

## SPECIAL SUTURING TECHNIQUES: A Review of Technique and Application

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Foot and ankle surgery requires a knowledge of tissue securing techniques to repair tissue damage from trauma or reinforce surgical reconstructions. These tissue repair and securing techniques may involve absorbable suture, non-absorbable suture, or a myriad of new implantable anchoring devices. A versatile understanding of these options for repair can greatly enhance not only the security of the repair but permit earlier mobilization of the extremity to rehabilitation and return to activity. These techniques involve both soft tissue to bone and tissue to tissue options. Suturing methods can be as simple as a simple suture secured with a surgeon's knot or as complex as a double-pass pants-over-vest technique. Each varied suturing method has a role and place in reconstructive foot and ankle surgery or trauma repair. The ability of the surgeon to visualize and utilize the more complex suturing maneuvers can greatly impact the security of the repairs. Several techniques will be reviewed here in terms of method and application. Principles of basic suturing will be reviewed. The more complex suturing maneuvers build on a basic understanding of the simple suture and its affect on tissue and the security of the repair. The more complex suturing maneuvers will be broken down into procedural steps with emphasis on the visualization of the final repair to make application more practical. Foot and ankle surgery has been described as more art than science, an understanding of suture techniques is the foot and ankle surgeon's pallet.

### TISSUE APPPOSITION OPTIONS

Before an understanding of suturing techniques can be undertaken, a review of options for tissue apposition should be reviewed. Many surgeons do not understand these basic concepts of tissue orientation and how to exploit them to reinforce tissue repairs. These tissue apposition options may predicate the type of suturing method needed to secure the repair. Three basic tissue apposition options are possible. The first is a side-to-side type of repair. This tissue repair involves securing back side-to-side a cut or torn tissue layer. No modification in

the tissue plane apposition is performed, basically the tissue is repaired back as it was found. An example of this type of repair is the skin layer. No overlap of one cut side of the skin surface over the other cut skin surface to reinforce the repair or gross eversion of the margins can be utilized or performed by the nature of the tissue layer. The external surface must be maintained and exposed as the outer surface. This tissue repair represents strictly an apposition of the tissue layer, or skin in this instance, side-to-side.

The second type of repair is termed pants-over-vest. In this type of repair the tissue plane is purposefully overlapped as part of the repair. The cut or torn tissue margins are not directly apposed. A doubling over of a portion of the tissue layer occurs along the margin of the repair. This maneuver requires a redundancy of tissue that is exploited to reinforce the repair. Many times a redundancy is excised to tighten a tissue repair and a side-to-side suturing technique employed. With the pants-over-vest technique, the doubling over of the layer adds reinforcement to the repair. A step effect at the tissue margins is created due to the doubling over of the tissue both on the internal and external surface of the repair. This may or may not be desirable based on the tissue layer thickness and the potential for external shoe or joint structure irritation that can result. The pants-over-vest technique is commonly employed in lateral ankle stabilization surgery.

The third type of tissue apposition is the everted margins. In this apposition method the tissue margins are grossly everted one to the other. This maneuver maintains a planer surface on one side of the repair while taking up redundancy and permitting ample tissue to secure and seat the suture itself. The opposite surface of the repair has a prominence where the suture has been placed and the cut surfaces everted. This surface must be buried and protected. This maneuver is employed in the plication of the spring ligament in pes valgoplanus surgery. Here a minimal amount of tissue at best is available to secure the suture even with plication due to the short length of the spring ligament. The spring ligament surface towards the talar head is articular as an extension of the sustentaculum

tali and needs to be smooth and even without any step effect. The opposite surface is deep and well protected in the arch of the foot effectively burying the suture knot and redundancy of tissue away from the joint articular surface.

