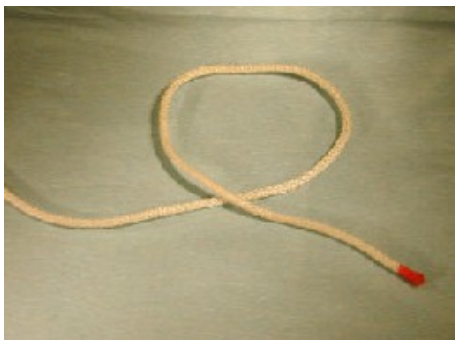


# Techniques of the hand tie and instrument tie

## 1. The Anatomy of a Square Knot

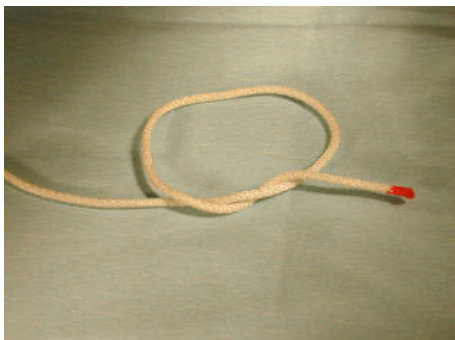


A square knot consists of two "throws".

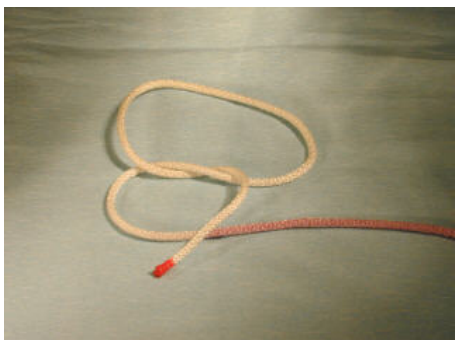


Throws are constructed by crossing the ends of the suture to form a loop and then wrapping one end of the suture around the other.

Here, the short end has been crossed over the long end to form a loop.

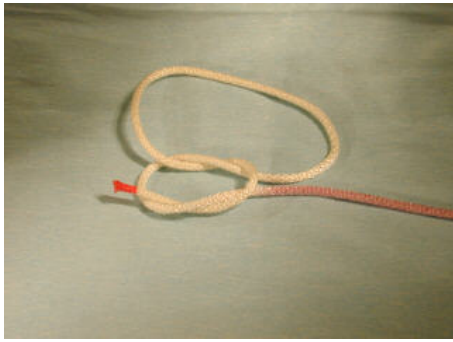


The short end has been wrapped around the long end by passing it under the long end and up through the loop to complete the first "throw".



The loop for the second throw is initiated by once again crossing the short end over the long strand from right to left.

[NOTE: A "granny knot" results if the short end crosses above the long end for one loop and below it for the other.]



The short end has been wrapped around the long end a second time by passing it under the long end and up through the loop to complete the second "throw".



The knot has now been tightened, and the result is a square knot.

Each of the techniques for tying square knots (one hand tie, two hand tie, or instrument tie) achieves the same steps illustrated here.

## 2. The techniques of a Square Knot

The two hand square knot is the most fundamental knot for the surgeon.

Well-constructed square knots with flat throws have less likelihood of slipping.

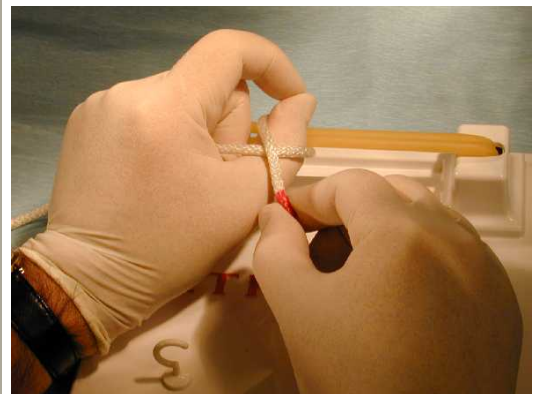
1) This shows the beginning of knot construction.

Note that the short end is in the right hand, and the thumb of the left hand is beginning to create a loop by pushing the long strand to the right.



2) The right hand has brought the short end toward the surgeon and across the left hand strand to form a loop. The left thumb protrudes through the loop.

Note that the left forefinger contacts the thumb, so the thumb can guide the index fingertip down through the loop.



3) The left index finger has been rotated down into the loop.



4) The short strand is now placed between the thumb and forefinger in order to transport the short end up through the loop.



5) The left hand is now rotated counterclockwise to bring the thumb back up through the loop, pushing the short end up with it.



6) The short end has now emerged completely through the loop and will be re-grasped with the right hand in order to tighten the "throw" that has been created..



7) The surgeon begins to tighten the throw by pushing the long strand away... and pulling the short strand toward himself.

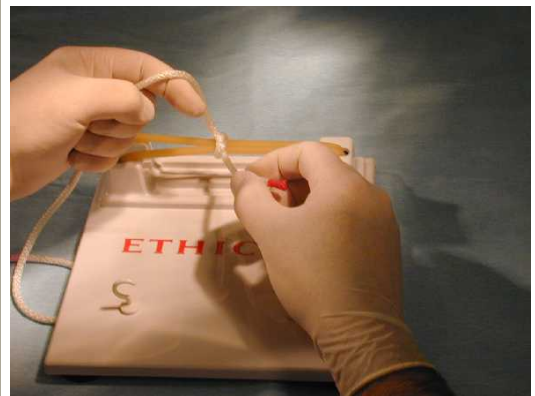


8) The throw is now snugged down.

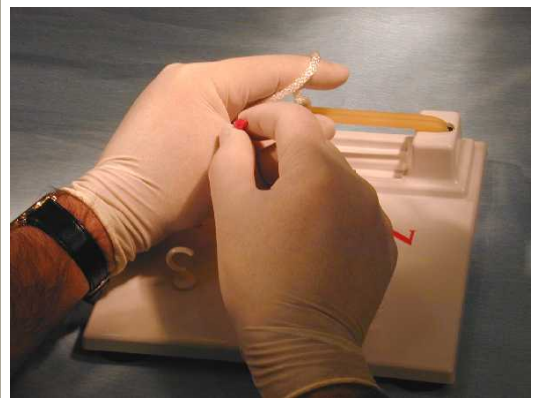
Note that tension is applied by pulling the two strands in opposite directions at an angle of 180 degrees.



9) The left forefinger now begins to form the loop for the next throw by sliding beneath the long strand and pushing it to the right.



