Key Points:

- The viscoelastic property of skin should be used to reduce tension on skin closures, to avoid situations such as suture ‘pull out’.
- Undermining is basic to tension relieving procedures, as well as the placement of a variety of suture types and patterns to spread the tension evenly over the skin, away from the edges.
- Several pretensioning and skin stretching options will increase the amount of skin available.
- Relaxing incisions (single or multiple) can also be employed to gain primary closure.
- Future directions in tension-relief include assessing the effects of negative pressure wound therapy over closed incisions.

Full thickness skin has a remarkable tendency to retract when wounded; fortunately it also carries the innate ability to adapt to applied stress. One can take advantage of this viscoelastic nature to relieve tension on suture lines when closing a wound. If simple approximation of wound edges produces such tension that suture ‘pull-out’ is likely, a tension-relieving technique that mobilizes adjacent skin should be considered. The tension-relieving techniques discussed in this document allow local tissues to be mobilized to cover a cutaneous defect without raising a flap or harvesting a graft. Before considering any reconstructive closure technique, the wound should be free of infection, have a good blood supply and the periwound tissue should be healthy.

Tension lines in the skin of a dog are formed by the predominant pull of the fibrous tissue within the skin (they are called “Langer’s Lines” in humans). Although there is general agreement regarding the main direction of tension lines dogs, there clearly individual and breed variations, e.g., Greyhounds v. Labradors! Tension lines in dogs should always be considered when closing a defect. One of the best ways of assessing the amount of tension on wound edges is to manually approximate the edges several ways. Closing the wound parallel to tension lines will place less tension on the sutures, minimize puckering and “dog ear” formation, and reduce the incidence of “biological tourniquet”.

**Undermining:** Undermining is the use of scissors or a scalpel to separate the skin from underlying tissue. This allows the full elastic potential of the skin to be utilised. On areas of the body that have a panniculus muscle layer, undermining should be performed deep to this layer to preserve the deep subdermal plexus supplying the dermis and epidermis. Try to preserve any direct cutaneous vessels encountered when undermining.

**Strong Subcutaneous Sutures:** A strong subcutaneous suture line will significantly reduce tension on skin sutures. Bites should be taken in the fibrous portion of the hypodermis and the skin edges should be almost touching following a well-placed subcutaneous layer. Such placement relieves tension on the skin closure and allows the surgeon to place finer skin sutures that concentrate more on accurate apposition.

**Walking Sutures:** Walking sutures are interrupted sutures of 3-0 (or occasionally 2-0) absorbable suture material, placed from the deeper portion of the dermis to the underlying fascia. They are placed following undermining and act to diffuse the tension evenly across the skin,
away from the edges. Walking sutures are placed in staggered rows on both sides of the wound, ‘walking’ the skin across the defect and allowing it to meet in the middle with minimal resulting tension on the primary suture line. Final skin closure is then accomplished with routine subcutaneous and skin sutures. If walking sutures are correctly placed, i.e., with the bite taken through the dermis, the overlying skin will appear dimpled at that point (a temporary cosmetic problem). Be careful not to penetrate the skin with the walking sutures, as this may introduce contamination and lead to subcutaneous infection. This technique is easier to perform in dogs with a thick dermis, and may not be appropriate to cats and thin skinned dogs.

_N.B._ Although walking sutures reduce tension on the primary suture line, they can be transiently uncomfortable, and can also compromise the vascular supply to the skin. Increased suture material in the wound is not desirable in contaminated wounds.

**Stent Sutures:** These sutures are usually pre-placed deep into the tissues, at some distance from the wound edges. The padding material beneath the suture loops must be soft and extend the length of the wound, or be short lengths under each suture. Stent sutures can be pre-placed as large, simple interrupted sutures and tied over a soft bandage roll bolster (Figure 1), or as large vertical mattress sutures, supported with some form of pad (e.g., Penrose drain) to prevent the suture cutting into the skin (Figure 2). Wide Penrose drains or bolsters of bandage roll are ideal, buttons are not (they do not disperse the tension widely enough, and can cause pressure necrosis underneath the button). Once the stent sutures are placed, the wound is closed in two layers, then the stent sutures snugged down as necessary. Stent sutures should be removed on the 3rd or 4th day post-operatively, once stress relaxation of the skin has occurred.

_Figure 1: Bolster stent_  
_Figure 2: Vertical mattress stent_

**FNNF and FFNN Sutures:** These sutures are indicated for closure of wounds with just a small increase in tension, or in which tension on the wound edges cyclically increases and decreases during movement, e.g., a flexion surface or lacerated paw pad. Far-near-near-far and far-far-near-near sutures are combinations of tension and approximating sutures, and refer to entry or exit distance from the primary suture line. Both FNNF and FFNN sutures are placed in the order that their names indicate (Figure 3). The “far-far” component provides tension relief, while the “near-near” component is appositional. All entrance and exit points of these sutures are linear, and placed perpendicular to the skin edges.
Skin Stretching Techniques

Mechanical creep is a phenomenon of skin that allows it to elongate under constant short-term loading. Within the extracellular matrix of the dermis, the coiled collagen fibers straighten and realign in a more parallel orientation when stress is applied over time, releasing water molecules and increasing skin viscosity. The delicate elastic fibers, also in the extracellular matrix, become fractured and lose their elasticity. Thus, over time, the skin will elongate (mechanical creep) and lose its tendency to recoil when the load is removed (stress relaxation).

