

**Wayne State University
Department of Surgery**

Knot Tying II Module

Syllabus

Knot Tying II Module

COGNITIVE OBJECTIVES

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

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

TECHNICAL SKILLS OBJECTIVES

By the end of this laboratory session participants should:

- 1) Tie a series of one-handed square knots
- 2) Tie a series of two-handed and one-handed square knots at depth

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 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!

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.

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.

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.

- **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.

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.

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.**

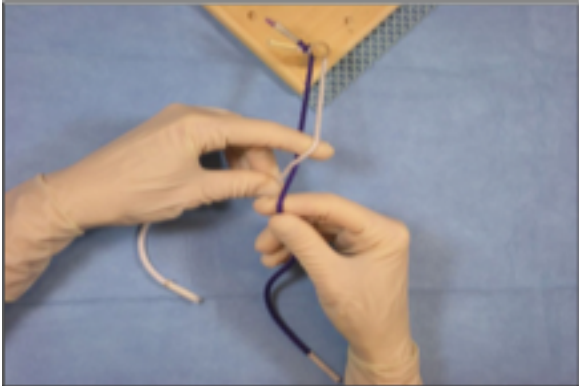
- The specific error that students tend to make with this knot tying skill relates to the length of the suture strand grasped by the instrument to secure the square knot. It tends to be either too long or too short. If this suture “tail” is left too long, it makes manipulation cumbersome particularly 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.**

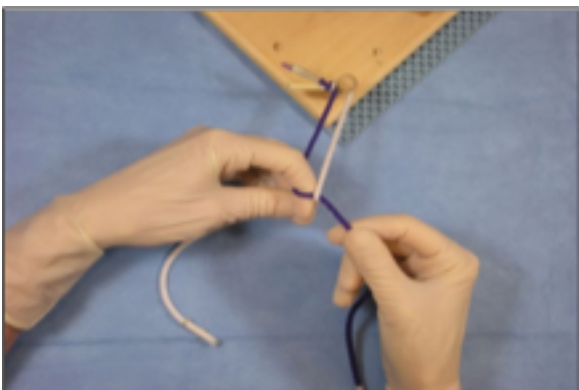
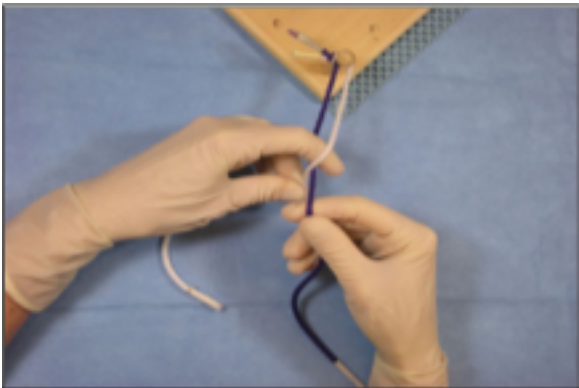
- Final end knots should be tied with the suture strands in a horizontal direction to ensure proper sitting of the knot.
- Knots should be as small as possible to prevent excessive amount of tissue reaction.
- Avoid “sawing” of the suture strands as this can weaken the integrity of the suture. Also avoid 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!

Exercise – One-handed knot tie

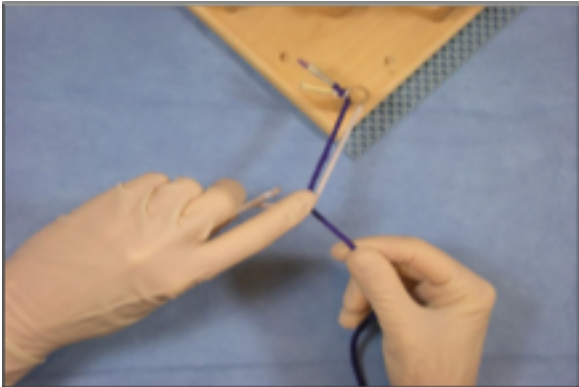
1. Start with the light-colored string crossed over the top of the dark string. The right hand holds the dark string. The light string is pinched between the thumb and middle finger of the left hand, and over the top of the index finger, as shown in the image.



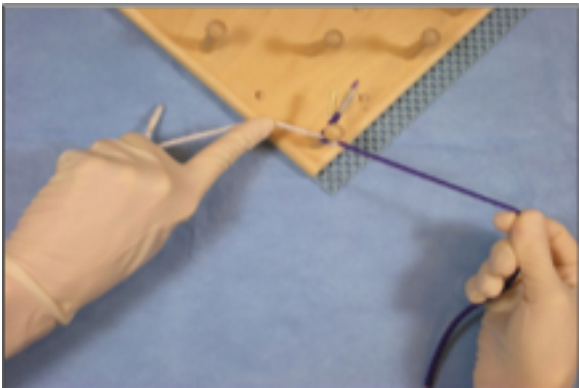
2. Bend the left index finger downward, over and around the dark string, until the light string is on top of the nail bed of the index finger.