10) The short strand is now brought to the left and beneath the long strand to form the new loop.



11) The left thumb contacts the forefinger and begins to rotate up into the loop.



12) The left thumb has now emerged from the loop, and the short strand will be pinched between the thumb and forefinger of the left hand.



13) The right hand releases the short end, and the left hand is now rotated in the opposite direction to drive the short end through the loop toward the surgeon.



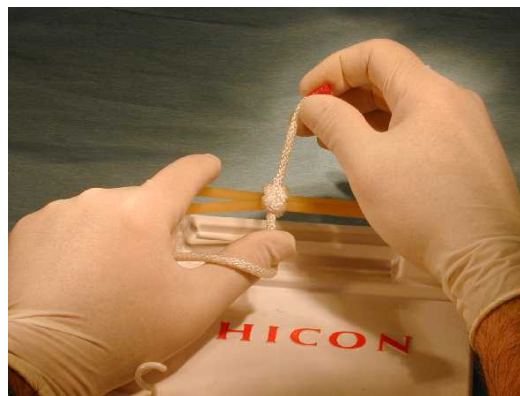
14) The short end is re-grasped by the right hand and pulled away from the surgeon, and the long strand is pulled toward the surgeon.



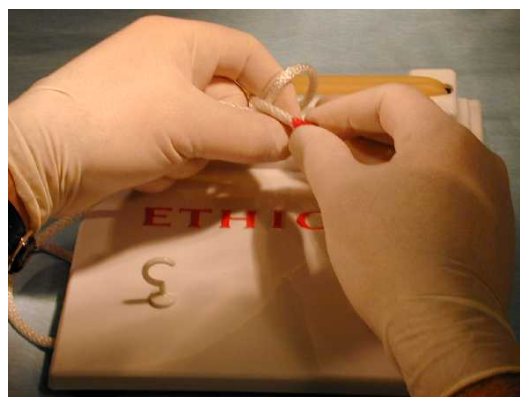
15) Equal tension is applied to both strands as they are pulled in opposite directions to secure a flat square knot.



16) To secure the knot, a third throw will be added, using the same technique for the first throw.



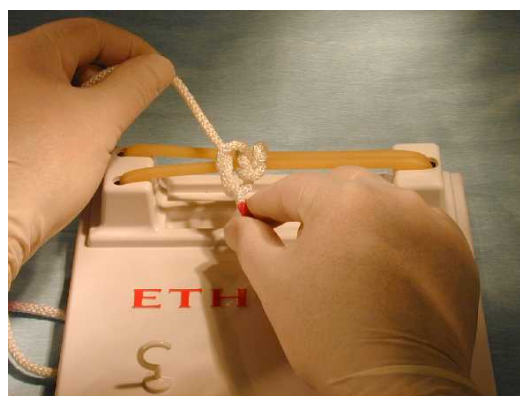
17) After creating the loop, the left index finger is rotated clockwise into the loop, and the short end is placed between the thumb and index finger of the left hand.



18) The left hand is rotated back in a counterclockwise direction to pass the short end through the loop.



19) Finally, the short end has been re-grasped with the right hand and pulled toward the surgeon as the left hand pushes the long strand away to secure the third throw.



Multifilament or braided materials such as silk can usually be secured with just three throws. The throws are alternated to create successive square knots, so with three alternating throws, one essentially creates a double square knot.

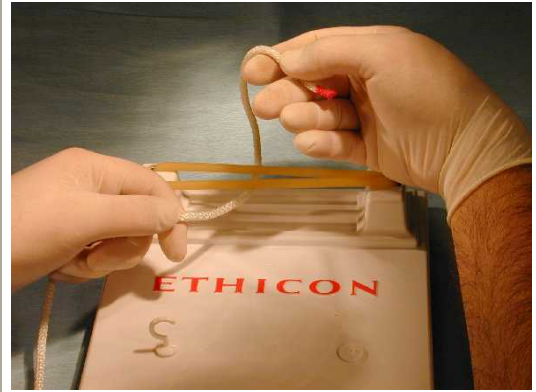
Slippery monofilament suture material, such as nylon or prolene, requires 5 or 6 alternating throws because it has a tendency to slip and untie itself.



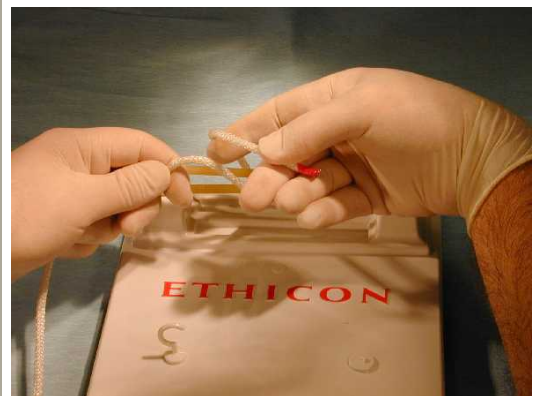
### 3. The techniques of a One Hand Square Knot

Two hand ties are generally preferred by most surgeons, but one hand ties can also be used.

1) Note that the short end has been placed beneath the tubing and is held in the right hand, away from the surgeon. The long strand is held in the left hand.



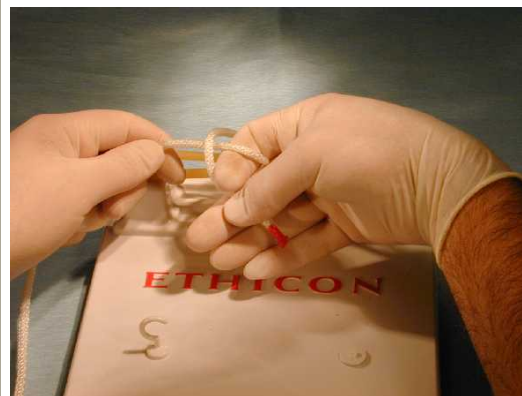
2) The right index finger initiates formation of the first loop by pushing the short strand to the left and above the long strand. The left hand begins to move the long strand to the right.



3) The right index finger is shown inserted into the loop that has been created.



4) The right index finger now begins to roll behind the short strand, which is still being grasped by the thumb and middle finger.