**Pretensioning:** Pretensioning is a valuable tool to consider when contemplating closure of a large defect, and can even be considered when developing a flap. This technique takes advantage of mechanical creep and stress relaxation over the 24 to 72 hours before definitive wound closure. The technique works particularly well in truncal and proximal limb regions of dogs and cats, because of their weak hypodermal attachments. It can also be effective around the hock joint, antebrachium, and carpus in some animals. Pretensioning can be used when the surgeon can only achieve partial closure because of concern for biological tourniquet formation. When contemplating pretensioning or presuturing, it is essential that the periwound tissues are healthy. Several methods of presuturing or pretensioning can be performed. A simple continuous suture line through skin and hypodermis of the wound edges with 2-0 or 0 nonabsorbable monofilament suture material is a simple way of preparing the wound for being pretensioned. The suture line is gently loaded every 8, 12, or 24 hours over 2 to 3 days, gradually drawing the skin edges closer. At each periodic loading, the sutures will be noticeably looser as the initial tension has dissipated because of stress relaxation. After 2 to 3 days of pretensioning, even quite large defects can often be approximated directly. It is always surprising how much skin can be ‘persuaded’ to close over a few days. If you are unsure of whether to develop a flap or perform a direct appositional closure, consider pretensioning for a few days. At the time of definitive closure, the pretensioning sutures are removed completely, and the area is prepared for surgery. Closure is performed in two layers and requires minimal undermining and minimal disruption of the granulating tissue bed (which contributes to the contraction process).

Externally applied skin stretching devices are available that use Velcro pads glued to the skin and adjustable elasticized Velcro straps to relieve load the skin on either side of a wound. These devices can also be used postoperatively to minimize incisional tension.

**Intraoperative skin expansion:** This technique takes the opportunity to obtain a degree of stress relaxation and limited mechanical creep during the surgical procedure. By loading the skin edges following undermining, adequate tension relief on the primary suture line may be
obtained. The skin can be loaded using skin hooks, towel clamps or stay sutures to provide constant tension on the undermined skin for 30 – 45 minutes. This technique will not obtain the same degree of stress relaxation as pretensioning over several days, and may not even provide any advantage over simply undermining, but can be useful when positioning loose-skinned animals.

**Chronic Skin Expansion:** The use of skin expanders has been reported intermittently in the small animal veterinary literature. This technique is worth mentioning because in certain situations where skin loss is significant (e.g., severe burns), this may be the only technique that will enable robust, full thickness re-coverage. Skin expansion is not suited to acutely traumatized skin and is usually undertaken as part of a delayed or staged reconstructive effort. The technique takes advantage of the phenomenon of ‘biological creep’, which is defined as the creation of new dermal and epidermal components following prolonged constant loading. An inflatable or expandable silicone elastomer device of predetermined volume (e.g., 100 mls) is surgically or endoscopically placed in the subcutaneous tissues of pliable skin adjacent to an existing or proposed defect. After an initial healing period of several days, the device is expanded by 10-15% of final volume every 2 or 3 days until final volume is achieved. During expansion, subcutaneous fat decreases, dermal thickness decreases, and epidermal proliferation occurs. A dense, fibrous capsule forms over the implant, thus the skin is not quite as pliable as normal skin. Skin perfusion is enhanced, however. Following completion of the expansion period, the addition of a ‘maintaining period’ following expansion appears to improve the quality of the expanded skin.

**Tension-Relieving Incisions (Relaxing Incisions)**

*Mesh expansion:* This technique involves the administration of small, parallel, staggered incisions in the skin adjacent to the wound to relieve the tension on closure. This technique is particularly useful in the extremities below the elbow and stifle, the ear, and tail. The skin around the wound is undermined, and an initial row of 1cm stab incisions is created, using a #15 or #11 scalpel blade, 1cm away from the wound edge with 1 cm space between each incision. Depending on the amount of tension, one, few, or many rows may be placed. Rows should be staggered (i.e., offset from each other) and 1cm space allowed between the rows. A limb can be undermined and meshed circumferentially if necessary. Following mesh expansion, a non-adherent, semi-occlusive dressing and bandages should be applied until the meshes are healed. When the mesh expansion is substantial, the meshed skin may appear transiently compromised (red-purple discoloration). The mesh incisions should not be made too large (>1 cm), as this can cause vascular compromise to skin. Mesh expansion of skin flaps are not recommended as they will compromise the circulation.

*Simple Relaxing Incision:* A simple relaxing incision is useful when closing a defect near an orifice (to prevent distortion), and in covering vital structures (such as exposed joints, tendons, nerves, and orthopedic implants). It can also be used to close a chronic wound where edges are scarred and nonpliable, as it can mobilize adjacent, more elastic skin. An incision is created parallel to the long axis of the defect with the width of the skin bridge being equivalent to the width of the wound, and the length of the relaxing incision no longer than the length of the defect. The surgeon should keep in mind that if the length to width ratio of the bipedicle flap exceeds 4:1, vascular supply to the central skin bridge may become compromised. The bipedicle flap is undermined and advanced into the defect, which can then be closed without tension. The relaxing incision can allowed to heal by second intention, or closed with or without tension.
sutures. Although this procedure creates a new wound (the relaxing incision), generally this incision is in a less critical area, in healthy, pliable skin, and not challenging to address. A variation of a simple relaxing incision is a V-Y Plasty.

Incisional Negative Pressure Wound Therapy

Negative Pressure Wound Therapy (NPWT) has been shown to enhance open wound healing in several species, with a rapid appearance of granulation tissue in the wound. Recent medical reports suggest that this modality may be useful over closed surgical incisions as well. The application of incisional NPWT may reduce tension and shear forces on the wound edges by immobilizing and splinting the incision in the immediate post-operative period. In addition, early production of granulation tissue across the incision could provide increased tensile strength to the incision.

References: