Knots, sutures, and skin flaps

In today’s laboratory, we will apply our knowledge of anatomical layers, and the tissue properties of these layers, to wound closure. We will practice knot-tying, five basic sutures, and four ways to use skin flaps to close skin defects.

For this exercise, you will need pigs’ feet and/or ears, a sharp scalpel, small dissecting scissors, tissue forceps, a needle driver, a marking pen, a small ruler (or calibrated scalpel handle), and several packets of suture material.

Knots

Two ways to tie a surgeon’s knot. A surgeon’s knot resembles the familiar square knot except that the first throw consists of two loops instead of the single loop used for a square knot (Figure 1). Initially, many students find it strange to tie familiar knots using unfamiliar motions. The ability to tie secure knots quickly and skillfully is an essential clinical skill, and the time spent practicing surgical knot-tying is well-rewarded.

Two-hand tie. Practice tying five two-hand surgeon’s knots, using your knot board, or a chair arm, as shown in Figure 1. Complete five or six throws per knot.

Instrument tie. When you have completed the five two-hand ties, complete 10 instrument tie surgeon’s knots using your knot board, or a towel, as shown in Figure 2.
Figure 1. Steps in completing a two-hand surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 1 continued. Steps in completing a two-hand surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
**Figure 1 continued.** Steps in completing a two-hand surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. *Basic Surgical Skills*. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
**Figure 2.** Steps in completing an instrument tie surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. *Basic Surgical Skills*. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 2 continued. Steps in completing an instrument tie surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 2 continued. Steps in completing an instrument tie surgeon’s knot (all Figures modified from, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Sutures

The basic rules of wound closure should be observed when practicing wound closure on the pigs’ ears and feet provided for today's laboratory, and when working with the cadavers in the anatomy lab.

Tissue trauma should be minimized. Scalpel blades and scissors should be sharp. Traction and undermining should be gentle. Nerves and blood vessels should be preserved. Skin incisions should be made with a sharp scalpel blade and generally placed perpendicular to the skin surface to enable precise approximation of the wound edges.

The needle driver should be correctly armed. Arm the needle holder by grasping the needle as shown in Figure 3. The needle holder should grasp the needle about 1/3 of the way between the swaged end and the tip. Why is the needle curved?
Needles should be positioned perpendicular to the skin surface for each bite (Figure 4). Rotation of your forearm and the needle driver should follow the arc of the needle.

**Figure 4.** Correct position of the needle tip and a review of anatomic layers.

Anatomic layers should be closed separately. In today's laboratory, we will begin practicing three sutures placed in the full thickness of skin (both dermis and epidermis), one suture placed in the dermis only, and one suture used to close potential dead spaces in the superficial fascia.

Wound edges should be under appropriate tension with the edges slightly everted. Gently undermining skin edges, in the plane between the dermis and superficial fascia, often enables better approximation of the wound edges with less tension. The wound edges should be slightly everted, not inverted or overlapped. Sutures tied too tightly will be uncomfortable and can lead to tissue strangulation. Sutured wounds should lie flat with no puckers or standing cones (‘dog ears’).

Knots should be secure and flat. Knots and knot tails should be placed as far as possible from the wound edges.

**Three skin sutures**

Interrupted sutures. These useful sutures require only one bite of the needle per suture (Figure 5). Interrupted sutures should extend through both epidermis and dermis, but not into superficial fascia.

Make at least two incisions in the pig foot or ear and practice closing both incisions with interrupted sutures. Apply the ‘principle of halving’, and place your first interrupted suture (central suture) in the middle of the incision. Your next suture should be placed halfway between the central suture and one end of the incision. Subsequent sutures should similarly be placed at halfway points until the sutures are completed and evenly placed (Figure 5). After you have completed both closures, remove the sutures from one closure, following the instructions in Figure 5.
Figure 5. Steps in completing interrupted sutures (all Figures modified from, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
**Figure 5 continued.** Steps in completing interrupted sutures (all Figures modified from Sherris, DA and EB Kern. 1999. *Basic Surgical Skills*. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).

Running Suture. The running suture ("baseball stitch") requires many needle bites with the suture carried between the bites and only the two ends of the suture knotted (Figure 7). Make at least two incisions in the pig foot or ear and practice closing both incisions with a running suture. After you have completed both closures, remove the sutures from one closure, following the instructions in Figure 8.

Horizontal Mattress Suture. The horizontal mattress suture requires two needle bites per suture (Figure 9). Make at least two incisions in the pig foot or ear and practice closing both incisions with horizontal mattress sutures. After you have completed both closures, remove the sutures from one closure, following the instructions in Figure 10.
Figure 7. Steps in completing a running suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Figure 7 continued. Steps in completing a running suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Figure 8. Steps in removing a running suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Figure 9. Steps in completing a horizontal mattress suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Figure 10. Steps in removing a horizontal mattress suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
TWO SUTURES IN DEEPER LAYERS

RUNNING INTRADERMAL SUTURE. Subcuticular sutures are placed in the dermis only and, except for an optional central suture and the suture ends, the needle bites do not extend into the epidermis (cuticle) (Figure 11). Running subcuticular sutures reduce the likelihood of keloid scar formation, and they are relatively quick and easy to remove.