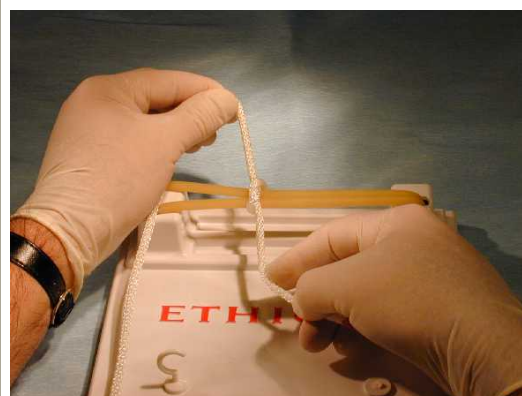
5) The end of the short strand has now been released by the right thumb, and the index finger is being used as a lever to rotate the short end up through the loop.



6) As the short end emerges from the loop, the middle finger pinches it against the forfinger to re-grasp it.



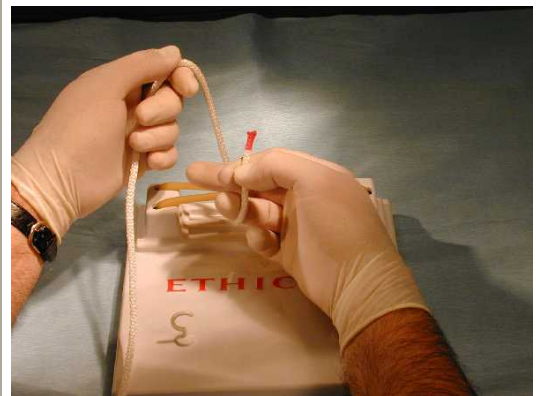
7) And the throw is tightened by pushing the long strand away... and pulling the short strand toward the surgeon with equal tension. Note that tension is applied by pulling the two strands in opposite directions at an angle of 180 degrees.



8) As the second throw is initiated, the short end is toward the surgeon and is being grasped by the thumb and index finger.



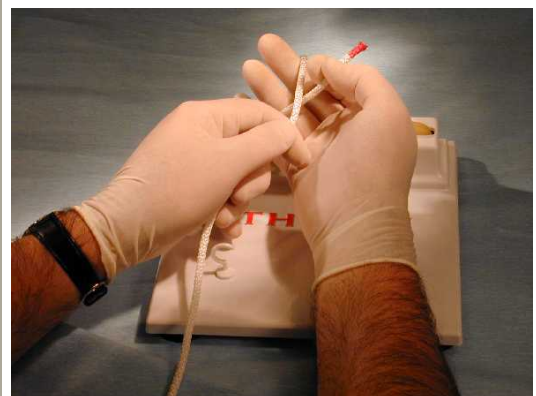
9) The right index finger and thumb continue to grasp the short end, as the middle and ring fingers are placed behind the short end to begin creating a loop. The left hand has begun to bring the long strand toward the surgeon.



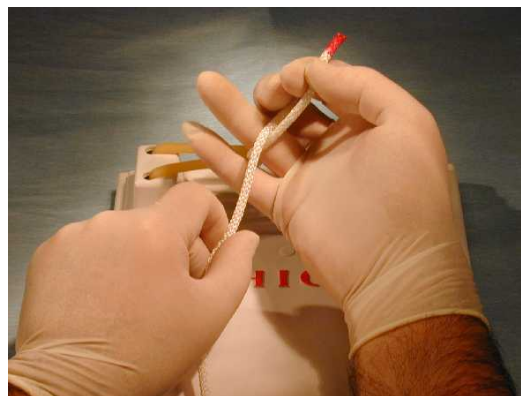
10) The right hand has supinated slightly ...



11) ... as the left hand brings the long strand toward the surgeon and across the short strand to form a loop.



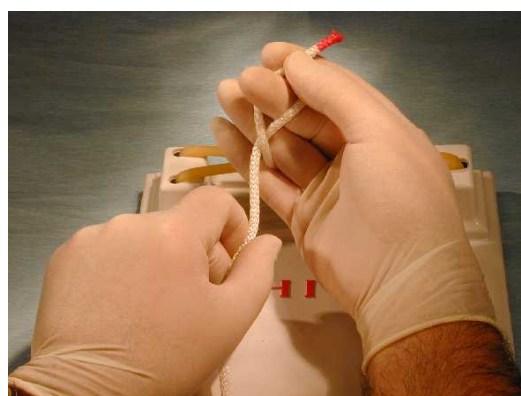
12) The right middle finger has now been flexed so it can slide behind the short strand.



13) The right middle finger is now behind the short strand, which is still being grasped by the thumb and index finger.



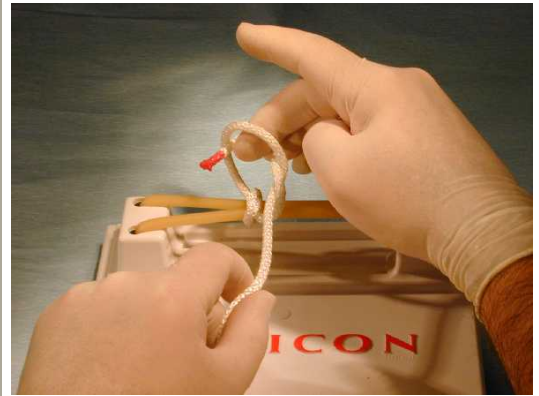
14) The right middle finger is now used as a lever to rotate the short end away from the surgeon.



15) The short end is released by the thumb, but the ring finger pinches the short end inside the loop by squeezing it against the middle finger.



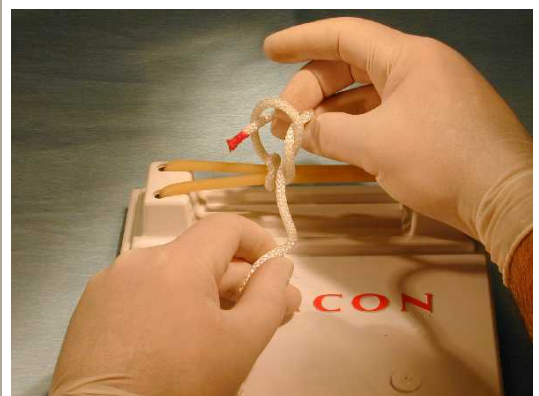
16) The short end is now drawn through the loop away from the surgeon by the middle and ring fingers.



17)



18) As the short end moves through the loop, the thumb squeezes it against the middle finger.



