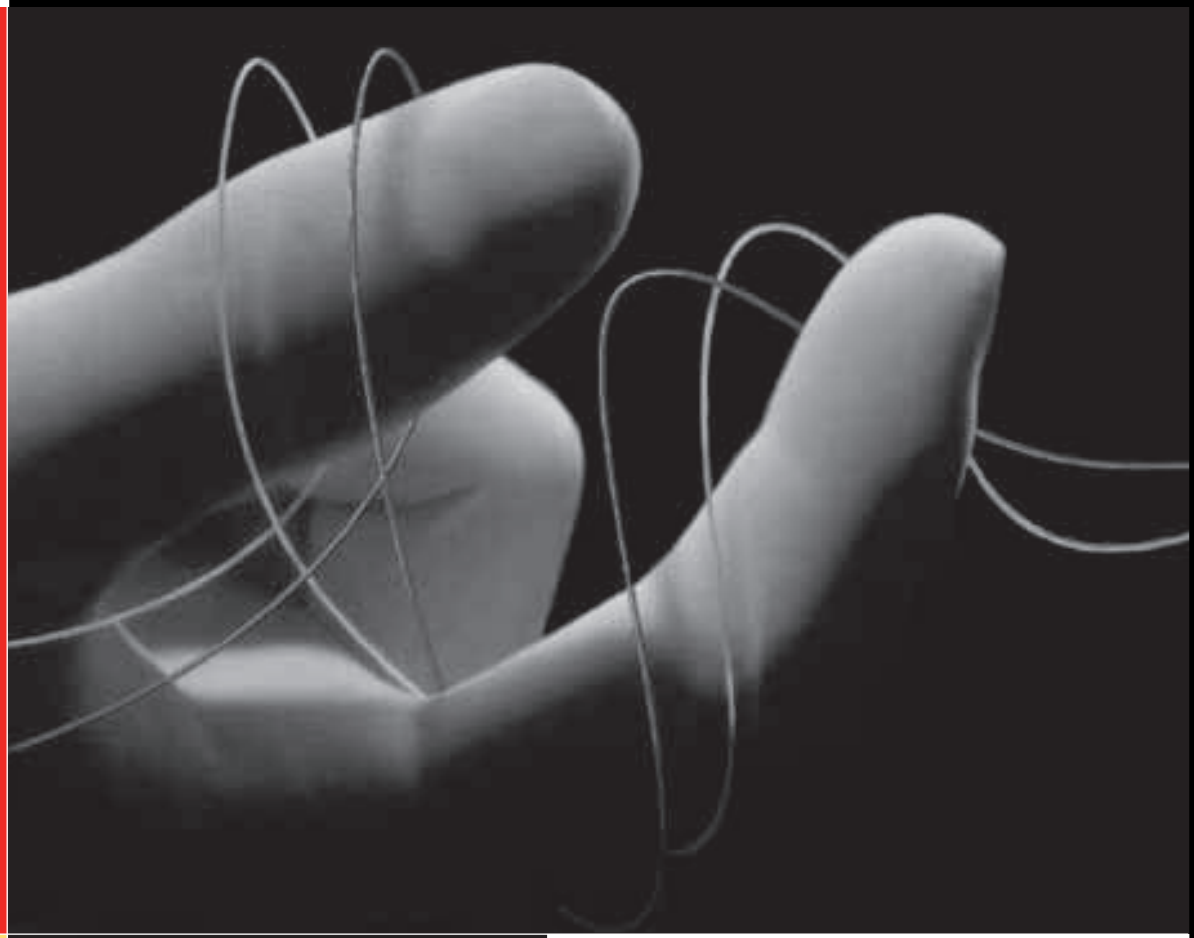
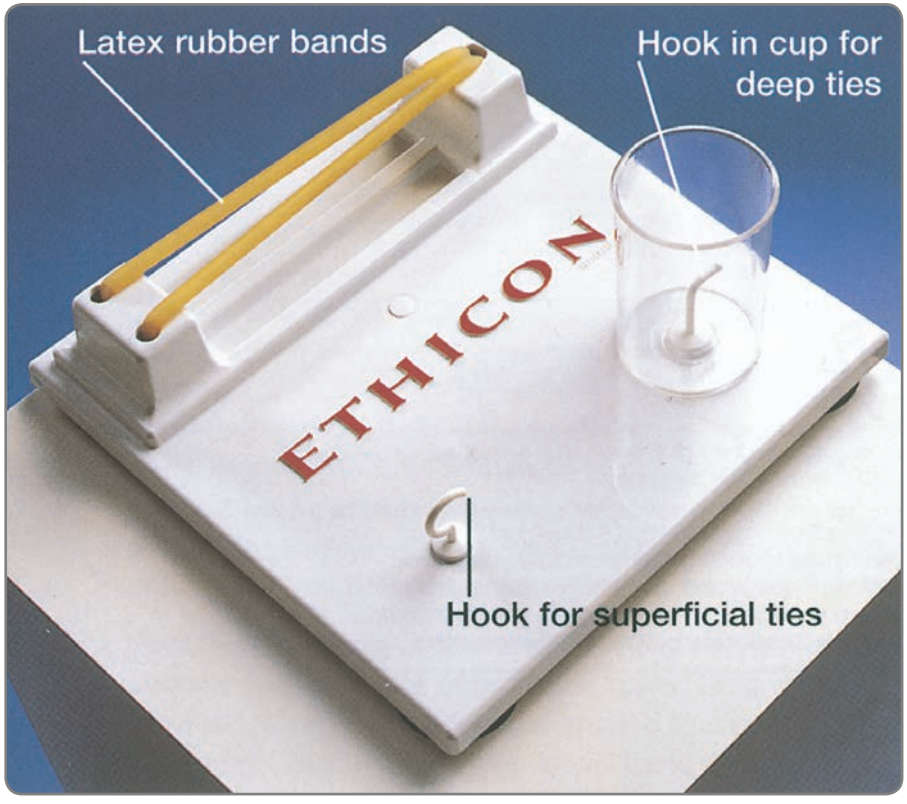


Knot Tying Manual

ETHICON, INC.
a Johnson & Johnson company

Practice Board†



The KNOT TYING MANUAL and practice board are available from **ETHICON, INC.**

† Contributing Designer–Bashir Zikria, MD, FACS

Forward

Surgery draws upon all the sciences, but its very nature places it in the category of an art. Dexterity and speed in tying knots correctly constitute an art which only practice can make perfect.

Of more than 1,400 different types of knots described in THE ENCYCLOPEDIA OF KNOTS, only a few are used in modern surgery. It is of paramount importance that each knot placed for approximation of tissues or ligation of vessels be perfect. It must hold with proper tension.

In the early days of surgery, materials were heavy and crude, knots bulky and inefficient. It was not unusual for the surgeon the place three or even four knots in the suture strand "just to be sure" it would hold.

