Sim*Tie

Training Guide

-Two-handed and One-handed Surgical Knots-

Square knots, slip knots, tying against resistance, tying with difficult access, tying delicate tissues, tying under a clamp

Suggested Exercises and Homework Assignments

Visit us on the web at

www.sim-vivo.com

SIM*VIVO

…in the hands of the learner!

Sim*Tie

-Two-handed and One-handed Surgical Knots-
Suggested Exercises

Welcome to the Sim*Tie Learning System. The purpose of this training module is to provide you with a program that will demonstrate proper technique for the completion of two-handed and one-handed surgical knots and then provide you with a guide to direct the continuing development of your skills. At Sim*Vivo, we are firm believers in the value of dedicated and distributive practice that has been shown to be the best way to learn a skill to a level of competence. After showing you how to complete various surgical ties through reference to our complimentary training videos, the major purpose of this manual is to suggest repetitive exercises that will guide your practice efforts. The ultimate goal is for you to attain a level of confidence in tying surgical knots that will make your transition into the OR smooth and seamless … *and impressive to your colleagues!*

While we do provide instructional videos, we suggest that you work closely with an experienced mentor to monitor your technique. For your success in a surgical field, it is important that your own technique for knot tying is accurate and efficient. To avoid "bad practice" (which is worse than no practice at all) the quality and efficiency of your work should be assessed by intermittent review by a competent mentor or instructor.

In order to encourage practice, sufficient tying materials have been provided in this learning system to assure that you perform enough repetitions to satisfactorily acquire the skill. Most of all, throughout all of these exercises, challenge yourself to continually improve your skills with each knot, and have some fun while doing it! Remember: *there is no room for fumbling in the operating room!*

A little definition is in order: the proper name for the tying strand that we are using is a *ligature*. In this set of exercises, the words ligature, tie, and suture are used interchangeably. All strands are long enough (45 cm) to be used by the novice without much difficulty. Don't hesitate to use a tie twice if there is enough residual length.

So how do we get started? There are several ways to learn the techniques of surgical knot tying including instruction from mentors and friends, reading an instruction manual, or trying to find something on *You Tube*. To help you master knot tying skills with the Sim*Tie learning system, Sim*Vivo has produced several instructional videos that will take you step by step through the learning exercises for two-handed and one-handed knots. This may be accessed at ***www.sim-vivo.com***. Go to the "Guides + Video" link and feel free to open up the Sim*Tie video of the skill you are trying to acquire. We believe that these videos will provide much better guidance to learning the skill than any printed publication. The purpose of this guidebook is not to provide you step-by-step instruction, but rather to guide you through the learning videos and give you direction for the appropriate practice of the skills that you will acquire.

Getting started …

So first, let's go to the Sim*Vivo instructional videos on our web site. Here, you will find eight short video segments:

1. Introducing Sim*Tie
2. Some knot tying theory
3. The two-handed tie
4. The one-handed tie
5. Tying against resistance
6. Tying with restricted access
7. Tying delicate structures
8. Tying around clamps

As we present practice exercises, the pertinent video clip will be listed on the right. ⇩

Introducing Sim*Tie- As you open the Sim*Tie box, you will find a sturdy knot tying board with two hooks, two posts, and several circles on the surface. There is also a cup for the practice of delicate knot tying, a cylinder to simulate difficult access and a bag of supplies. In the bag are three separate packages of ties (3-0 silk, 0 nylon, and 6-0 nylon), rubber bands, a clamp, scissors, scalpel, and a simulation system for tissue (fabric strands and post cover). In the series of videos, we will show you how to use all of the accessories and supplies in the module.

Video #1
Introducing Sim*Tie

To begin with, we will be using the 3-0 silk ties. Each is 45 cm in length which is standard for surgical ties. For practice, we suggest that you place the tying board on a table top that is of a height that provides a comfortable distance for tying if you are standing or sitting down. Sitting will require a tall chair or a low table top. There should be good lighting to help with depth perception. The presence of other distractions is up to you … in our simulation laboratory, we sometimes practice with the hottest new rock tunes in the background … it helps with the potential boredom of serious practice!

