attempts at performing this knot will invariably result in dropping of the rope or suture and/or subsequent loss of tension as the first and second loops are formed. Furthermore, as the students gain speed and efficiency in this skill there is a tendency to relax their hold on the ends of the suture. These common yet preventable errors often results in loss of the first or second knot loops resulting in complete failure to tie this knot, and/or inadequate ligation of the structure due to formation of “air knots”. The students should understand that maintaining tension on the rope or suture is a more important goal than speeding carelessly through this skill. The students should be instructed to maintain tension on the sutures at the expense of speed at all times during this module.

- *Hands located too close to knots.* The result of this error is that it becomes difficult to pass the straight end of the suture, thumb or finger through the loop and the suture end is either dropped completely or tension is lost. The other error related to poor hand position is the inability to form a second loop. Either outcome results in a loss of knot tying efficiency. To prevent these errors the students should be instructed to grasp the sutures at a point along their length which allows for the formation of the first or second loop and prevents dropping of the suture or loss of tension to the suture.

- *Hands located too far away from the knots.* Here when the hands are too far away from the knots it is difficult to maintain tension on the suture. Coincidentally, it is difficult to gauge how much tension on the suture is required to successfully place the knots while avoiding excessive outward tension on the tissue being tied.

- *Failure to cross hands and suture.* Formation of a true square knot requires that the student crosses his/her hands and fingertips while performing the two half-hitches. Failure to do so will result in a non-squared knot, the so-called “Granny Knot”. This error can be avoided by demonstrating the difference between the

two knots. Using the rope, the instructor can demonstrate the clinical result of performing a non-squared knot. The instructor will explain how the non-squared knot will slip in almost all clinical scenarios and what the expected outcome will be if this knot failure occurs in an actual patient.

- **Two Handed Knot Tying at Depth.**

- The major error that occurs with this knot is the failure of the student to slide the knot completely down to the intended depth. This error results in the formation of gaps between each previous knot loop (e.i., air knots) resulting in an incomplete tissue ligation or closure. The instructor can show the student how to avoid this error by demonstrating how each loop should be slowly and deliberately slid down to the intended depth and secured with appropriate tension. Additionally, knots should be secured using opposite index fingers to avoid producing ‘granny knots’. Index finger should be placed on knots directly on the target tissue.

- Another common error is that the length of the suture tail (mobile hand) is too short in relation to the depth of the target tissue. This can result in loss of appropriate tension on suture during knot tying or dropping of the suture itself.

- **One Handed Knot Tying at Surface or Depth.**

- The same major errors that can occur with two handed knot tying can occur with one handed knot tying. In particular, residents will have difficulty maintaining tension as they manipulate the strands of the suture. In addition, the students will struggle with maintaining the proper size loop to allow the left index finger to bring the opposite suture strand through the loop. The key practice instruction for this skill is to proceed slowly enough to maintain tension on the suture strand while maintaining a large enough loop to manipulate the suture strand through the loop.

- **Instrument Tying.**

- The specific error that students tend to make with this knot tying skill relates to the length of the suture strand grasped by the instrument to secure the square knot. It tends to be either too long or too short. If this suture “tail” is left too long, it makes manipulation cumbersome particularly in deep closed spaces and thus creates inefficiencies. If the suture tail is left too short, it becomes difficult to grasp the suture strand and pull it through the loop. Again, creating inefficiencies and increasing the length of time for completion of the knot. The instructor can help the students avoid these errors by describing the optimal suture strand length, and demonstrating the differences between an optimal length of suture strand versus suture strands which are either too long or too short. Caution must be used when performing this knot tying technique with a monofilament suture. Repeated grasping and bending of the monofilament suture with a needle holder may cause the suture to weaken or break at a critical area.

▪ **Miscellaneous Issues.**

- Final end knots should be tied with the suture strands in a horizontal direction to ensure proper sitting of the knot.
- Knots should be as small as possible to prevent excessive amount of tissue reaction.
- Avoid “sawing” of the suture strands as this can weaken the integrity of the suture. Also avoid excessive tension as this may cut tissue and break the suture.
- Tie only the appropriate number of knots. Extra ties do not add to the strength of a properly tied knot. Bulk is not better!