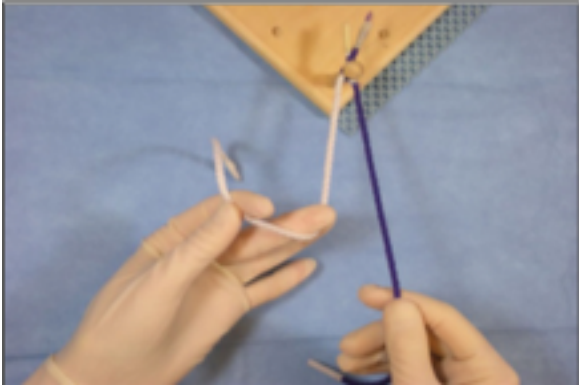
3. Straighten the left index finger, with the light-colored tie looped over its tip, and then pull the light tie through the loop.



4. Complete your first throw by laying the knot down.



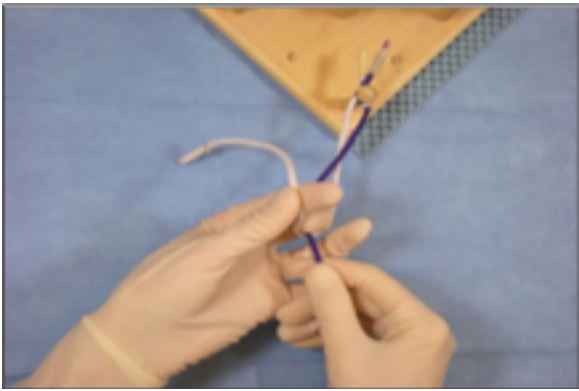
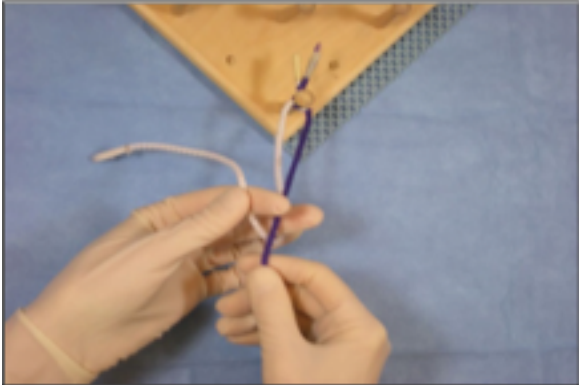
5. Begin the second throw with your left hand supinated, the light string across your hand, pinched between thumb and index finger.



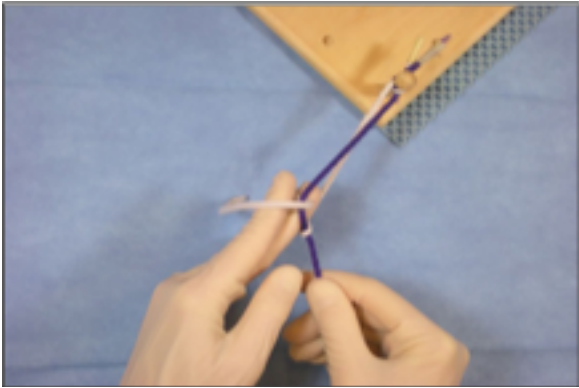
6. Move the dark tie between index and middle finger. ^[1]_[SEP]



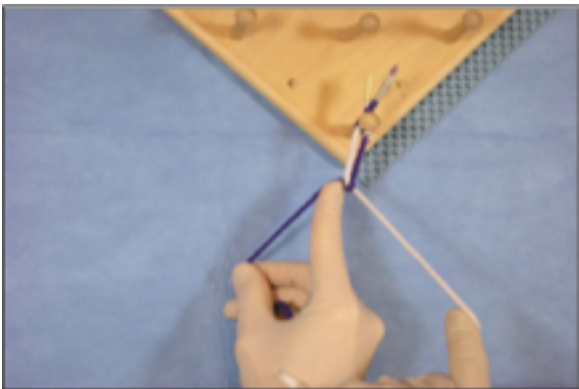
7. Bend the middle finger, and position it over the dark tie and under the light tie.



8. Straighten the middle finger, pulling the light tie through the loop.



9. Cross the left hand over the right to lay the knot down square.



Knot Tying OSAT ASSESSMENT

INSTRUCTIONS:

Place a knot (instrument tie; two-handed tie; one-handed tie) with 6 throws.

ITEM	Not done Or Incorrect	Done Correctly
1. Places square knots	0	1
2. 1 st throw down is square	0	1
3. 2 nd throw down is square	0	1
4. Maintains appropriate tension while tying	0	1
5. Maintains appropriate tension on knot	0	1
6. Conserves motion	0	1
7. Holds hands at an appropriate distance from the knot	0	1
8. Avoids air knots	0	1

Maximum Total Score

(8)

Total Score

Comments

Resident: _____

Date: _____ **Examiner:** _____