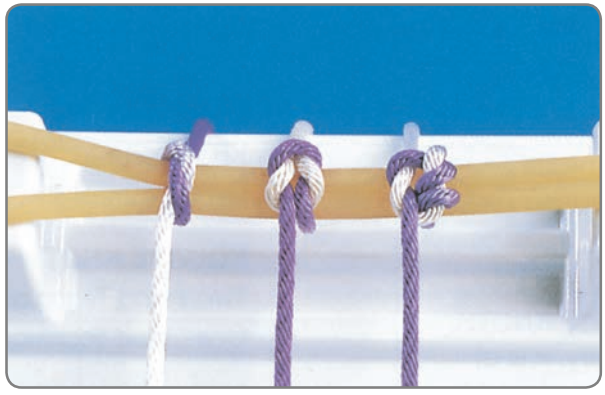
Research and refinements of manufacture and sterilization have provided the surgeon of today with a wide choice of natural and synthetic suture materials. The successful use of any of these is dependent upon skillful knot tying and meticulous care in the handling of the suture. The adoption of finer gauge sutures has been accompanied by more refined, simplified, and standardized suturing techniques.

It is the hope of ETHICON, INC that this KNOT TYING MANUAL will help train medical students, surgical residents, physician assistants, and others in training In the techniques of know tying and the handling of sutures.

Table of Contents

BASIC KNOTS

The knots demonstrated on the following pages are those most frequently used and are applicable to all types of operative procedures. The camera was placed behind the demonstrator so that each step of the knot is shown as seen by the operator. For clarity, one-half of the strand is purple and the other white. *The purple working strand is initially held in the right hand.* The left-handed person may choose to study the photographs in a mirror.



1. Simple knot: incomplete basic unit

2. Square knot: completed common knot

3. Surgeon's or Friction knot: completed tension knot

Knot Security

The construction of Ethicon™ sutures has been carefully designed to produce the optimum combination of strength, uniformity, and hand for each material. The term hand is the most subtle of all suture quality aspects. It relates to the feel of the suture in the surgeon's hands, the smoothness with which it passes through tissue and ties down, the way in which knots can be set and snugged down, and most of all, to the firmness or body of the suture. Extensibility relates to the way in which the suture will stretch slightly during knot tying and then recover. The stretching characteristics provide the signal that alerts the surgeon to the precise moment when the suture knot is snug.

Multifilament sutures are generally easier to handle and to tie than monofilament sutures, however, all the synthetic materials require a specific knotting technique. With multifilament sutures, the nature of the material and the braided or twisted construction provide a high coefficient of friction and the knots remain as they are laid down. In monofilament sutures, on the other hand, the coefficient of friction is relatively low, resulting in a greater tendency for the knot to loosen after it has been tied. In addition, monofilament synthetic polymeric materials possess the property of **memory**. Memory is the tendency not to lie flat, but to return to a given shape set by the material's extrusion process or the suture's packaging.

Suture knots must be properly placed to be secure. Speed in tying knots may result in less than perfect placement of the strands. In addition to variables inherent in the suture materials, considerable variation can be found between knots tied by different surgeons and even between knots tied by the same individual on different occasions.

General Principles of Knot Tying

Certain general principles govern the tying of all knots and apply to all suture materials.

1. The completed knot must be firm, and so tied that slipping is virtually impossible. The simplest knot for the material is the most desirable.
2. The knot must be as small as possible to prevent an excessive amount of tissue reaction when absorbable sutures are used, or to minimize foreign body reaction to non absorbable sutures. Ends should be cut as short as possible.
3. In tying any knot, friction between strands ("sawing") must be avoided as this can weaken the integrity of the suture.
4. Care should be taken to avoid damage to the suture material when handling. Avoid the crushing or crimping application of surgical instruments, such as needle holders and forceps, to the strand except when grasping the free end of the suture during an instrument tie.
5. Excessive tension applied by the surgeon will cause breaking of the suture and may cut tissue. Practice in avoiding excessive tension leads to successful use of finer gauge materials.
6. Sutures used for approximation should not be tied too tightly, because this may contribute to tissue strangulation.
7. After the first loop is tied, it is necessary to maintain traction on one end of the strand to avoid loosening of the throw if being tied under any tension.
8. Final tension on final throw should be as nearly horizontal as possible.
9. The surgeon should not hesitate to change stance or position in relation to the patient in order to place a knot securely and flat.
10. Extra ties do not add to the strength of a properly tied knot. They only contribute to its bulk. With some synthetic materials, knot security requires the standard surgical technique of flat and square ties with additional throws if indicated by surgical circumstance and the experience of the surgeon.

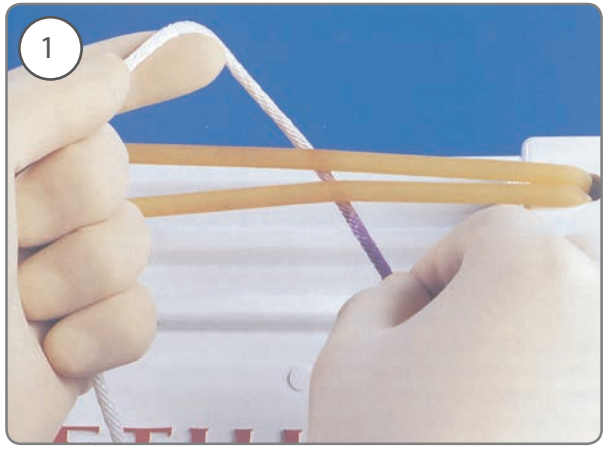
An important part of good suturing technique is correct method in knot tying. A seesaw motion, or the sawing of one strand down over another until the knot is formed, may materially weaken sutures to the point that they may break when the second throw is made or, even worse, in the postoperative period when the suture is further weakened by increased tension or motion.

If the two ends of the suture are pulled in opposite directions with uniform rate and tension, the knot may be tied more securely. This point is well-illustrated in the knot tying techniques shown in the next section of this manual.

SQUARE KNOT

Two-hand Technique

The two-hand square knot is the easiest and most reliable for tying most suture materials.



White strand placed over extended index finger of non-dominant acting as bridge, and held in palm of non-dominant hand. Purple strand held in dominant hand.

Purple strand held in dominant hand brought between non-dominant thumb and index finger.