## BASIC SUTURE PRINCIPLES

From the simple suture to more complex suturing maneuvers, the basic suture principles are the same. Understanding suture principles aids application as well as modifications in technique to tailor the suture maneuver to the specific need of the surgical situation. Wherever the suture is started in tissue to the point where the suture exits the tissue and the suture maneuver ends, the knot will lie at some point in between. This may seem a simple principle, but its understanding aids burying suture knots as well as not passing suture loops over tissue margins to avoid binding and the inability to tighten and secure the suture. By starting and ending the suture where the knot is desired inadvertent knot prominence, especially in non-absorbable sutures close to the skin surface or near gliding surfaces, can be avoided and the possibility of irritation diminished. The distance between the starting and stopping points is important as well. Those two points will be drawn together as the knot is secured. The greater the distance between these points the more tissue is bound and bunching or strangulation can occur. Relatively avascular tissue like joint capsule may not be a problem but skin would be, as practical examples.

Where tissue planes are joined with multiple pass suture maneuvers and multiple entrance and exit points in tissue planes, careful attention to the future position of the tissue planes and the alignment of the exit and entrance points is critical. If these points become confused and not properly aligned, binding of the suture passes will occur and inability to tighten the suture. As long as the entrance and exit point are on the same side of the same plane and all entrance and exit points are directly apposed, the suture should perform in the desired way. This simple principle aids the understanding of the most complex maneuvers. With multiple pass maneuvers as in the simple suture, the points of tissue penetration come together as the suture is tighten and tied. In a simple suture, two points come together one to the other. In a box or over-and-over type suture, the four corners come together to a central point. In certain suture maneuvers, the suture itself may not be intended to actually cross the tissue margin, as in joining planes of tissue in the pants-over-vest repair or the everted margins repair. If the suture is passed inadvertently over the tissue margin, binding of tissue and inability to secure the

suture will occur. This concept of margins can be likened to joining sheets of paper together with staples or paper clips. The staple is similar to a suture for a pants-over-vest repair as the metal does not cross the margin of the paper. A paper clip would be as a suture that crosses the margin of a tissue repair. If a suture is placed in this location in a pants-over-vest type repair, it will bind over the edge of the tissue margin and be ineffective.

## PANTS-OVER-VEST

Certain foot and ankle reconstructions may involve the reinforcing of weakened soft tissues that are necessary to maintain a degree of stability for stance and gait. These damaged tissues may be simply torn or display gaps that require reinforcement in the form of various graft materials either natural or synthetic. The tissue layer may not be torn, but intact and stretched unable to aid the stability needed. If intact, the stretched tissue redundancy may be excised and repaired primarily to shorten or tighten the layer. No reinforcement is provided in this tissue apposition technique, yet the repair may be sufficiently strong as in the medial capsule of a first metatarsophalangeal joint following buionectomy with capsulotomy. The tissue redundancy may be incised and not repaired primarily in a side-to-side fashion but the margins overlapped and repaired. This is not practical in the medial capsulotomy following bunioectomy as the tissue layer created would be thick and prominent medially for shoe pressure. The delayed primary repair of weakened lateral ankle ligaments and repair of chronic subluxating peroneal tendons are examples where overlap as part of the tissue repair is practical. In these examples the tissue layer is intact, yet stretched and weakened and not ineffective in maintaining the stability needed. This redundancy of tissue can be exploited to reinforce the repair. This is termed a "pant-over-vest" repair.

The suturing maneuver involved in the pants-over-vest technique is not direct apposition of the layer side-to-side but an overlap of the cut tissue plane that can reinforce the repair by doubling the tissue thickness (Figure 1). The tissue margins may be overlapped with either margin placed over or under the other which ever is practical and aids suture placement. The pant-over-vest suture itself is not placed at either edge of the tissue to be repaired but more centrally in the area of tissue overlap. This location provides optimal seating of the suture to prevent tearing of the tissue and suture pull-out. The suture can be visualized in the final completed overlapped tissue position.