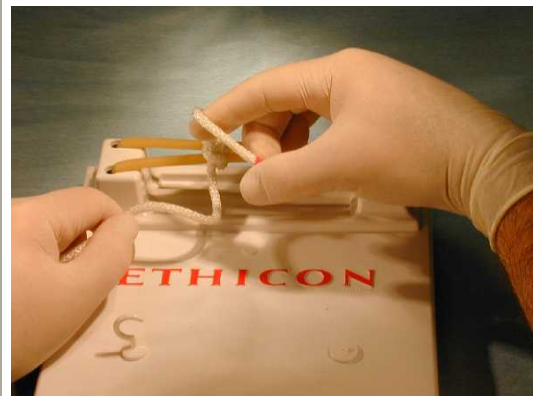
19) Finally, the short end has been re-grasped with the right hand and pulled away from the surgeon as the left hand pulls the long strand to secure the second throw.



20) The 3rd throw is initiated in the same way as the 1st throw, by pushing the short end to the left with the right index finger.



21) The left hand brings the long strand to the right, beneath the short end.



22) The right index finger is inserted into the loop that has been created.



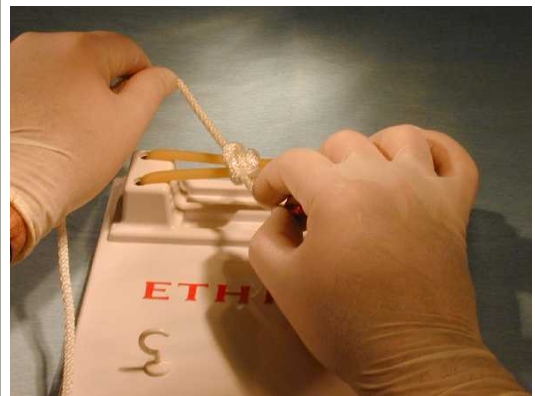
23) And the right index finger rolls behind the short end in order to rotate it up through the loop.



24) The short end has emerged from the loop and has been re-grasped by the right hand.

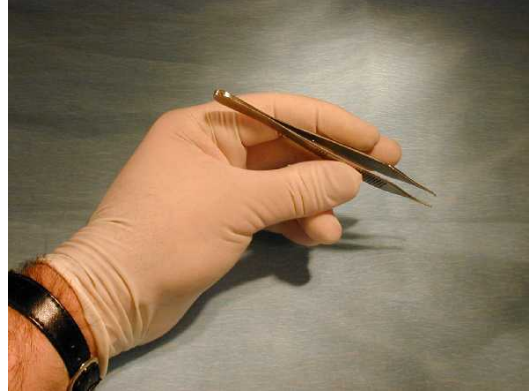


25) And the 3rd throw is secured by pulling the short strand toward the surgeon, as the long strand is pulled away at an angle of 180 degrees.

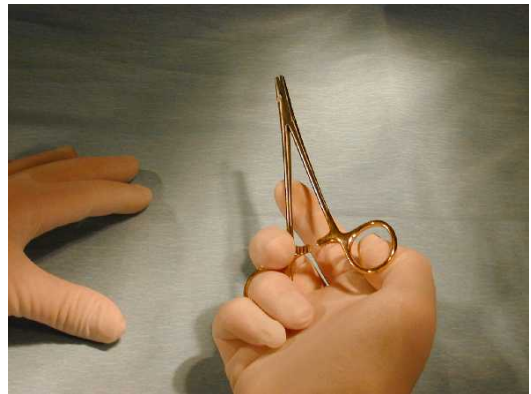


## 4. The techniques of a Simple Interrupted Suture

Small toothed forceps, such as the Addison forceps shown here, should be used to grasp the skin edges during suturing. Forceps with teeth provide a secure grasp with minimal pressure, thereby avoiding crushing of the skin edge. The forceps should be held in the first three fingers as one would hold a pen, using the first three fingers.



The needle holder should be held in a way that is comfortable and affords maximum control. Most surgeons grasp the needle holder by partially inserting the thumb and ring finger into the loops of the handle. Note that the index finger provides additional control and stability.

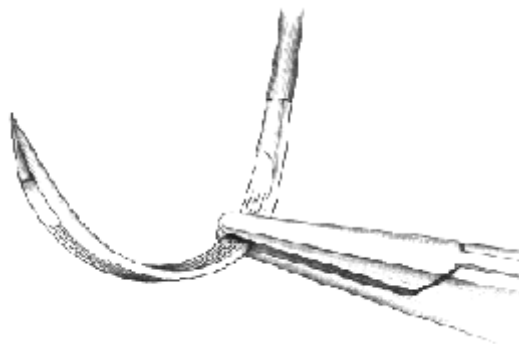


This illustrates the same grasp, but with the hand pronated. Supination and pronation are required to manipulate the curved needles used in surgery.

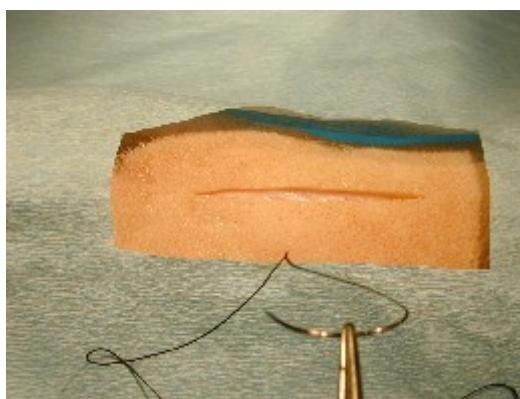




As a rule, the needle should be grasped at its center or perhaps 50-60% back from the pointed end. The needle should be grasped 1-2 mm from the tip of the needle holder.

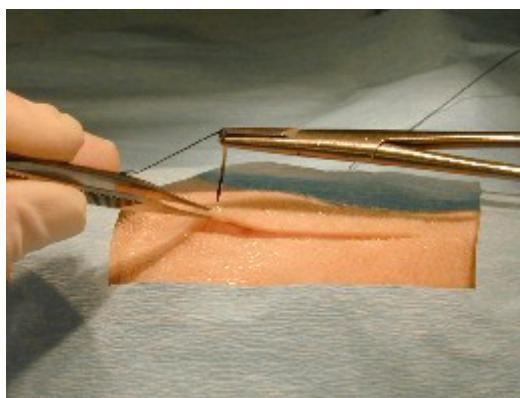


One should avoid grasping the suture material or the distal end of the needle with the needle holder, since this will damage the suture.