SQUARE KNOT

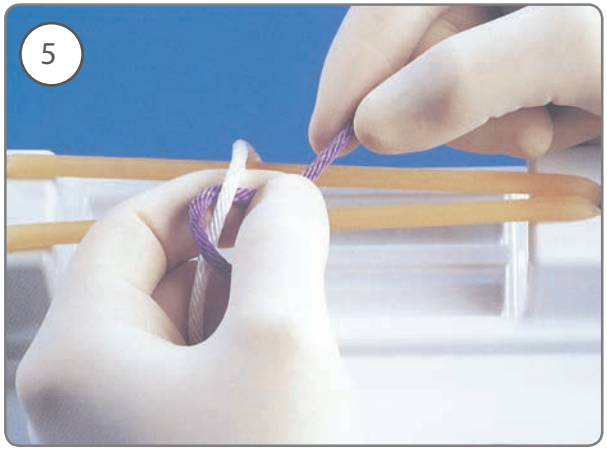
Two-hand Technique

Standard technique of flat and square ties with additional throws if indicated by the surgical circumstance and the experience of the operator should be used to tie Coated VICRYL* Plus Antibacterial (polyglactin 910) suture, Coated VICRYL* (polyglactin 910) suture, MONOCRYL* (poliglecaprone 25) suture, Coated VICRYL RAPIDE* (polyglactin 910) suture, PDS* II (polydioxanone) suture, ETHILON* nylon suture, ETHIBOND* EXCEL polyester suture, PERMA-HAND* silk suture, PRONOVA* polyhexafluoropropylene-VDF) suture, and PROLENE* polypropylene suture.

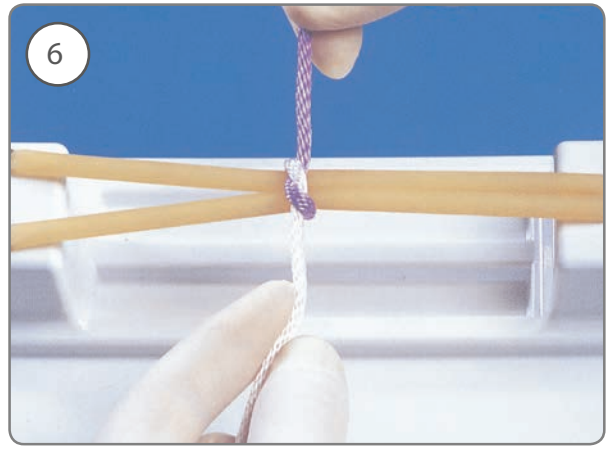
Non-dominant hand turned inward by pronation, and thumb swung under white strand to form the first loop.

Purple strand crossed over white and held between thumb and index finger of on-dominant hand.

SQUARE KNOT
Two-hand Technique

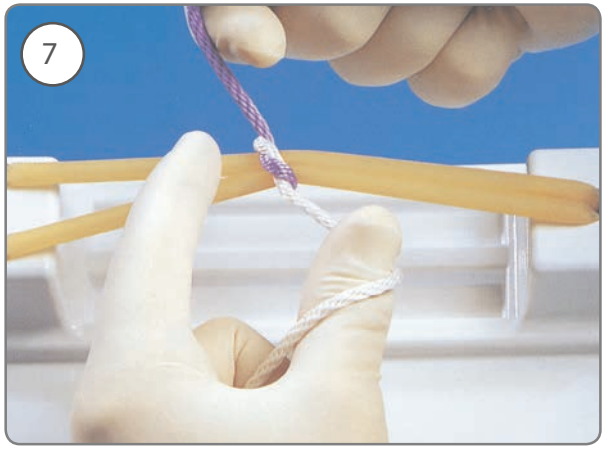


Dominant hand releases purple strand. Then nondominant hand supinated, with thumb and index finger still grasping purple strand, to bring purple strand through the white loop. Regrasp purple strand with dominant hand.

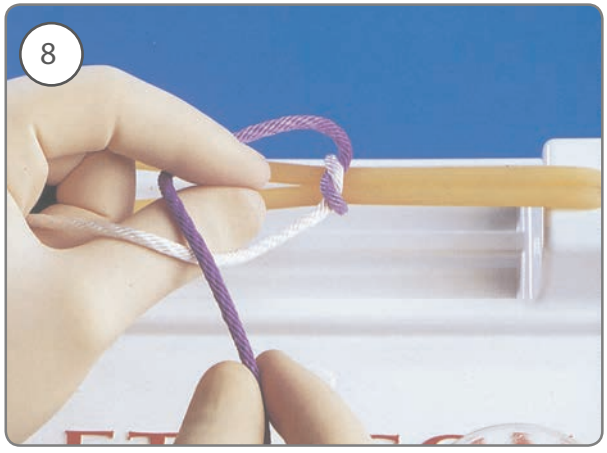


Purple strand released by non-dominant hand and grasped by dominant. Horizontal tension is applied with non-dominant hand toward and dominant hand away from operator. This completes first half hitch.

SQUARE KNOT
Two-hand Technique



Non-dominant index finger released from white strand and non-dominant hand again supinated to loop white strand over non-dominant thumb.



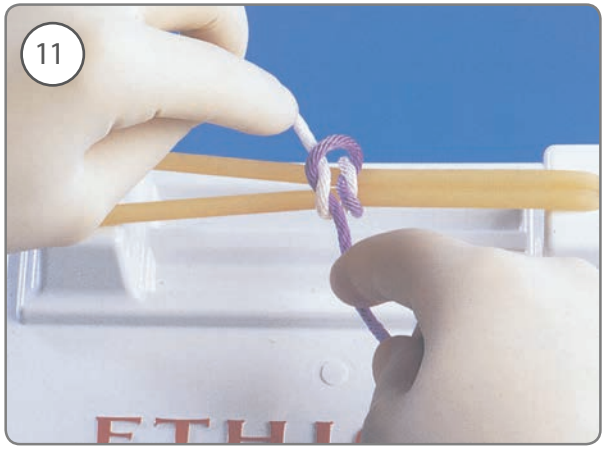
Purple strand held in dominant hand is angled slightly to the non-dominant side. Purple strand brought toward the operator with the dominant hand and placed between non-dominant thumb and index finger. Purple strand crosses over white strand.

SQUARE KNOT
Two-hand Technique

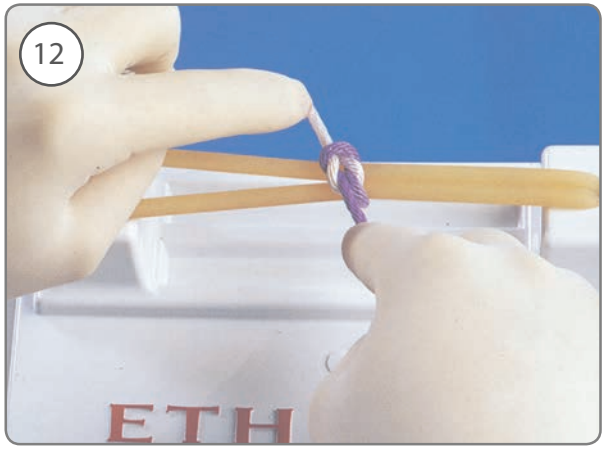
By further supinating non-dominant hand, white strand slides onto non-dominant index finger to form a loop as purple strand is grasped between non-dominant index finger and thumb.

Non-dominant hand rotated inward by pronation with thumb carrying purple strand through loop of white strand. Purple strand is grasped between dominant thumb and index finger.