The suture is placed from the top of the layer to be over-lapped down to and through the top of the layer to be under-lapped. The second pass is the reverse of the first to end on the surface that will seat the knot. The greater the distance between the two passes the more bunching of tissue can occur. As the knot is tightened the tissue plane can become wavy at each suture and the repaired plane of tissue less flat and even. The pants-over-vest suture can be thought of as a simple suture down through two layers that does not involve a margin. The suture is typically started then finished parallel to the cut margin of the repair not perpendicular to the cut margin of the repair. This parallel suture orientation adds greater strength to avoid suture pull-out. Multiple single pass sutures may be seated along the margin of the repair. These are typically left untied until all are seated to aid visualization as in digital syndactyly. A double-pass maneuver may be utilized in the pants-over-vest suture if further reinforcement and security in the face of more friable tissues is needed. The double pass binds more tissue in the suture providing further reinforcement to the suture itself. Once the pants-over-vest sutures are completed, the exposed more superficial tissue margin may be secured to the under-lapped layer with further sutures of choice to reinforce the repair even more.

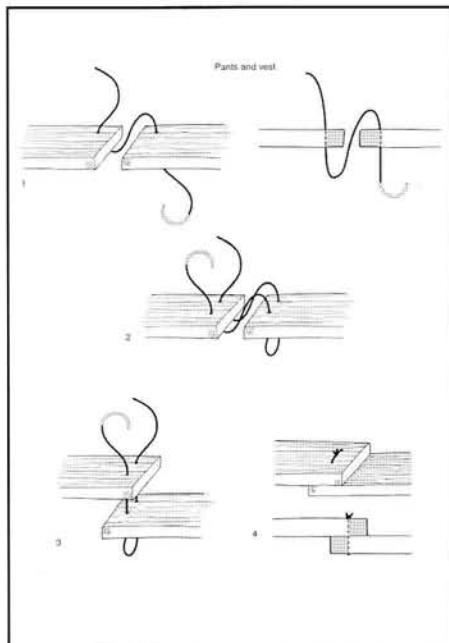


Figure 1. Pants-over-vest Tissue Repair. 1. The suture is begun through the first surface then into the second surface on that side to be directly apposed to the first. 2. The second pass is initiated a short distance from the exit point of the first pass parallel to the free margin. 3. As the suture is secured the surfaces of the tissue will overlap. 4. Completed single pass suturing maneuver.

## MODIFIED MATTRESS SUTURE REPAIR

When two tissue plane margins are to be apposed and redundancy is present in a weakened or overly lengthened tissue layer, it may be important following the repair that one of the surfaces be maintained smooth and congruous (Figure 2). This smooth and congruous surface may be toward a joint surface and articular or potentially prominent subcutaneously and result in shoe irritation. This type of tissue repair is demonstrated by the spring ligament plication component of the medial arch reconstruction in pes valgoplanus surgery. The deeper surface of the ligament is articular with the talar head. The repair must maintain as smooth and even a surface for midtarsal joint motion as possible. A pants-over-vest repair here would result in a step effect that could affect smooth talar excursion beyond the sustentaculum tali. Simple sutures would result in suture material exposed to the articular surface that could likewise affect smooth talar motion. By utilizing the modified mattress suture technique, one congruous surface can be maintained while taking advantage of the redundant tissue to aid suture security.

The suture is initiated on the side away from the surface to be maintained as smooth though to the apposing surface. The second pass is the reverse of the

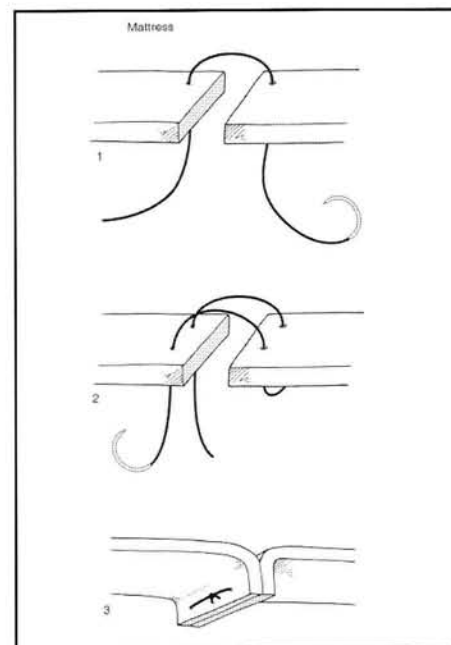


Figure 2. Modified Mattress Suture. 1. The suture is begun through the first surface from that side of the tissue plane away from the side to be maintained as congruous. The pass continues through the second surface ending on the non-congruous side. 2. The second pass of the suture recreates the first in the opposite direction. 3. The knot is secured and the margins evert away from the congruous surface.