Some Knot Tying Theory- There are no exercises or practice for this section of the curriculum. We just want to emphasize the difference between a square knot and a slip knot and, for the square knot, the importance of bringing the individual throws down **flat** and **square**. The square knot is the ultimate surgical knot as it is secure once the two throws are complete. The slip (or granny) knot differs from the square knot in that both of the initial two throws are in the same direction. This allows the completed knot to slip down to the correct tension when it is tied against resistance. Of course, "slipping" can occur in both directions, so slip knots always need to be secured with additional throws that alternate into a square knot. Hey, did you know why the slip knot is called a "granny?" Folklore has it that sailors preferred the square knot for securing their boats and sails. The slip knot came to be called the granny knot because "real" sailors thought that this was the knot more often tied by women (grannies) and landlubbers (Hey, don't shoot me for political insensitivity … I'm just telling the story).

Video #2
Some Knot Tying Theory

Tying the Two-Handed Knot- While it is less slick and sexy than the one-handed knot, you should first master the two-handed knot which will be invaluable for difficult access, short strands, and slipping throws. For the square knot, the direction of the throws is alternated. The different directions are created by first using either your thumb or index finger as a "post" around which the free end of the tie is passed. Apposing your thumb and index finger around the free end and passing it through the loop completes the throw as you retrieve the free end and bring it down on the structure to be tied. In order to easily bring the first throw down "flat" the ends of the sutures should be crossed prior to beginning the throw. This seems like a nuisance but is essential to the efficiency and smooth movement of your hands as the throw is laid flat. The the second throw of the square knot uses the other digit (thumb or index finger not used previously) as the post resulting in a throw in the opposite direction. The hands must be crossed slightly to bring it down flat. When the throw is brought down to the hook, your index finger should be right there to apply the appropriate amount of tension on the completed knot. This is

Video #3
Tying the Two-Handed Knot

especially important for finer suture which might break if the tension on the knot is applied from the ends of the strands. Watch the video … it will make sense! Use the scissors or scalpel to cut the knots off of the hooks.

Are you comfortable and efficient tying a square knot? Now let's work on style. During each throw of a two-handed knot, as you push the strand all the way through the loop with your finger or thumb, you should be able to retrieve it with your other hand on the first attempt. No fumbling or bumbling! You should be able to do this with your eyes shut. As the throw goes down, make sure that your index finger goes all the way down to the knot to secure each throw.

OK … now for some exercises. When you have completed each of the outlined tasks, check off the boxes. Don't cheat! Feel free to practice these exercises more than once.

With one strand, place 25 square throws – back and forth, alternating. Make them flat and secure. Place your index finger on the knot to apply the appropriate amount of tension to tighten each throw.	□
Repeat this exercise making sure that you do not move the board … no fair pulling up on the hook! Try to avoid putting too much tension on the hook as you tie.	□
Repeat this exercise with your eyes shut!	□
Tie 5 knots, each with three throws, on the hook making sure that the first throw is flat and the knot is square. Pull on one strand. Did it slip? If so, then start over and tie 5 more.	□

For slip (granny) knots, the first two throws of the knot are in the same direction. You can use your thumb or your index finger as a post … it doesn't matter. While the first throw is brought close to the hook, the real tension will be placed on the second throw to cinch the knot down appropriately. Be careful not to put too much tension on the knot as you might strangulate the tissue to the point that the knot cuts through and falls off. The second and third throws of this knot should be in opposite directions (square knot) to secure it appropriately and keep it from "slipping backwards". Try some more repetitive exercises:

With one strand, place 25 slip knot throws in the same direction. To mix it up, place 5 throws in one direction and then 5 throws in the other direction, and so forth.	□
Repeat this, making sure that you do not move the board while tying.	□
Repeat this with your eyes shut!	□
Tie 5 knots each with three throws on the hook making sure that the first throw and the second are in the same direction. Gently push down on the second throw of the knot with your index finger to tighten it on the hook to the appropriate tension. Complete the knot with final throws in alternating directions.	□

Before you go any further, try your hand at tying two-handed knots with the 0-nylon sutures. The technique is the same but the sutures are little less flexible and require a little more force to secure the throws. Unlike silk that has a high coefficient of friction, nylon is very slippery and, in order to secure

the knot, the material must be deformed which requires more force to be applied to the completed knot. Try a few of the above exercises with the 0 nylon suture.