SQUARE KNOT
Two-hand Technique



Horizontal tension applied with non-dominant hand away from and dominant hand toward the operator. This completes the second half hitch.



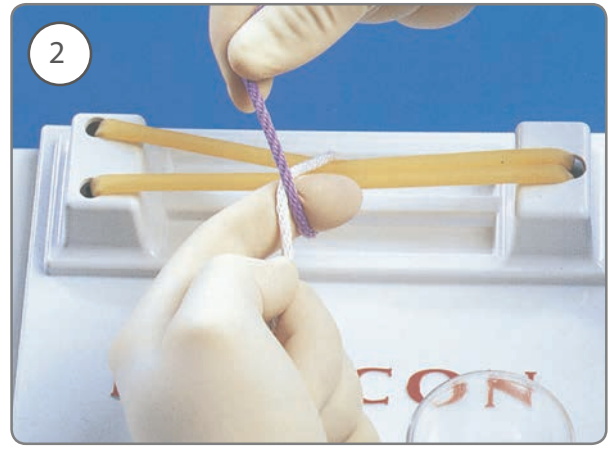
The final tension on the final throw should be as nearly horizontal as possible.

SQUARE KNOT

One-hand Technique

Wherever possible, the square knot is tied using the two-hand technique. On some occasions it will be necessary to use one hand, either the non-dominant or the dominant, to tie a square knot. These illustrations employ the left-handed technique.

White strand held between thumb and index finger of non-dominant hand with loop over extended index finger. Purple strand held between thumb and index finger of dominant hand.

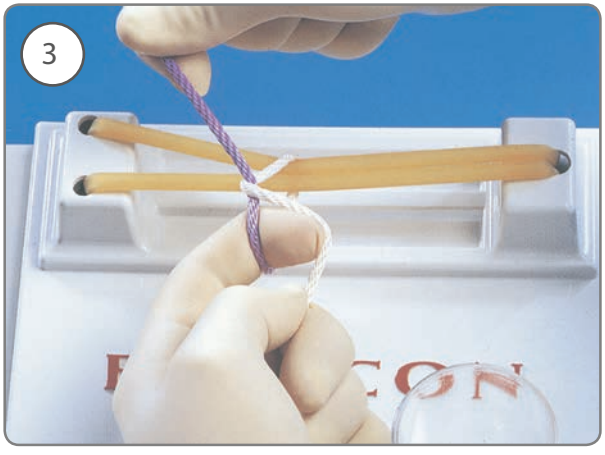


Purple strand brought over white strand on nondominant index finger by moving dominant hand away from operator.

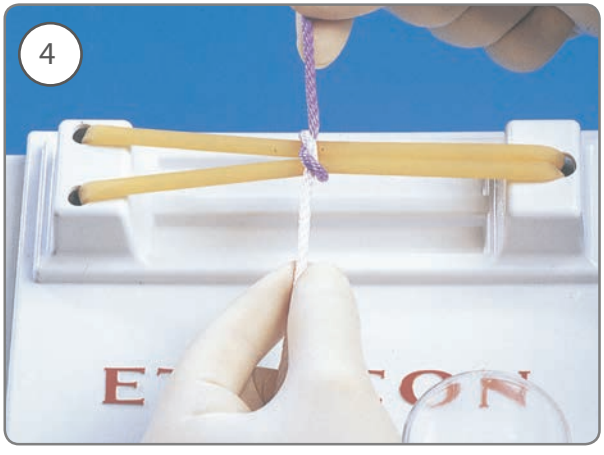
SQUARE KNOT

One-hand Technique

The sequence of throws illustrated is most commonly used for tying single suture strands. The sequence may be reversed should the surgeon be holding a reel of suture material in the right hand and placing a series of ligatures. In either case, it cannot be too strongly emphasised that the directions the hands travel must be reversed proceeding from one throw to the next to ensure that the knot formed lands flat and square. Half hitches result if this precaution is not taken.



With purple strand supported in dominant hand, the distal phalanx of non-dominant index finger passes under the white strand to place it over tip of non-dominant index finger. Then the white strand is pulled through loop in preparation for applying tension.



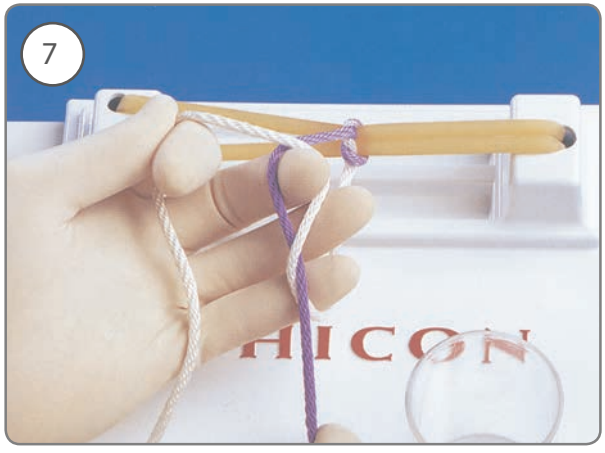
The first half hitch is completed by advancing tension in the horizontal plane with the non-dominant hand drawn toward and dominant hand away from the operator.

SQUARE KNOT
One-hand Technique

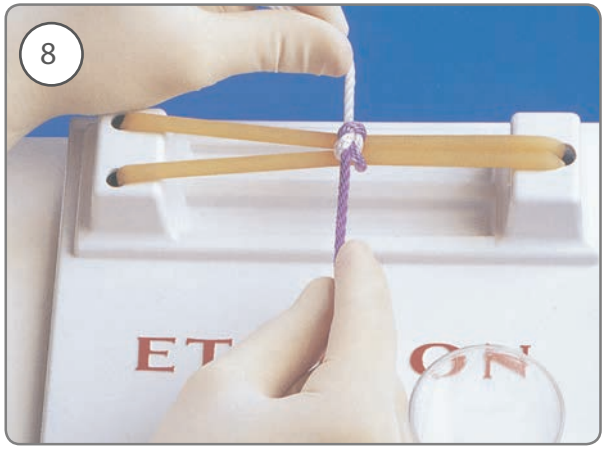
White strand looped around three fingers of non-dominant hand with distal end held between thumb and index finger.

Purple strand held in dominant hand brought toward the operator to cross over the white strand. Continue hand motion by flexing distal phalanx of non-dominant middle finger to bring it beneath white strand.