first back to the original surface plane side. The knot is secured and the two apposing margins will evert one to the other taking up redundancy as the suture is pulled tighter. The margins may need encouragement to turn in the appropriate direction as the knot is tightened. To execute the suture maneuver correctly the end product is visualized and the sequence becomes self-evident. The more tissue between the entrance and exit points, the more chance for bunching of the tissue layer and an uneven surface. Multiple sutures may be placed along the margin for additional security.

### RUCH ADDUCTOR SUTURE

The Ruch adductor suture maneuver can be utilized to bring one tissue plane into another in a perpendicular relationship (Figure 3). The intracapsular adductor tendon transfer utilized as a component of hallux valgus surgery is an example of the application of this maneuver, but other possibilities in foot and ankle surgery exist. The adductor tendon is brought across the dorsal metatarsal transversely into the vertically oriented medial joint capsule. The visualization of the final product greatly aids this rather complex suture. When executed appropriately, the tissue are brought together securely and a firm repair occurs. The double pass version greatly facilitates the repair where only one suture is possible.

The suturing maneuver is begun and ended on the same surface outside the more stable tissue plane therefore drawing the second plane to the first. The knot is then secured outside the more stable plane. Once through the first tissue plane the second plane is entered and exited exactly opposite the penetration points of the first tissue plane. This approach avoids bunching of the tissue and encourages a smooth pulley effect while tightening the knot. This pulley effect is especially critical when a double pass version is employed. Once secured and tightened, a firm binding of tissues perpendicular to each other is effected.

### CONCLUSION

The pants-over-vest, modified mattress, and Ruch adductor suture are only some of the special suturing techniques employed in foot and ankle surgery. Foot and ankle surgery requires a thorough understanding of tissue securing techniques to repair damage from trauma or reinforce surgical reconstructions. A versatile understanding of these options for repair can greatly enhance not only the security of the repair but permit earlier mobilization of the extremity to rehabilitation and return to activity. Each varied suturing method has a role and place in reconstructive foot and ankle surgery or trauma repair. The ability of the surgeon to visualize and utilize the more complex suturing maneuvers can greatly impact the security of the repairs.

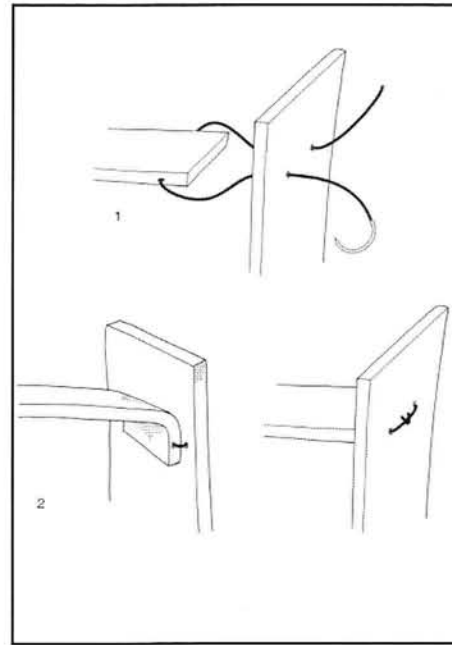


Figure 3. Ruch Adductor Suture. 1. The suture is begun on the more stable surface from outside to inside towards the second tissue plane. The pass through the second plane is directly opposite the exit and entrance points for the first plane. The suture is then passed back to outside of the first plane. 2. The finished and secured suture looking from the inside outward. 3. The finished and secured suture looking from the outside inwards.