Make at least two incisions in the pig foot or ear, and practice closing both incisions with running subcuticular sutures (Figure 11). After you have completed both closures, remove the sutures from one closure, following the instructions in Figure 12).

SUPERFICIAL FASCIA SUTURE. This suture may be used to eliminate dead space resulting from a wound extending into the superficial fascia. Dead spaces are open areas within a wound where tissues are not closely approximated. Seromas or hematomas may form in dead spaces as serous fluid or blood accumulates, and bacterial overgrowth may ensue.

Make at least two incisions in the pig foot or ear and practice closing both incisions with a superficial fascia suture (Figure 13).
Figure 11. Steps in completing a running subcuticular suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 11 continued. Steps in completing a running subcuticular suture (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 13. Steps in closing dead space within the superficial fascia (all Figures modified from Sherris, DA and EB Kern. 1999. *Basic Surgical Skills*. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 13 continued. Steps in closing a dead space within superficial fascia (all Figures modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
FLAPS

Skin flaps may be used to close defects resulting from skin excision following removal of a lesion or the revision of jagged wound edges to provide better approximation and closure. Viable skin flaps remain connected to skin adjacent to the wound, and they receive their blood supply, and often their innervation, through a vascular pedicle continuous with the intact skin.

ELLiptical excision. An elliptical excision is shown in Figure 14. To complete your own elliptical excision on the pig foot or ear, draw a small ‘lesion’ with your marker pen, draw a correctly-proportioned ellipse around the ‘lesion’, and use your scalpel to incise the skin and excise the ‘lesion’ (Figure 14). Working in the plane between the skin and superficial fascia, use your scalpel or dissecting scissors to undermine the skin edges for 1-2 cm on either side of the wound. Approximate the edges of the wound using forceps or a skin hook. Place a suture centrally, and close the defect using interrupted sutures placed according to the principle of halving.

Figure 14. Steps in completing an elliptical excision and closure of the defect (Figure modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Rotation Flap. A rotation flap is shown in Figure 15. To complete your own rotation flap, draw a small 'lesion' on the pig foot with your marker pen, draw a correctly-proportioned rotation flap adjacent to the 'lesion', and use your scalpel to incise the skin and excise the 'lesion' (Figure 15). Working in the plane between the skin and superficial fascia, use your scalpel or dissecting scissors to undermine the skin edges for 1-2 cm on either side of the wound. Approximate the edges of the wound using forceps or a skin hook. Place your first suture in the corner of the rotation flap, then secure the edges of the rotation flap using interrupted sutures placed according to the principle of halving.

Advancement Flap. An advancement flap is shown in Figure 16. To complete your own advancement flap, draw another small lesion on the pig foot, draw a correctly proportioned advancement flap adjacent to the 'lesion', and use your scalpel to incise the skin and excise the 'lesion' (Figure 16). Working in the plane between the skin and superficial fascia, use your scalpel or dissecting scissors to undermine the skin edges for 1-2 cm on either side of the wound. Approximate the edges of the wound, and use your first suture to secure the middle of the short edge of the advancement flap (Figure 16). Use sutures to secure the corners of the short edge of the advancement flap. Close the lower edge of the advancement flap with interrupted sutures placed according to the principle of halving. Beginning at the upper corner of the short edge of the advancement flap, secure the upper edge of the advancement flap by placing evenly spaced interrupted sutures. This will eventually produce a standing cone ('dog ear') of redundant skin. Resolve the standing cone by following the steps in Figure 17, and complete your closure of the advancement flap.

Z-Plasty. A Z-plasty is shown in Figure 18. Z-plasty incisions produce two adjacent triangular flaps each with its own vascular pedicle. The triangular flaps are transposed in order to simultaneously lengthen scars and reorient their long axes. The apical angles of the Z-plasty triangles should be no less than 30° and no more than 60° degrees. Triangles with apical angles more acute than 30° may undergo apical necrosis at the triangle tips; triangles with apical angles more obtuse than 60° may be difficult to rotate.

On the pig foot, draw a dotted line 3 cm long to represent the original scar. Draw the other limbs of the Z-plasty incisions using appropriate lengths and angles according to Figure 18. Undermine the edges of the two triangular flaps using a scalpel or small scissors. Transpose the two triangular flaps and secure the apex of each triangle with an interrupted suture. Complete your closure of the Z-plasty with additional interrupted sutures placed according to the principle of halving. The length of your Z-plasty 'scar' should exceed the length of the original scar by 25%.

Whenever possible, practice your knots, sutures, and flaps in the lab.
Figure 15. Steps in completing a rotation flap (Figure modified from Sherris, DA and EB Kern. 1999. *Basic Surgical Skills*. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.)
Figure 16. Steps in completing an advancement flap (Figure modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100.
Figure 17.  Steps in resolving a standing cone (‘dog ear”) (Figure modified from Sherris, DA and EB Kern.  1999.  *Basic Surgical Skills*.  Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).
Figure 18. Steps in completing a Z-plasty (Figure modified from Sherris, DA and EB Kern. 1999. Basic Surgical Skills. Rochester, MN: Mayo Clinic Scientific Press, pages 99-100).