SQUARE KNOT
One-hand Technique



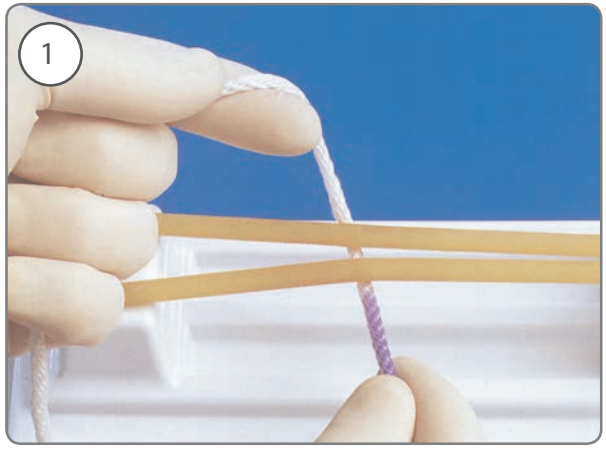
As the middle finger is extended and the non-dominant hand pronated, the white strand is brought beneath the purple strand.



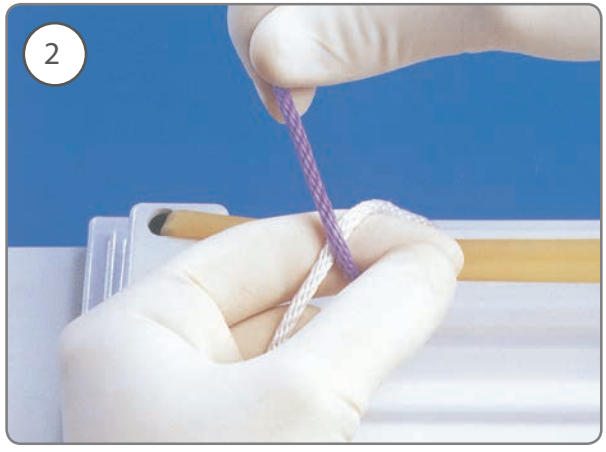
Horizontal tension applied with the non-dominant hand away from and the dominant hand toward the operator. This completes the second half hitch of the square knot. Final tension should be as nearly horizontal as possible.

SURGEON'S OR FRICTION KNOT

The surgeon's knot also may be performed using a one-hand technique in a manner analogous to that illustrated for the square knot one-hand technique.



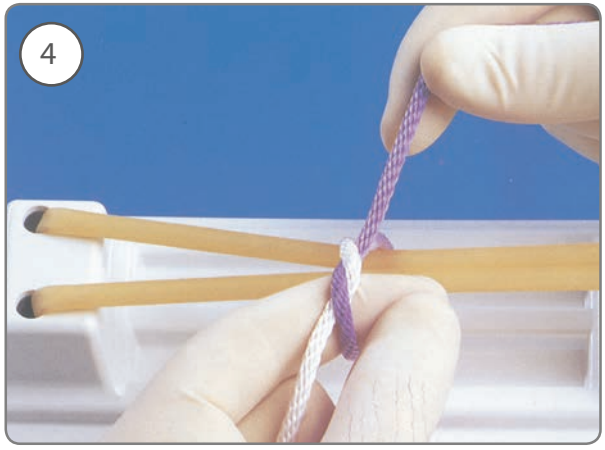
White strand placed over extended index finger of non-dominant hand and held in palm of non-dominant hand. Purple strand held between thumb and index finger of dominant hand.



Purple strand crossed over white strand by moving dominant hand away from operator at an angle to the non-dominant. Thumb and index finger of non-dominant hand pinched to form loop in the white strand over index finger.

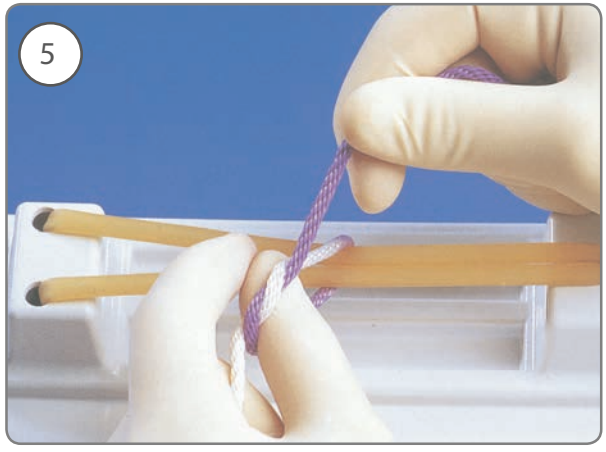
SURGEON'S OR FRICTION KNOT

Non-dominant hand turned inward by pronation, and loop of white strand slipped onto non-dominant thumb. Purple strand grasped between thumb and index finger of non-dominant hand. Release dominant hand.



Non-dominant hand rotated by supination extending non-dominant index finger to pass purple strand through loop. Regrasp purple strand with dominant hand.

SURGEON'S OR FRICTION KNOT

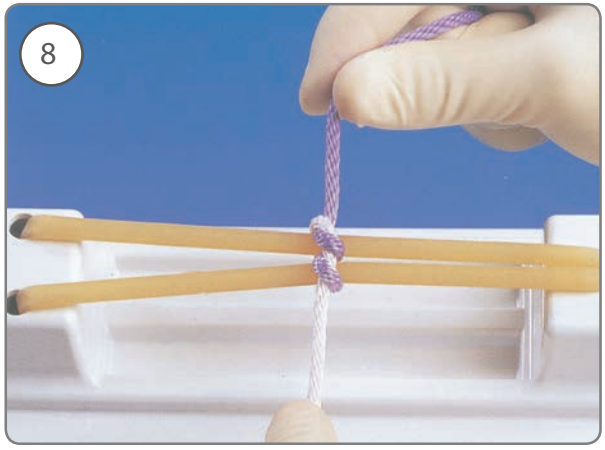


The loop is slid onto the thumb of the non-dominant hand by pronating the pinched thumb and index finger of non-dominant hand beneath the loop.

Purple strand drawn non-dominant with dominant hand and again grasped between thumb and index finger of non-dominant hand.

SURGEON'S OR FRICTION KNOT

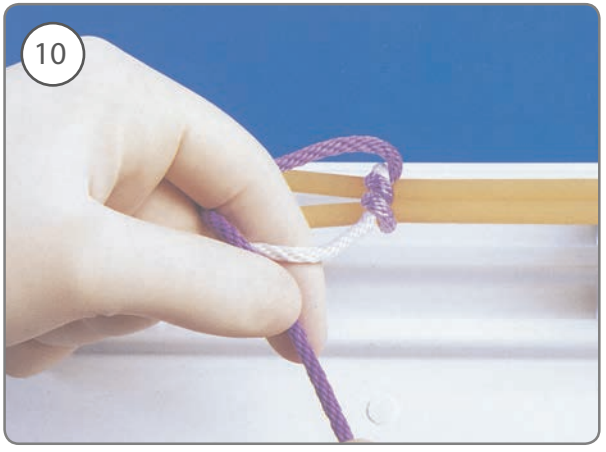
Non-dominant hand rotated by supination extending non-dominant index finger to again pass purple strand through forming a double loop.



Horizontal tension is applied with non-dominant hand toward and dominant hand away from the operator. This double loop must be placed in precise position for the final knot.

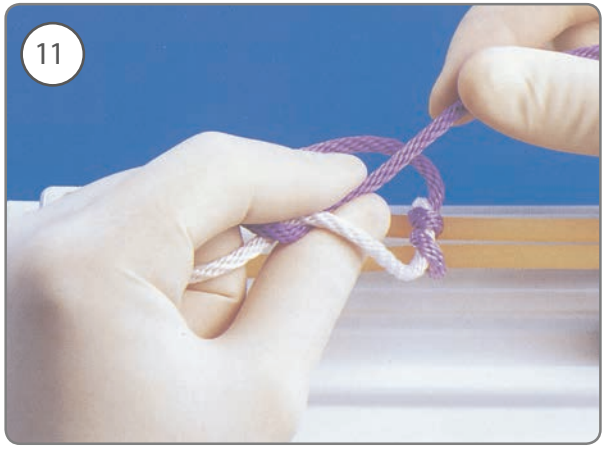
SURGEON'S OR FRICTION KNOT

With thumb swung under white strand, purple strand is grasped between thumb and index finger of non-dominant hand and held over white strand with dominant hand.

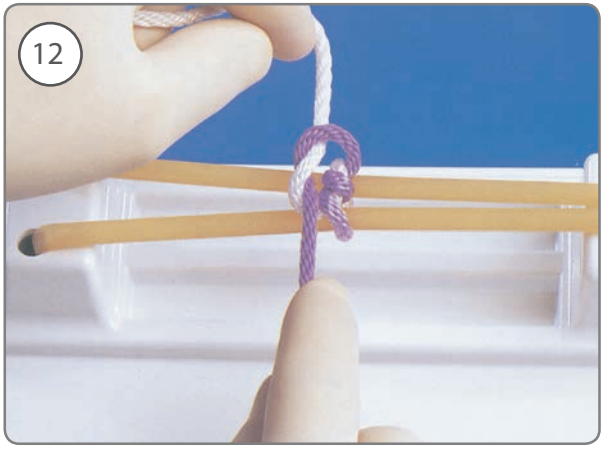


Purple strand released. Non-dominant hand supinates to regrasp purple strand with index finger beneath the loop of the white strand.

SURGEON'S OR FRICTION KNOT



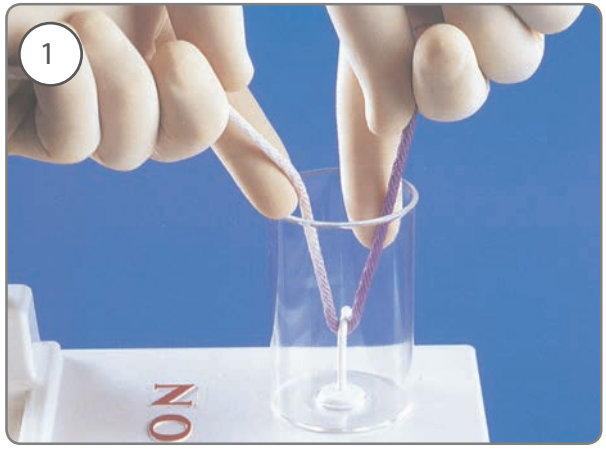
Purple strand rotated beneath the white strand by supinating pinched thumb and index finger of non-dominant hand to draw purple strand through the loop. Dominant hand regrasps purple strand to complete the second throw square.



Hands continue to apply horizontal tension with non-dominant hand away from and dominant hand toward the operator. Final tension on final throw should be as nearly horizontal as possible.

DEEP TIE

Tying deep in a body cavity can be difficult. The square knot must be firmly snugged down as in all situations. However the operator must avoid upward tension which may tear or avulse the tissue.

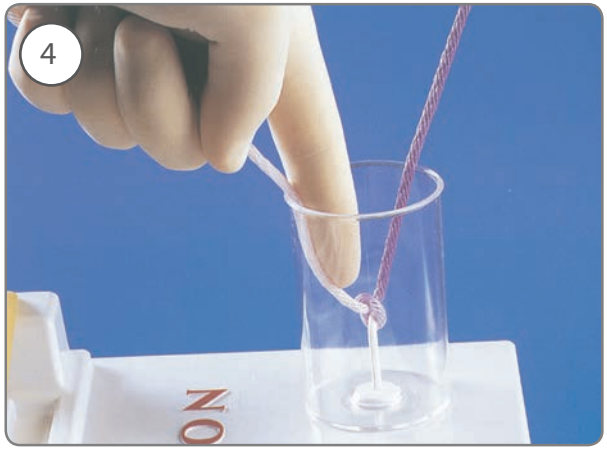


Strand looped around hook in plastic cup on Practice Board with index finger of dominant hand which holds purple strand in palm of hand. White strand held in non-dominant hand.

Purple strand held in dominant hand brought between non-dominant thumb and index finger. Non-dominant hand turned inward by pronation, and thumb swung under white strand to form th first loop.

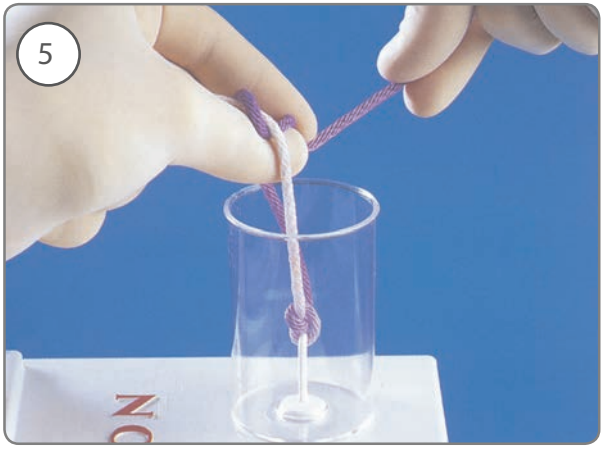
DEEP TIE

By placing index finger of non-dominant hand on white strand, advance the loop into the cavity.

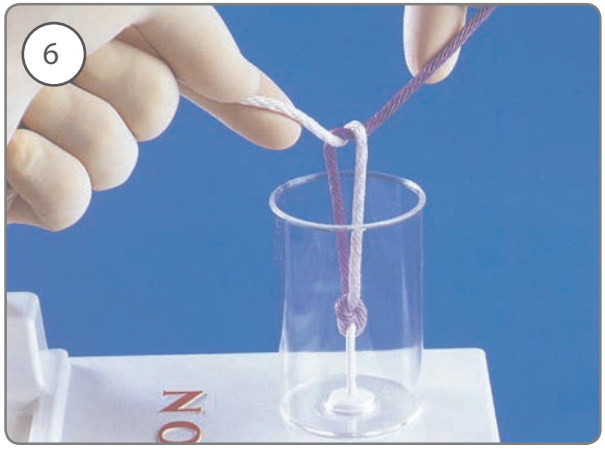


Horizontal tension applied by pushing down on white strand with non-dominant index finger while maintaining counter-tension with index finger of dominant hand on purple strand.

