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Reconstruction techniques using tension relieving and axial pattern flaps

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1. WHY IS SKIN TENSION CLINICALLY IMPORTANT?
Excess skin tension creates many potential clinical problems, and increases the risk of local wound complications. This is why one of the most important basic principles of wound closure and reconstruction is to avoid tension. Closing wounds under tension particularly on extremities may create vascular and lymphatic compromise to distal areas or reduce perfusion to wound edges causing delayed healing or even complete wound disruption. Excessive extrinsic suture tension creates a high risk of suture cutout. In addition, this tension creates constant pain to the patient increasing the risk of self-trauma to the wound. For example, in a simple elective dewclaw removal (if excess skin is accidentally removed around the base of the digit), the wound is closed under tension, and this rather simple procedure winds up causing many problems such as pain, edema to the paw, infection, and wound disruption. These problems could have been avoided simply by reducing skin tension.

2. PREVENTING SKIN TENSION
A. Proper patient positioning
With proper preoperative planning, surgeons can avoid skin tension in their wound closures. Place the patient in a position during surgery to help free up surrounding skin, if possible.

B. Proper planning of incisions and wound closure
Especially in curvilinear wounds, plan the closure first by placing stay sutures in the middle or most difficult areas to close so that early suture placements do not restrict closure of more distant areas or create unnecessary dog-ear formation. Make incisions parallel to the natural lines of skin tension. This wound orientation reduces skin tension and also minimizes skin distraction during closure.

3. MANAGING SKIN TENSION
A. Pre-emptive skin tension management
Presuturing is a method of stretching skin with the use of large mattress sutures. Large suture bites are taken on opposite sides of a problematic wound or lesion scheduled for surgical removal or closure. As the skin sutures are tightened, the skin is pulled toward the central surgical area; the neighboring skin is placed under tension. Within a day, small amounts of skin can be stretched, (by mechanical creep mechanism) to help in wound closure. Mechanical creep is the biomechanical property in which skin is capable of further extension beyond the limits of its inherent extensibility by applying a stretching force to the skin. Collagen fibers progressively align to the force applied as the surrounding interstitial fluid is slowly displaced from around the compacting collagen fibers. As a result, the skin can stretch or advance beyond its natural extensibility. We experience this often when an apparently tight wound closure appears to be under significantly less tension the day following surgery. This method does not recruit significant amounts of skin, and is primarily used in distal extremities where elastic skin is limited. These sutures are not adjustable and the high load dissipates as the skin stretches. Unfortunately, presuturing is often uncomfortable to the patient.

Skin Stretchers is a system that allows skin to be stretched in a variety of directions around a wound. Specialized designed anchor pads are “glued” to the skin, and elastic cables are connected to the opposing pads using a Velcro hook system. Clinical research has shown that skin stretchers are most effective in closing wounds involving the trunk, neck and head of the dog and cat. They may be effective in such clinical situations as; stretching skin prior to an elective surgical procedure (like a skin tumor excision) when closure is expected to be difficult, stretching skin in the later phases of open wound management, or application on opposite sides of a closed wound to prevent wound dehiscence. Skin is usually stretched sufficiently to close wounds within 2-3 days. Cable tension is increased in increments 4 times daily. After the stretching has occurred, the pads are removed manually or left in place to spontaneously separate within about a week after application.

Tissue expanders are silicone elastomeric “balloons” inserted under the skin in the subcutaneous layer. They are inflated in stages by means of sterile saline infused through an adjacent injection port. Once fully inflated, the expander is removed and the recruited skin is moved to the adjacent defect. These ex-
panders are quite expensive so their use in veterinary surgery is limited. Furthermore, the stretching process may take several weeks before skin can be employed for closure. Extra skin is created much like what happens to abdominal skin in pregnant animals. The stretched skin undergoes a process called intussusceptive growth, where microseparation in dermal elements is filled in with new collagen. Therefore, adnexal structures, such as hair or glands in the stretched skin will be distributed more sparsely as these microtears are filled in.