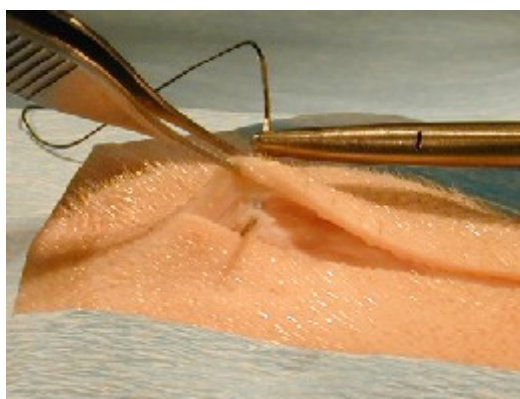


Placement of the 1st suture is begun by grasping and slightly everting the skin edge. The right hand is rotated into pronation so that the needle will pierce the skin at a 90° angle.

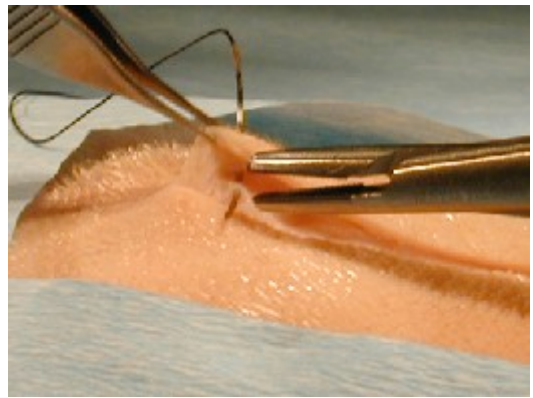
Note that the trailing suture is placed away from the surgeon to avoid tangling.



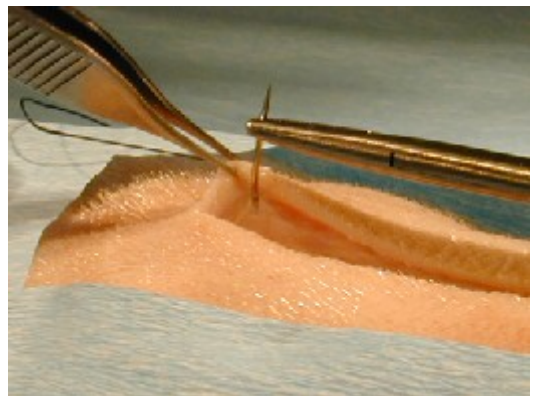
The needle is driven through the full thickness of the skin by rotating the needle holder (supinating). By keeping the shaft of the needle perpendicular to the skin surface at all times, one takes advantage of the needle's curvature in traversing the skin as atraumatically as possible.



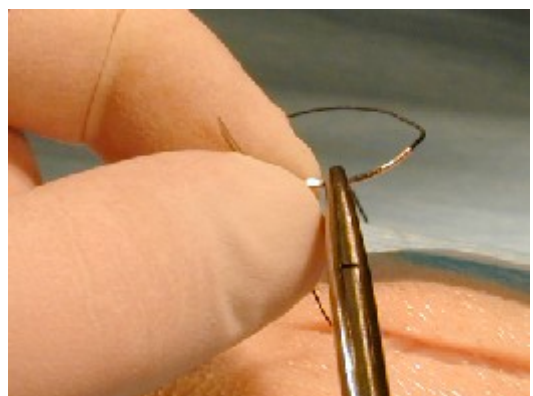
The needle has been released and is about to be regrasped. Note that the forceps maintain their grasp, thereby preventing the needle from retracting. The right hand has been fully pronated in preparation for regrasping the needle.



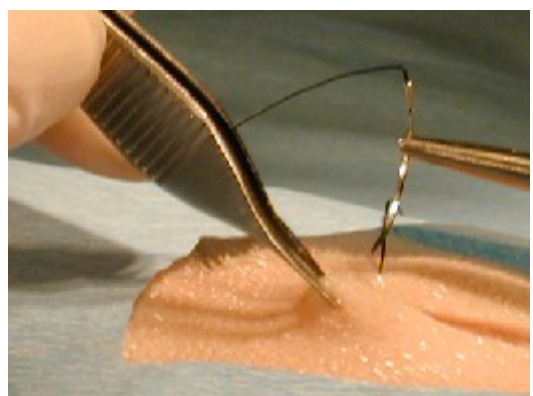
Pronation in the previous step makes it possible to complete passage of the needle with a smooth, natural supination which rotates the needle upwards and away from the surgeon. Again, this minimizes trauma to the tissues.



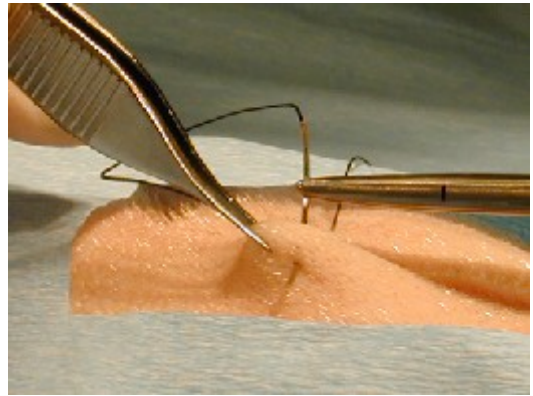
Here the needle is being regrasped in preparation for passage through the opposite skin edge. This was traditionally done by grasping the needle with the non-dominant hand. However, given the risks of HIV and hepatitis, it is probably advisable to train yourself to use the forceps for this instead of fingers.



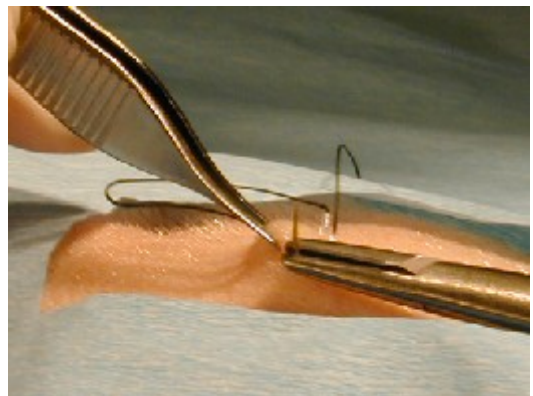
The skin edge closest to the surgeon has been grasped and everted slightly, while the right hand is pronated to "cock" the needle and position it for passage through the skin.



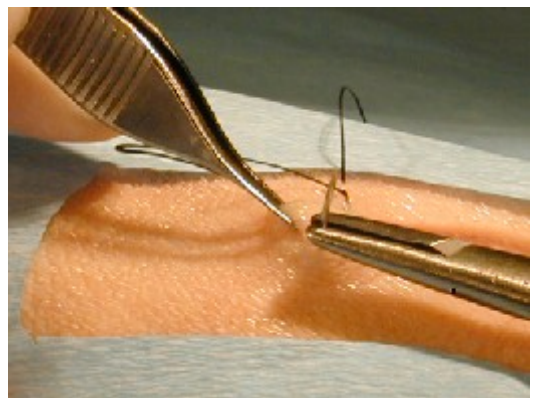
Again, the right hand is supinated in order to rotate the needle through the full thickness of the skin, keeping the shaft at a right angle to the skin surface.