DEEP TIE

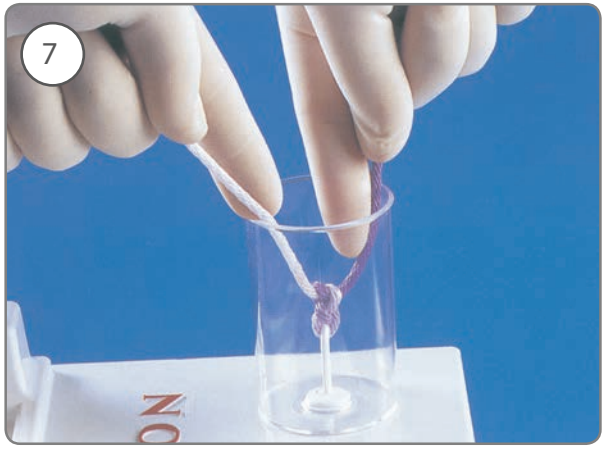


Purple strand looped over and under white strand with dominant hand.



Purple strand looped around white strand to form second loop. This throw is advanced into the depths of the cavity.

DEEP TIE

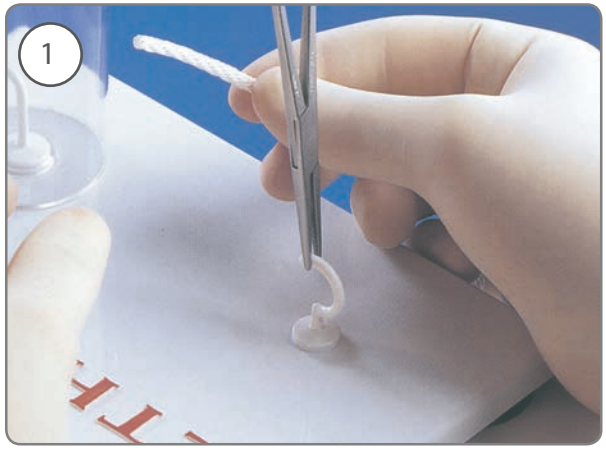


Horizontal tension applied by pushing down on purple strand with dominant index finger while maintaining counter-tension on white strand with non-dominant index finger. Final tension should be as nearly horizontal as possible.

LIGATION AROUND HEMOSTATIC CLAMP

More Common of Two Methods

Frequently it is necessary to ligate a blood vessel or tissue grasped in a hemostatic clamp to achieve hemostasis in the operative field.



When sufficient tissue has been cleared away to permit easy passage of the suture ligature, the white strand held in the dominant hand is passed behind the clamp.

Non-dominant hand grasps free end of the strand and gently advances it behind clamp until both ends are of equal length.

LIGATION AROUND HEMOSTATIC CLAMP

More Common of Two Methods

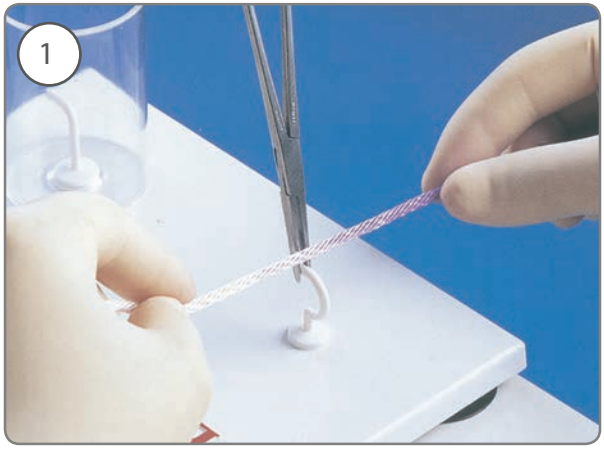
To prepare for placing the knot square, the white strand is transferred to the dominant hand and the purple strand to the non-dominant hand, thus crossing the white strand over the purple.

As the first throw of the knot is completed, the assistant removes the clamp. This maneuver permits any tissue that may have been bunched in the clamp to be securely crushed by the first throw. The second throw of the square knot is then completed with either a two-hand or one-hand technique as previously illustrated.

LIGATION AROUND HEMOSTATIC CLAMP

Alternate Technique

Some surgeons prefer this technique because the operator never loses contact with the suture ligature as in the preceding technique.



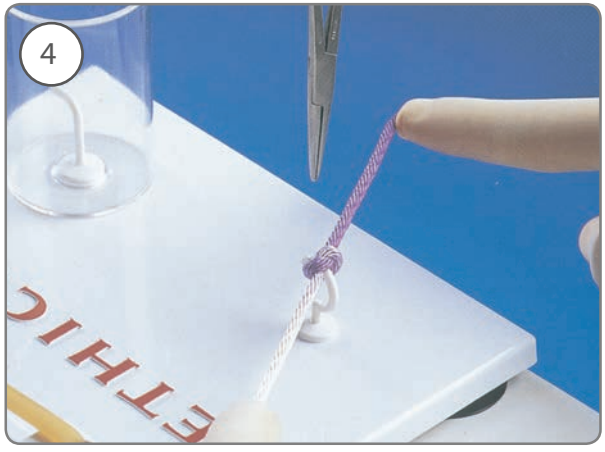
Center of the strand placed in front of the tip of hemostatic clamp with purple strand held in dominant hand and white strand in non-dominant hand.

Purple strand swung behind clamp and grasped with index finger of non-dominant hand. Purple strand will be transferred to non-dominant hand and released by dominant.

LIGATION AROUND HEMOSTATIC CLAMP

Alternate Technique

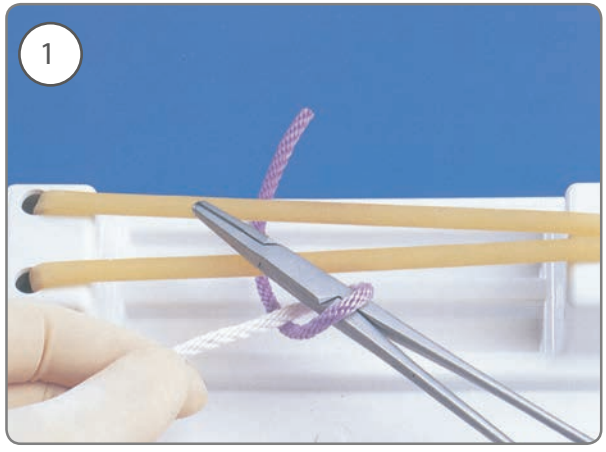
Purple strand crossed under white strand with non-dominant index finger and regrasped with dominant hand.