Tying the One-Handed Knot - Now that you have mastered the two-handed knot, learning the one-handed knot will be a piece of cake! The principles are the same: alternate the throws for a square knot and repeat the throws for a slip (granny) knot; always place your index finger on the knot to provide the final tension as the throw comes down; and lay the throws down flat. Watch the video for the details of the alternating throws of the one-handed knot. As you can see, by crossing the strands at the beginning, you can avoid crossing your hands to bring the knot down flat. Your practice for one-handed knots is very similar to that for the two handed knots:

Video #4
Tying the One-Handed Knot

With one strand, place 25 alternating square throws with the one-handed technique. Make them flat and secure. Place your index finger on the knot to apply the appropriate amount of tension to tighten each throw.	□
Repeat this exercise making sure that you do not move the board. Try to avoid putting too much tension on the hook as you tie.	□
Repeat this exercise with your eyes shut!	□
Tie 5 knots each with three throws on the hook making sure that the first throw is flat and the knot is square. Pull on one strand. Did it slip? If so, then start over and tie 5 more.	□

Tying a slip (granny) knot one-handed is pretty easy … just put your throws in the same direction to facilitate the slipping of the knot. Always complete the knot with an alternating throw to secure it. Try these exercises:

With one strand place 25 slip knot throws in the same direction. To mix it up, place 5 throws in one direction and then 5 throws in the other direction, and so forth.	□
Repeat this with your eyes shut!	□
Tie 5 knots each with three throws on the hook making sure that the first throw is and the second is in the same direction. Gently push down on the knot with your index finger to tighten it on the hook to the appropriate tension. Complete the knot with a final throw in the opposite direction.	□

As before, try a few knots with the 0-nylon as you repeat some of the above exercises.

Tying Against Resistance – Wouldn't it be easy if tying knots in surgery was as simple as tying them on brass hooks? Alas, that is not the case!! In many situations, as you are tying, the tissue "fights back" with elastic rebound that tries to undo all those good knots that you are tying. To deal with this, we can use the surgeon's knot or gently keep a little tension on our tightened first throw, while we manipulate the strands for our second throw. To simulate tissue resistance, rubber bands are placed around the posts, and we tie knots to appose the bands against their natural elasticity. Start by placing a

Video #5
Tying the Against Resistance

rubber band around the posts and pick a spot to place your knot about 1/3 the length from the post. Try to tie a regular square knot … does the rubber band tend to push your first throw apart. Darn!!!

A surgeon's knot is simply the first throw of a square knot in which the loop is repeated twice in the same direction and subsequently brought down flat on the tissue. You can use your thumb or index finger as the post for a surgeons knot but the suture ends should be crossed prior to starting in order to get a flat throw without having to cross your hands. Watch the video and then practice this first throw a few times. The second throw of a surgeon's knot is exactly the same as a regular square knot. Practice this a few times by completing the following exercises with two-handed and one-handed surgeon's knots on the rubber band:

	Two-handed	One-handed
Tie three surgeon's knots on a rubber band wrapped around the posts. Square and flat! Make sure that there is sufficient tension on the first throw to hold it in place	□	□
Cut the knots out with your scalpel and repeat three more times (that means a total of nine knots). For the final practice session, tie the sides of the rubber band together as close to the posts as you can.	□	□

An alternative to the surgeon's knot is the simple slip knot in which the first two throws are placed loosely and then cinched down to the appropriate tension against the resistive tissue. Make sure that you complete the knot with a square knot throw: Try these exercises:

	Two-handed	One-handed
Tie three slip (granny) knots on a rubber band wrapped around the posts. Cinch down to the appropriate tension. Not too tight!	□	□
Cut the knots out with your scalpel and repeat three more times (that means a total of nine knots)	□	□

Tying with Restricted Access – Now comes the fun part. There are many situations in which the exposure is awful and in a deep space but the bleeding from a large vessel or nasty tissue bed still needs to be controlled. This scenario requires skill in "tying in a hole" … and if you want to see somebody sweat, just watch a young, inexperienced surgeon try to get control of the cystic artery or deep mesenteric bleeder as the patient is trying to exsanguinate. Skill with the following exercises is going to make you look like a *maestro* if you are ever caught in this clinical situation.