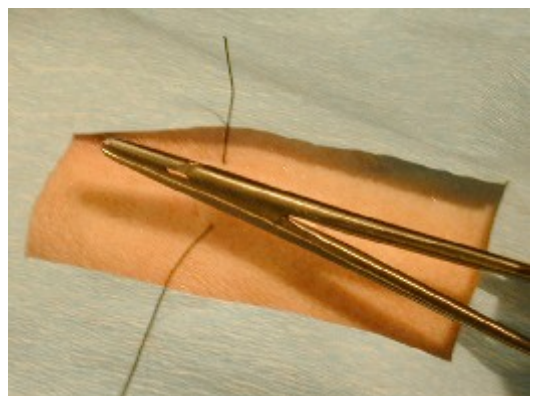
After releasing the needle, the right hand is pronated before the needle is regrasped...



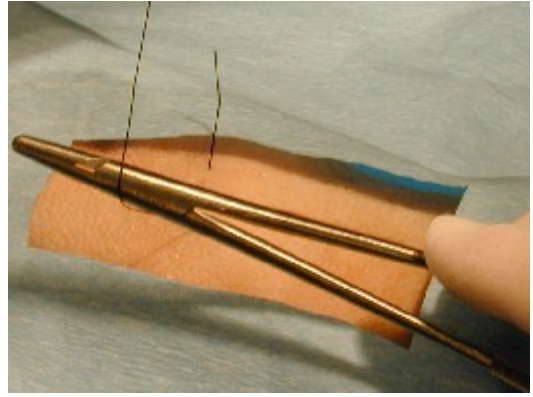
... and the right hand is then supinated in order to rotate the needle through the skin atraumatically.



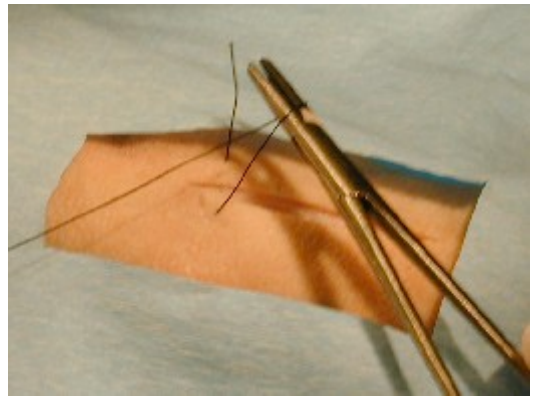
The suture material is drawn through the skin, leaving 2-3 cm. protruding from the far skin surface. The forceps are then dropped or "palmed" so the left hand can grasp the long end in preparation for an instrument tie. Note that the needle holder is positioned between the strands over the wound.



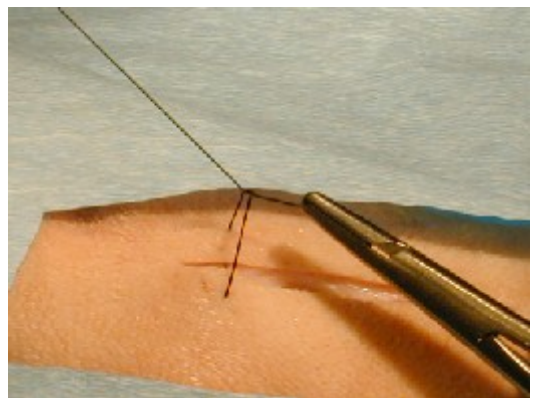
The long strand is being wrapped around the needle holder to form the loop for the first throw of a square knot.



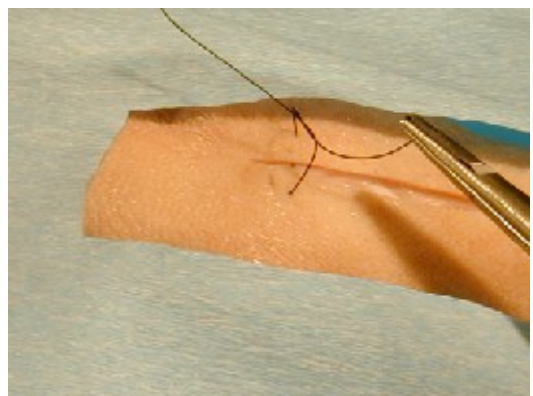
The needle holder is then rotated away from the surgeon to grasp the short end of the suture.



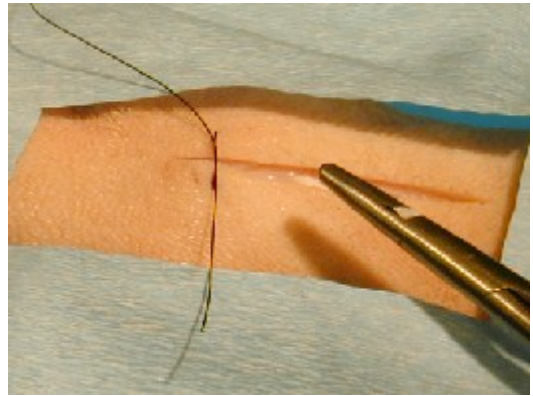
The short end is grasped and drawn back through the loop toward the surgeon.



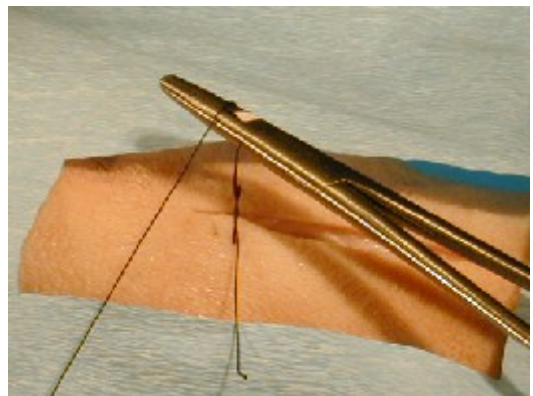
The throw is tightened...