B. Immediate skin tension reduction

For skin tension relief during primary wound closure, a number of different methods can be used to relieve tension. Generally, wound tension can be defined as static (constant) or dynamic (tension only during changes in position or movement). The type of technique used to reduce tension depends on the type and amount of tension encountered. For minor skin tension (the wound edges can be apposed but the skin tends to separate widely when released, subcutaneous or skin suture techniques alone are often successful. Subcutaneous sutures are the most common mean of reducing tension on primary skin incisions. Simple interrupted sutures placed in healthy hypodermis effectively reduce tension on the primary skin closure. Undermining the skin edges will also help reduce this minor tension. Walking sutures are used to help distribute tension along an undermined skin edge or flap. If tension across the wound is found only under dynamic conditions, various skin suture techniques are often useful. These include, for example, vertical mattress sutures with tube stents, and far-far-near-near suture patterns. Do not rely on skin suture methods to relieve wounds under moderate to severe "static" tension, as they may interrupt blood supply to the wound edges or cut through the skin. When skin is difficult to hold together with thumb forceps (moderate to severe tension), other means (in addition to methods listed above) of reducing skin tension may be required. Determine if the wound tension is broad (across the entire wound) or aligned in a narrow band. If wound tension is broad but minimal, undermining along with simple or mesh releasing incisions may be employed. Remember, releasing incisions should not be used on skin flaps or when skin adjacent to the wound is not healthy. Z plasty or, the more preferred, V to Y plasty are used when tension is in a more linear direction, especially around body orifices such as the eye. If the wound cannot be closed reasonably with the mentioned tension relieving techniques, transferring skin, either by creating a flap or by grafting, should be considered.

C. On-going skin tension management

In split shot wound management mattress sutures are placed on opposing skin margins (about 1-1.5 cm from the wound edges) and the sutures are re-tensioned several times daily adding an additional split shot to the suture ends to maintain progressive tension. Alternately, commercial skin stretchers as describe above can be used. These methods are applied to open wounds or sutured wounds under tension to relieve incisional tension.

REFERENCES


AXIAL PATTERN FLAP RECONSTRUCTION OF LARGE SKIN DEFECTS

An axial pattern flap is a skin flap containing a single, consistent myocutaneous artery, vein and nerve that supply a specific region of dermal tissue.1,2 As a result, axial pattern flaps have a more (reliable) and robust blood supply as compared to randomly chosen local flaps, which rely on the subdermal plexus alone for their circulation. Axial pattern flaps are used most commonly to facilitate wound closure following a traumatic event or after extensive tumor resection.

Axial pattern flaps provide a durable full thickness skin cover for skin defects that can be closed primarily without the need for a vascular (well granulated) wound bed or strict postoperative immobilization (which are critical to the success of skin grafts). Since the blood supply is well preserved and the flaps are created from full-thickness skin, the cosmetic appearance of the flaps are considered excellent (they can be expected to closely resemble the donor site skin). The main advantage of axial pattern flaps over randomly chosen subdermal flaps is that they can be made with a narrow base or with no skin connection, thereby allowing considerable flexibility in flap rotation and transfer of skin to more distant areas. In axial pattern flaps, the length of the flap that can be safely created is related to the known length of the axial vessel sup-
plying the flap. Since the blood supply is so reliable, the survival rate of axial pattern flaps is estimated to be about twice that for local random flaps of comparable size. In randomly chosen flaps, the safe length of a flap can only be estimated by the width of skin connected to the flap base. Smaller length to width ratios for random subdermal flaps are safer since there is better chance that the blood supply to the distal portions of the flap is secure. Thus, the use of these local flaps is usually limited to open wounds in the immediate vicinity of the flap base. One disadvantage of axial pattern flaps is that they have specific anatomical borders that must be followed to ensure survival of the flap (incorporating the axial vessel in the flap is imperative). When these borders have been damaged or the axial pattern flap landmarks have been altered by patient positioning, a previous surgery, or trauma, the axial vessel may not be located in the described boundaries and the risk of partial flap necrosis is high.

Axial vessels are distributed in many locations throughout the body surface so the application of these flaps is quite broad. There are, however, some body regions that are not readily covered by axial flaps. These include the more distal extremity areas, and the dorsal and ventral midline (in the central areas of the body). The most commonly used axial pattern flaps in small animal surgery are the thoracodorsal and the caudal superficial epigastric. The following list of axial pattern flaps includes the more common regions they are employed for wound closure.