Video #6
Tying in Restricted Areas

Note on your board that one of the hooks has a circle drawn around it. The cylinder that comes with the tying board should fit perfectly on that ring. Place the cylinder on the circle around the hook. Now, look at the videos that show you how to tie a knot on the hook in the middle of the cylinder without moving the cylinder. You can use the clamp as a "passer". Put the end of the tie in the tip of the clamp and use the clamp to encircle the hook with the tie. Unclasp the clamp and … *voila* … you are ready to tie!!

In this situation, the manipulation of the strands for the creation of the throw is done away from the hook or structure to be tied. For this exercise, it is completed outside the constriction of the cylinder. The throw is then gently guided by one of your index fingers down to the hook. The finger goes **slightly**

(minimally, barely, imperceptibly) beyond the hook (past pointing) so that the tension to the knot can be placed along the straight line. The throw is tightened by the simultaneous application of a small push of the index finger on the knot and the other end of the strand. Knots tied in restrictive areas can be either one- or two-handed: it doesn't make a difference. The key is how precisely they are tightened.

Now, you have completed the knot - do you see any of the black ring exposed around the cylinder? If so, then you have moved the cylinder and you haven't tied a "perfect knot" in the hole. Keep practicing until you can consistently accomplish this task without moving the cylinder. Here is an exercise:

	Two-handed	One-handed
Tie a knot within the cylinder on the hook. Did you move the cylinder? Repeat 5 times	□	□
Now, tie the knot with an 0 nylon suture. How did you do?	□	□

Tying Delicate Structures – Imagine this: you have just completed a complex arterial-venous anastomosis and there is one small bleeder right on the anterior surface. You perfectly place a single suture across the bleeder with a 6-0 nylon suture and start tying. While placing the first throw, you a pull a little too hard and the whole suture pulls through the tissue … and now the blood just jetted onto your face mask ….what a nightmare!!! It is clear that you need to practice tying around delicate structures.

Video #7
Tying delicate structures

To simulate this, we have provided a very light plastic cup with a hook attached to its top. The rim of the cup exactly fits on the circle drawn on the board behind the posts. So here is the challenge: *can you tie a knot on the hook without moving the cup?* The problem is not the creation of throws, but rather bringing down the throw onto the hook without placing any traction on it. As shown in the video, this is done by placing equal tension on both ends of the strands simultaneously in a lateral direction. The index fingers are then moved closer to the hook and each pulls in opposite directions to secure the throw to the hook. The knot can be created with a two- or one-handed technique away from the structure to be tied. The following practice session should be completed with a 3-0 silk and 6-0 nylon tie:

	3-0 silk	6-0 nylon
Using a two-handed technique, tie five square knots onto the hook on the cup without moving it. Keep going until all 5 are done	□	□
Repeat the above exercise with a one-handed technique … square knots! Continue until you have tied 5 knots.	□	□

Tying around a clamp – At this point, you should be feeling pretty confident about your knot tying skills - great! However, so far, we have just been tying around hooks and rubber bands. To get a little closer to reality, we have developed an exercise that simulates tying around a clamp placed on tissue. For this, you will need some help in the form of a person to remove the clamp when you are ready to provide the last little bit of tension to crimp your throw onto the tissue. It can be anyone: colleague, significant other, neighbor, kids …

Video #8
Tying around a clamp

To prepare for the simulation, we are asking you to take a small piece of the red cloth and stuff it down one of the posts leaving a small tail exposed. Over this, place an elastic post cover and unroll it down

the post. Make a small nick in the middle of the cover with the scalpel and, with the clamp, pull a small length of the cloth through. This now simulates bleeding tissue that will need to be clamped and tied.