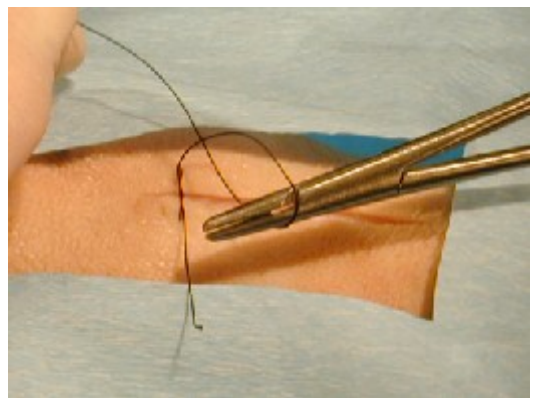
... creating a flat throw which will be tightened just enough to approximate the skin edges.  
Remember: approximate; do not strangulate.



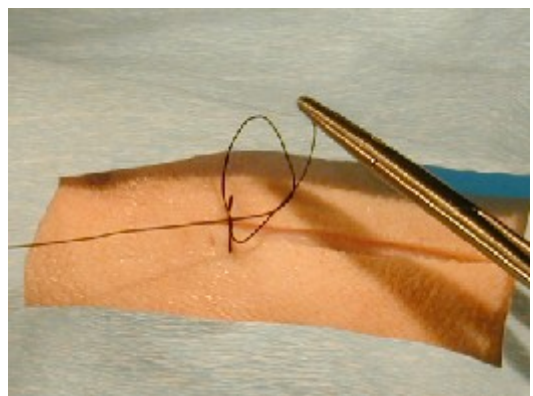
The second throw of the square knot is initiated with the needle holder pointed to the left as the long strand is wrapped around it by bringing the long strand toward the surgeon.



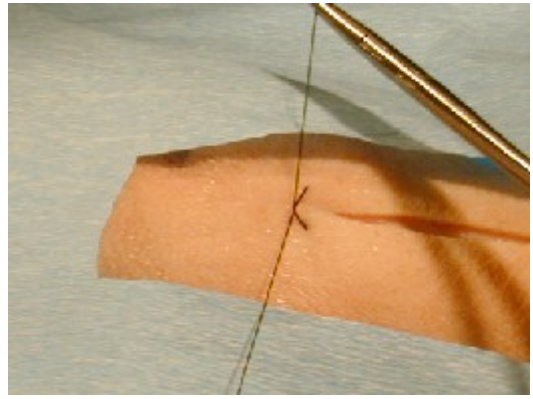
The needle holder is then rotated toward the surgeon to retrieve the short end, ...



... and the short end is drawn through the loop that has been created, pulling it away from the surgeon.



The second throw is then brought down and tightened securely against the first throw.



With a braided material, such as silk, a third throw (replicating the first) would be placed to secure the knot. If a slippery monofilament material, such as nylon, were being used, one would place 5 or 6 throws of alternating construction in order to minimize the likelihood of knot slippage.

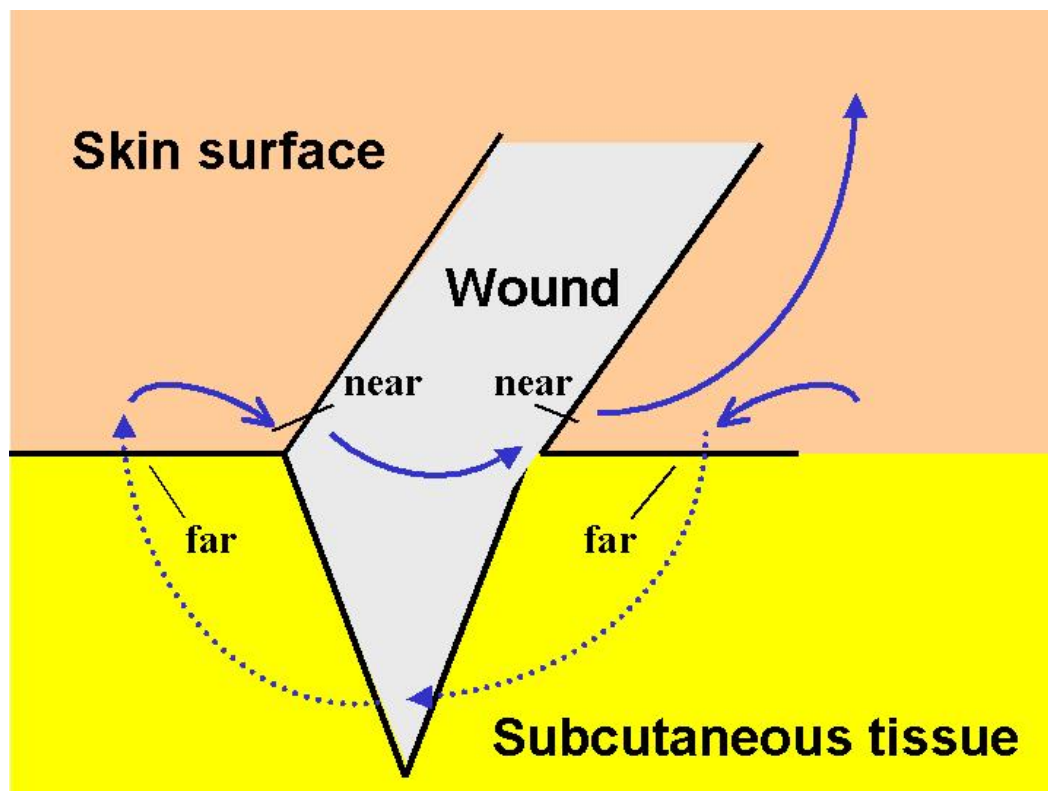
The suture will then be cut leaving 3-4 mm tails. The next suture will then be placed about 4 mm away from the first one. The distance between stitches will depend on how easily the wound edges can be approximated and how much tension or motion is likely to be exerted across the wound during healing. For example, a wound on a flexion surface, such as a knuckle, might require closer sutures than a wound in the scalp.

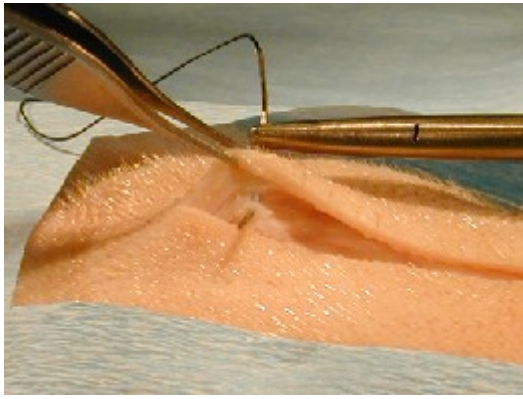
## 5. The techniques of a Vertical Mattress Stitch

The vertical mattress stitch is particularly useful in situations in which the skin edges have a tendency to invert or turn down into the wound, e.g. in the palm of the hand.

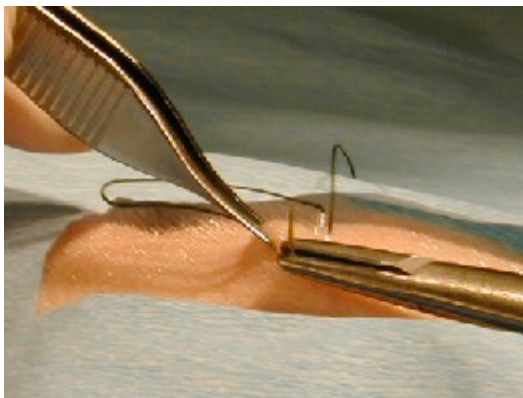
### Path of the vertical mattress stitch:

The vertical mattress stitch consists of "far-far" and "near-near" components. The "far-far" component is similar to the two bites for a simple interrupted stitch. These are about 4 mm from the wound edge. The "near-near" components are bites that are taken very close to the wound edge, and these are responsible for ensuring eversion of the wound edges when the suture is tied.

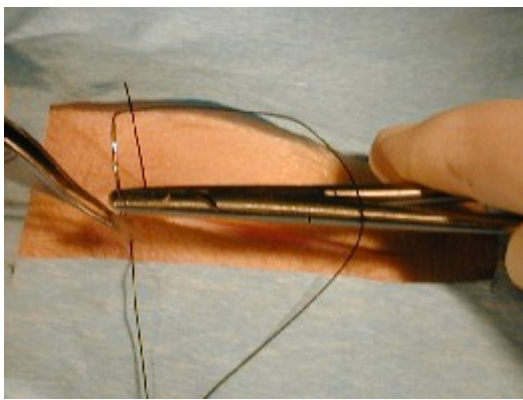




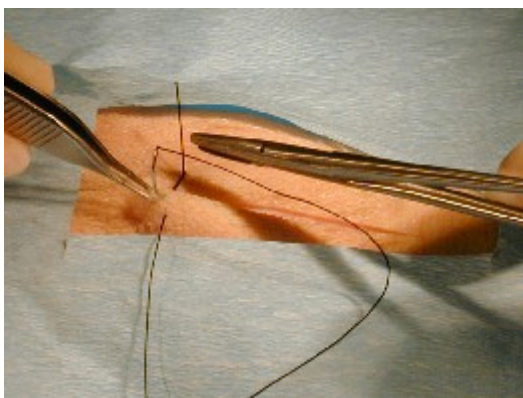
The first "far" bite is just like the beginning of a simple interrupted stitch - about 4 mm from the wound edge.



The second "far" bite is being placed in the proximal wound edge, and the needle emerges about 4 mm from the wound edge.

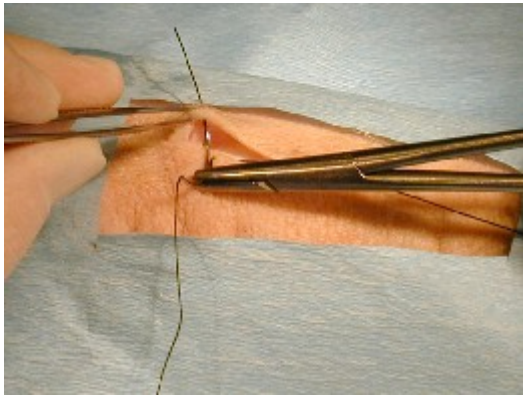


The first "near-near" component is placed by reversing the placement of the needle in the needle holder and "backhanding" the needle so that the bite is taken away from the surgeon.

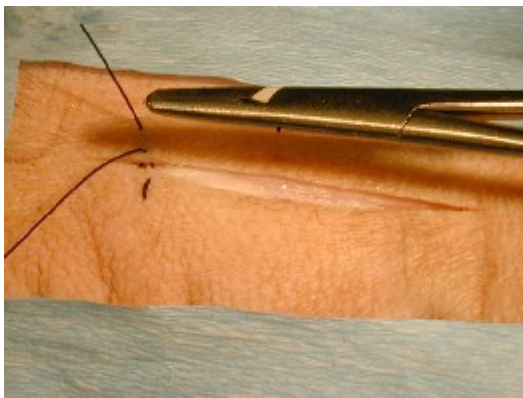


The first "near" bite has been taken, and the needle holder is about to regrasp the needle to complete the bite.

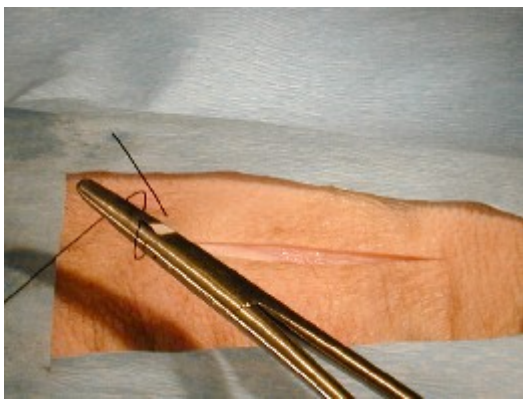




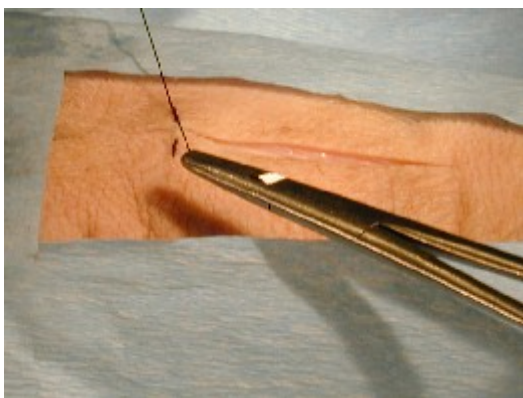
The needle has been regrasped, and now the second "near" bite is being taken on the wound edge furthest away from the surgeon.



Both the short and long strands emerge from the skin surface furthest away from the surgeon, and the needle holder is being positioned to begin an instrument tie.



The first loop of the square knot is formed by wrapping the long strand around the needle holder...



... and the short strand is grasped and pulled back through the loop toward the surgeon, bringing the throw down just tight enough to approximate the wound edges. After second and third throws are added to secure the knot, the next stitch will be placed about 4-5 mm to the right of the first stitch.