VIII. EXPERT PERFORMANCE DEMONSTRATION

- Video demonstration not available at this time
- “Live” faculty demonstration available

IX. EQUIPMENT REQUIREMENTS and MATERIALS NEEDED

Basic and Intermediate Knot Tying Skill Station

- W.L. Gore suture and knot tying board
- Ethicon suture and knot tying board
- Surgical foam suture pads
- 2-colored tying rope
- #3 tying thread
- 3-0 monofilament or braided suture
- Adson forceps
- 5”-6” needle driver
- Suture scissors
- Stopwatch
- Magnetic hooks
- 2-0/3-0 braided sutures on cutting needle or ties
- 2-0/3-0 monofilament sutures on cutting needle or ties
- #3 tying thread
- Tissue forceps with and without teeth
- Debaquey forceps (medium, long)
- 6”-8” needle driver
- Suture scissors
- Stopwatch

X. SUGGESTED TIME LENGTH

2 Hours

XI. DOCUMENTATION OF COMPETENCY/PROFICIENCY

Review the syllabus for this module prior to the teaching session. Following the formal teaching session of the knot tying module students will be expected to practice and engage in a self-improvement program known as “*Deliberate Practice*” for each of the technical exercises in the module. Deliberate practice is defined as a practice session where the task is well defined, has appropriate skill difficulty, allows for informative feedback and error correction, permits repetition of the task, and is performed within a defined time period. Previous experience has shown that a focused program of deliberate practice can help to improve the performance of residents and surgeons alike in becoming a “*surgical skills expert*”.

You are being asked to become proficient at 17 different knot tying skills in this module. You will be graded by one or more assessment tools as listed at the end of Section V. Based upon the results of these assessment tools a decision will be made to either verify whether or not you are proficient at the following knot tying skills.

Skill Task – Basic Knot Tying Skills	Skill Task Score	Skill task Completion Time
1. 10 instrument-tied square knots at surface	9 of 11	60 seconds
2. 10 two-handed square knots at surface (tying rope)	6 of 8	60 seconds
3. Surgeon’s knot + 9 two-handed square knots (tying rope)	8 of 10	30 seconds
4. 10 one-handed square knots at surface (tying rope)	6 of 8	60 seconds
5. Slip knot (2-handed) + 4 two-handed square knots (tying rope)	7 of 9	30 seconds
6. Slip knot (1-handed) + 4 one-handed square knots (tying rope)	7 of 9	30 seconds
7. 10 two-handed square knots at surface (2-0/3-0 suture)	6 of 8	60 seconds
8. Surgeon’s knot + 4 two-handed square knots (2-0/3-0 suture)	8 of 10	30 seconds
9. 10 one-handed square knots at surface (2-0/3-0 suture)	6 of 8	60 seconds
10. Slip knot (2-handed) + 4 two-handed square knots (2-0/3-0 suture)	7 of 9	30 seconds

11. Slip knot (1-handed) + 4 one-handed square knots (2-0/3-0 suture)	7 of 9	30 seconds
12. # two-handed square knots tied in 60 seconds	6 of 7	20 knots
13. # one-handed square knots tied in 60 seconds	6 of 7	20 knots
Skill Task – Intermediate-Advanced Knot Tying Skills	Skill Task Score	Skill task Completion Time
14. 10 two-handed square knots at 2” depth (2-0/3-0 suture)	7 of 8	60 seconds
15. 10 one-handed square knots at 2” depth (2-0/3-0 suture)	7 of 8	60 seconds
16. 10 two-handed square knots at surface (thin foam strips, 2-0/3-0 suture)	7 of 8	60 seconds
17. 10 one-handed square knots at surface (thin foam strips, 2-0/3-0 suture)	7 of 8	60 seconds
18. Slip knot (2-handed) + 4 two-handed square knots at 4” depth (2-0/3-0 suture)	7 of 8	75 seconds
19. Slip knot (1-handed) + 4 one-handed square knots at 4” depth (2-0/3-0 suture)	7 of 8	75 seconds
20. Slip knot (1-handed) + 4 one-handed square knots at 4” depth with needle driver in right hand (2-0/3-0 suture)	8 of 10	75 seconds
21. Slip knot (2-handed) + 4 two-handed square knots at 6” depth (2-0/3-0 suture)	7 of 8	90 seconds
22. Slip knot (1-handed) + 4 one-handed square knots at 6” depth (2-0/3-0 suture)	7 of 8	90 seconds
23. Slip knot (1-handed) + 4 one-handed square knots at 6” depth with needle drive in right hand (2-0/3-0 suture)	7 of 8	90 seconds