To start the exercise, place the curved Crile clamp across the exposed tissue simulator and have your assistant hold it with the tip exposed. Use a 3-0 silk tie and, while holding one end, place the other close to the clamp. Reach around the clamp with your free hand and grasp the end. The clamp may have to be rotated up while doing this to allow room for your hand to come around the back of it. Once you have grasped the free end, use your index finger to pass it around the point of the clamp. Cross the strands and place your first throw. As it contacts the fabric tissue simulator, ask your assistant to release the clamp slowly. With a coordinated effort, tighten your throw as the clamp is removed. If the tie comes down before the clamp is removed, it could tear the tissues still held tightly by the clamp. If the clamp comes off before the tie is placed … well …. it will bleed!! Place two more throws to complete a final square knot. After completing the knot, pull up the tissue simulator strip a short distance and cut it off. Practice this with two- and one-handed knots with the following exercise:

	Two-handed	One-handed
Tie a square knot around the clamp on the tissue. Repeat four times	□	□

Practice

Now that you have mastered the knot tying technique, it is time to practice, practice, practice. Take your board and ties home and spend some time repeating the tasks that you have already learned. To help you in organizing and completing your practice, why don't you try the following exercises. Check the box when you have completed them. (*For one handers: tie regular knots when the exercise calls for a surgeon's knot.*)

	Two-handed	One-handed
With the practice suture, tie twenty five surgeon's knot throws … that's right: two loops in each throw. For one handers, use regular throws.	□	□
Take two practice sutures and tie each on one of the hooks: a double throw followed by two single throws. (One handers tie regular knots). Once you have done this, add 7 more throws to each knot.	□	□
Take two practice sutures and repeat the above exercise … square and flat. Tie the knots with your eye shut (after putting the suture around the hook!). Now add 10 more throws to each knot with your eyes shut	□	□
Take two practice sutures and repeat the above exercise but tie as quickly as possible. Why don't you have somebody time you and place 5 throws on each knot! Repeat the above exercise (yeah, that's right – as fast as you can) five times. Record your best time here: _____ sec (or hrs or min … just kidding!)	□	□
Now, get out your rubber bands. Place a rubber band across the posts. Begin about a quarter of the way from		

one post and tie a two-handed three-throw surgeon's knot around the band. Now repeat with a one-handed slip knot. Repeat three times.	□	□
Now it gets tough. Tie one square surgeons knot within one inch of the post. Repeat near the other post. No whining if the suture wants to come apart after the first throw. Practice, practice, practice!!!	□	□
Repeat the above exercise with a slip-knot	□	□

Now for some more practice exercises in restricted spaces and on delicate structures:

	Two-handed	One-handed
Tie a knot within the cylinder on the hook. Use the 3-0 silk ties. Did you move the cylinder? Repeat until you perform this task five times in a row without moving the cylinder. Use the Crile clamp to pass the suture around the hook.	□	□
Tie a 3-0 silk around the hook on the cup. Repeat until you perform this task five times in a row without moving the cup. Repeat once or twice with the 0 nylon suture	□	□
Now shut your eyes. With a 3-0 silk, place 50 throws around one of the hooks. Don't peek. Keep the throws flat and square.	□	□
Turn on the TV to your favorite show. While you are watching, put a practice suture around a hook and tie one hundred throws. Don't look at your suture. Try and make this a skill that you could do your in sleep (or while watching TV).	□	□

Testing for Competency

Bring your board, clamp, scalpels, and a bunch of practice ties to the skills lab when your mentor is available. Be prepared to perform the following exercises … *perfectly!*

Ask your mentor to assess your skills on the following exercises and give you feedback:

	Two-handed	One-handed
Tie a knot using three throws around a hook. (*Hint: square and flat*)	□	□
Stretch a rubber band around the posts. Tie three evenly spaced knots with three throws on the rubber bands with end knots about one inch from the posts. You may use either a surgeons knot or a slip knot.	□	□
Put the cylinder on the circle around the hook. Tie a knot with three throws without moving the cylinder. Keep doing this until the cylinder remains perfectly on the	□	□

circle. How many times did it take?		
Put the cup on the circle. Tie a square knot around the hook without moving the cup. Do this with a 3-0 silk and a 6-0 nylon.	□	□

Continue with the 0-nylon suture:

	Two-handed	One-handed
Tie a knot using six throws around a hook. (*Hint: square and flat*)	□	□
Stretch a rubber band around the posts. Tie three evenly spaced knots with six throws on the rubber bands with end knots about one inch from the posts.	□	□
Put the cylinder on the circle around the hook. Tie a knot with six throws without moving the cylinder. Keep doing this until the cylinder remains perfectly on the circle. How many times did it take?	□	□

If your mentor is satisfied then have him or her document your competency.