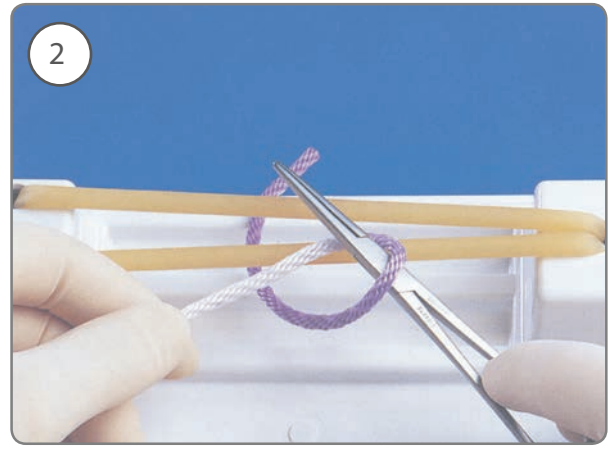
First throw is completed in usual manner. Tension is placed on both strands below the tip of the clamp as the first throw of the knot is tied. The assistant then removes the clamp. The square knot is completed with either a two-hand or one- hand technique as previously illustrated.

INSTRUMENT TIE

The instrument tie is useful when one or both ends of the suture material are short. For best results, exercise caution when using a needle-holder with any monofilament suture, as repeated bending may cause these sutures to break.

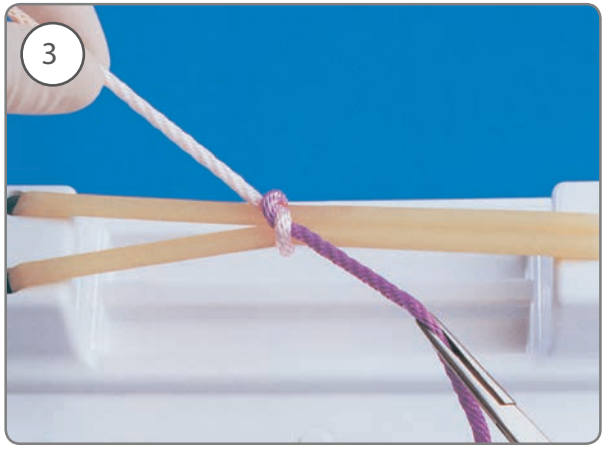


Short purple strand lies freely. Long white end of strand held between thumb and index finger of non-dominant hand. Loop formed by placing needleholder on side of strand away from the operator.

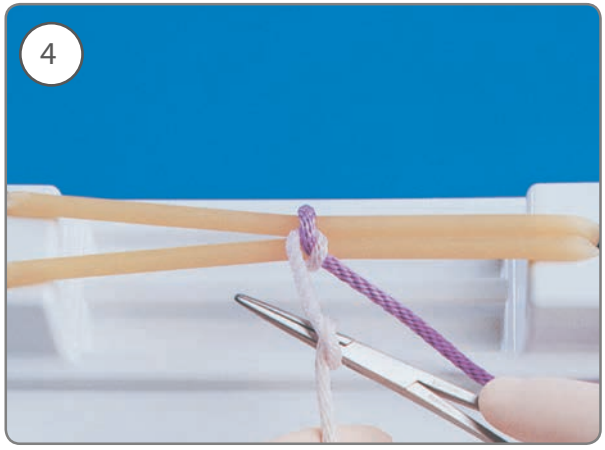


Needleholder in dominant hand grasps short purple end of strand.

INSTRUMENT TIE

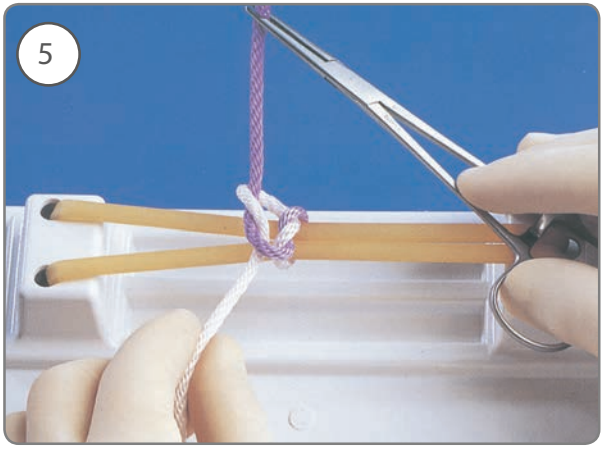


First half hitch completed by pulling needleholder toward operator with dominant hand and drawing white strand away from operator. Needleholder is released from purple strand.

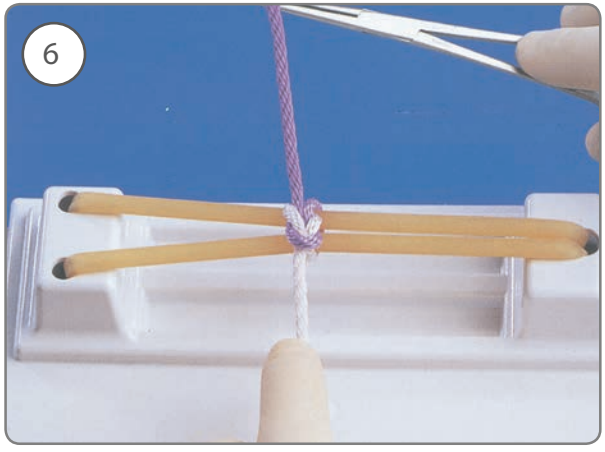


White strand is drawn toward operator with non-dominant hand and looped around needleholder held in dominant hand. Loop is formed by placing needleholder on side of strand toward the operator.

INSTRUMENT TIE



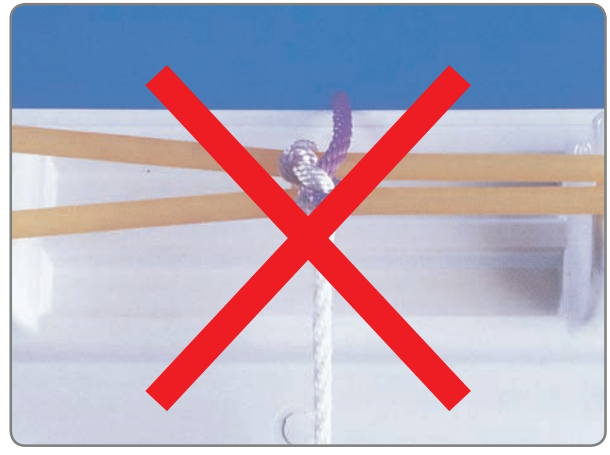
With end of the strand grasped by the needleholder, purple strand is drawn through loop in the white strand away from the operator.



Square knot completed by horizontal tension applied with non-dominant hand holding white strand toward operator and purple strand in needle-holder away from operator. Final tension should be as nearly horizontal as possible.

GRANNY KNOT

A granny knot is not recommended. However, it may be inadvertently tied by incorrectly crossing the strands of a square knot. It is shown only to warn against its use. It has the tendency to slip when subjected to increasing pressure.



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