**Axial Flap (Clinical Application-region of defects)**

**Omócervical Axial Flap**
(head and neck, brisket and axillary region)

**Thoracodorsal Axial Flap**
(thoracic defects, proximal forelimb defects, axillary region)

**Superficial Brachial Axial Flap**
(elbow and proximal forelimb defects)

**Caudal Superficial Epigastric Axial Flap**
(flank defects, perineal defects, stifle defects, preputial defects)

**Deep Circumflex Iliac Axial Flap**
(pelvic and sacral defects, flank defects, lateral abdominal wall, defects over the greater trochanter)

**Genicular Axial Flap**
(medial or lateral aspects of the proximal pelvic limb)

**Caudal Auricular Axial Flap**
(lateral aspects of the head, cervical area)

**Superficial Temporal Axial Flap**
(dorsal maxillofacial area)

**Technical Considerations**
Axial pattern flaps are made rectangular in shape (with a tapered or rounded end usually), but can be modified with a right angle extension (hockey stick) or by making the axial flap into an island flap (connected only by the neurovascular supply, but no skin). These modifications increase both the mobility and length of an axial pattern flap. Island flaps can be rotated up to 180 degrees to cover a specific defect provided there is minimal tension on the twisted vessels. The axial pattern flaps listed previously can be created using principles and boundary guidelines that are well described in most current veterinary surgical textbooks. Please refer to these texts for technical details. The following brief description is intended to outline the general perioperative principles of axial pattern flap application.

**Preoperative Considerations**
- Carefully plan the design of the flap (use a permanent marker if necessary to mark the planned procedure).
- Consider how the resultant defect at the donor area will be closed.
- Be sure the skin and the direct cutaneous artery that will be used for the flap are viable.
  Color flow doppler has been used recently to determine artery flow.
Surgical Procedure

Objectives
- Preserve viability of the direct cutaneous artery by avoiding excessive surgical trauma to the tissue. Know precisely where the direct cutaneous vessel originates so accidental disruption during flap dissection is avoided. Avoid surgical trauma to the flap.

Equipment
- General surgery pack, abdominal laparotomy sponges, skin hooks or stay sutures should be available. A (Jackson-Pratt) drain may be needed if the wound is susceptible to seroma formation.

Technique
1. Aseptically prepare a large skin region around the donor and recipient areas.
2. Be particularly careful when positioning the patient such that the vascular pedicle will not become distorted before planning the boundary incisions.
3. Create incisions along predetermined donor site boundaries of the skin to be transferred to the defect.
4. Control hemorrhage and make sure the boundary incisions extend deep to the panniculus muscle layer or layer containing the subdermal plexus.
5. Deeply undermine the flap beginning at the distal most aspect (use stay sutures or skin hooks to manipulate the flap margins).
6. Dissect very carefully around the origin of the direct cutaneous vessel to avoid inadvertent damage to this vessel that is vital to the survival of the flap.
7. Avoid creating a kink and avoid too much tension at the base of the flap, which could obstruct blood flow.
8. Drain the dead space if deemed necessary.
9. Suture or staple the flap to the defect edges. Interrupted subcutaneous and skin sutures are preferred. Begin suturing the flap at the most distant area first.

Postoperative Care and Complications
• Restrict exercise until suture removal.
• Apply an Elizabethan collar before the patient is recovered from anesthesia and leave it on the animal until the flaps are completely healed.
• Change wound dressings as necessary.
• Major complications resulting from skin flaps include local problems, such as partial or total ischemia of the flap, infection, seroma, and dehiscence of the flap or donor suture line. Once the flap necrosis has fully demarcated, debride the flap, and treat the area as you would for any open skin wound.
• Dehiscence of donor site incisions is usually due to excessive skin tension. If dehiscence occurs, allow these areas to heal by second intention.

Clinical Studies of Complications and Outcome
Partial flap necrosis was a frequent complication of thoracodorsal axial pattern flap reconstruction of forelimb skin defects and required additional wound care or surgical intervention to achieve healing in an earlier study published by the author. Thoracodorsal axial pattern flaps can provide full-thickness skin coverage of extensive skin defects of the forelimb, but owners should be aware of the likelihood of local wound complications.

The author has just completed another retrospective study evaluating the clinical applications of the caudal superficial epigastric axial pattern flap in dogs. There were few complications in this study, and partial flap necrosis or dehiscence was rare (this was most likely due to the robust blood supply of this axial vessel).

REFERENCES