Maintaining Competence

Obtaining a certificate or letter of competency is only the first step toward maintaining a skill. These procedures are not quite like riding a bike in which there is some inherent human capacity to do it right. Surgical and medical skills require continued practice. Here is a true story:

There once was a surgical resident who was exposed to a two week intensive skills boot camp training program during his first year of training. By the end of the session he could tie knots with his eyes closed while listening to the Grateful Dead. Two years later we were attaching a skin graft to a patient's chin with 4-0 nylon and I asked him to tie the suture in place. Watching him struggle with this simple task that he had previously learned so well would have been funny if it weren't so pathetic. It was clear that he had not practiced his knot tying skills that he had mastered only a short time ago.

The morale of this story is that "practice" is required for any maintenance of skill at any task no matter how simple it is. The knot tying board that you have is yours to keep and more practice suture can be ordered very cheaply. The following tasks are recommended to be performed at least once a month to keep your skills sharp. Remember that a poorly tied knot at the end of an aortic anastamotic suture can result in dire consequences for your patients (and may result in a quick trip to the court house for you … just kidding):

3-0 silk:

	Two-handed	One-handed
Tie a knot using fifty throws around a hook. (*Hint: square and flat*)	□	□
Stretch a rubber band around the posts. Tie three evenly spaced knots with three throws on the rubber bands with	□	□

end knots about one inch from the posts. Repeat five times		
Put the cylinder on the circle around the hook. Tie a knot with three throws without moving the cylinder. Keep doing this until the cylinder remains perfectly on the circle. How many times did it take?	□	□
Put the cup on the circle. Tie around the hook without moving the cup. Repeat until the cylinder does not move at all.	□	□

0-Nylon:

	Two-handed	One-handed
Tie a knot using six throws around a hook. (*Hint: square and flat*)	□	□
Stretch a rubber band around the posts. Tie three evenly spaced knots with six throws on the rubber bands with end knots about one inch from the posts.	□	□
Put the cylinder on the circle around the hook. Tie a knot with six throws without moving the cylinder. Keep doing this until the cylinder remains perfectly on the circle. How many times did it take?	□	□

Congratulations on maintaining your abilities in surgical knot tying. If you have any comments or suggestions for the improvement of this module please drop us a line on the "Contact Us" link at www.sim-vivo.com. We are always trying to maintain the quality of our products and skills and your observations or criticisms are always welcome! Thank you for using our learning systems.

JBF 2/10/2015

... In the hands of the learner!

Sim*Vivo, LLC
30 Albee Lane
Essex, NY 12936
518-963-7640

www.sim-vivo.com

Sim*Vivo learning modules, including Sim*Tie, are available on our website:

Sim*Suture – an inexpensive, complete module to learn simple interrupted and running sutures for skin closure. Contains suture board, instruments, suture, and guidebook. Free training videos available on our web site.

Sim*Cath – an inexpensive complete central venous catheter kit to facilitate the placement of central lines in all available manikins.

Sim*Supply - a single source supplier of surgical simulation materials

Sutures – 3-0, 4-0 nylon; 2-0, 3-0 silk; #1 nylon

Ties – 3-0 silk, 0 nylon, 6-0 nylon

Suture kits – Hegar needle driver, Adson forceps, suture scissors, scalpel, and assorted sutures and needles

Tying kits – Assorted ties, scissors, scalpel, Crile clamp, simulated tissue for clamping

Sim*Bandage – 4x4's, ABD pads, kerlix gauze roll for bandaging practice

Surgical instruments – Hegar needle driver; Adson, DeBakey, and Gerald forceps; Castroviejo vascular needle driver; Metzenbaum, suture, and iris scissors

Sim*Pad – a realistic suturing board with integrated guidelines to assist in novice education and practice