Taking the “tension” out of skin closure

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Presentation overview

- Inherent properties of skin
- How wounds heal
- Pre-operative measures to reduce skin tension
- Surgical methods to reduce skin tension

INTRODUCTION
Wound closure
- Large skin wounds are common
- Trauma
- Oncologic surgery
- No universal treatment or “cook-book”
- Use the simplest technique required for the situation - *don’t over-complicate things!*
- Pay attention to the details and principles

Tension relieving techniques
- Aim to distribute or eliminate tension
  - Undermining
  - Skin stretching
  - Suture patterns to distribute tension
  - Relieving incisions
  - Various “plasty” techniques
  - Flaps

Consequences of skin tension
- Vascular compromise
- Exceeds tissue strength
- Exceeds suture strength
- Functional impairment
- Cosmetic change
- Necrosis
- Dehiscence
Skin anatomy
- Epidermis
  - Variable thickness
  - Protective
  - Avascular
- Dermis
  - Thicker
  - Nourishes and supports
  - Collagen, reticular and elastic fibers in mucopolysaccharide ground substance
- Hypodermis
  - Fat dense

Mechanical creep and stress relaxation
MECHANICAL CREEP
Describes the capability of skin to stretch BEYOND inherent elasticity by the application of stretch or tension over time

STRESS RELAXATION
The progressive reduction in force required to keep the stretched dermal collagen fibers at a given length

Can be exploited with:
- Presuturing
- Skin stretchers
- Skin expander

Viscoelasticity
- Dependent on:
  1. Convolutions in dermal collagen progressively straightening
  2. Dermal collagen fibers aligning in parallel to each other in direction of load
  3. Fully aligned collagen fiber extension
Variability of skin

- Skin properties variable:
  - Between species
  - Between breeds
  - Between sexes
  - Between age groups
  - Between body conformations
  - Between locations

Durability of skin primarily related to dermal thickness.

Vascularity

- Dogs:
  - Direct cutaneous vessels
  - Vessels run parallel to skin
  - Subdermal plexi major role

- Humans:
  - Musculocutaneous vessels
  - Vessels perpendicular to skin
Congenital skin disorders

- Cutaneous asthenia
  - congenital hereditary, fragile hyperextensible skin
  - Autosomal dominant with incomplete penetrance
  - Seen in cocker spaniels, beagles, Manchester terriers, corgis, GSD, dachshunds, boxers, St. Bernards and mixes
  - Skin tears easily with minor trauma
  - Size, shape and orientation of collagen bundles altered: haphazard dissociated
  - Combination of tension relieving techniques helpful

HOW WOUNDS HEAL

Taking the "tension" out of skin closure
Wound healing

- Cascade of physical, chemical and cellular events
- Commences immediately post injury
- Aims to restore wounded tissue or replace with collagen

Wound healing

- Four main phases:
  - Inflammation
  - Debridement
  - Repair
  - Maturation
- Dynamic process

Stages of wound healing

- Inflammatory phase
  - Protective response
  - Initiated by tissue damage
  - Lasts about 5 days
  - Increased
    - Vascular permeability
    - Chemotaxis
    - Cell activation
Stages of wound healing
- Inflammatory phase continued:
  - Hemorrhage
  - Primary hemostasis
  - Soon followed by secondary hemostasis
  Blood clot:
  - Stabilizes wound edges
  - Barrier to infection and fluid loss
  - Some wound strength
  - Substrate for further wound healing

Stages of wound healing
- Debridement phase
  - Initiated by leucocyte leakage
  - Exudate formed
  - Initially neutrophils then monocytes
  - Phagocytosis and debridement

Monocytes
- Major player in wound healing
  - Synthesize and secrete growth factors
  - Mature to macrophages
    - Collagenases
    - Chemotactic and growth factors
    - Recruit mesenchymal cells
  - Healing impaired by suppressed macrophage function and not by lymphopenia or neutropenia
Stages of wound healing

- Repair phase
  - Usually commences 3-5 days post injury
  - Fibroblast driven
  - Synthesize collagen, elastin, proteoglycans
  - Matures into fibrous tissue
  - Increase in wound strength
  - Angiogenesis
  - Forms granulation tissue

Granulation tissue

- Combination of collagen and new capillary buds
- Healthy when bright and fleshy
- Provides:
  - Barrier to infection
  - Surface for epithelial cell migration
  - Wound contraction via myofibroblasts

Epithelialization

- Begins within 24-48 hours
- Repair involves mobilization, migration, proliferation and differentiation of epithelial cells
- Provides barrier to infection and fluid loss
- Random migration but tends to follow collagen
- Occurs under scabs and then secrete collagenase
Epithelialization continued

- Occurs faster in a moist environment
- Anoxia, dead or foreign material inhibit
- Wet to dry dressings delay process
- Hyperbaric oxygen therapy may enhance

Wound contraction

- Occurs subsequent to fibroblast reorganizing collagen in granulation tissue
- Centripetal full-thickness edges are pulled inward by contraction
- 5-9 days post injury
- Surrounding skin stretches
- Stops when edges meet, tension excessive or inadequate myofibroblasts
- Inhibited by steroids or local application of smooth muscle relaxants

Maturation

- Wound strength peaks
- 17-21 days post injury
- 20% of original wound strength
- May continue for years
- Reduction in collagen
- Wound reaches approximately 80% of original strength
- Scar becomes paler and flat
Healing differences

**Dogs**
• Granulation tissue formation 7.5 days
• Granulation originates from entire wound

**Cats**
• Granulation tissue formation 19 days
• Granulation originates from border of wound
• Contraction and migration lags behind cf. dogs
• Wound tensile strength 50% cf. dogs
• Subcutaneous tissue very important

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**PRESURGICAL PLANNING**

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**Skin defects**

• Pre-surgical planning
  • Assess wound for complicating local factors
  • Infection
  • Debris
  • Motion
  • Assess patient for systemic factors that may influence wound healing such
  • Starvation
  • Metabolic
  • Diabetes Mellitus
  • Hyperadrenocorticism
  • Other co-morbidities
Skin defects
- Pre-surgical planning
  - I ask myself...
    - Can this wound heal on its own?
    - Do I think the wound can be closed directly?
    - Will I need to simply relieve tension?
    - If a wound: does it need closure or can it be allowed to heal by 2nd intention?
    - Is it ready to be closed (clean!)
  - Abide by Halsted’s Principles!
    - Don’t close contaminated or infected wounds!
- More on assessment:
  - Assess tension of skin around mass/wound (both awake and especially after induction)
  - Assess for skin thickness, elasticity, and general mobility - this varies between patients, breeds, etc
  - Clip extensively to ensure that sterility is not compromised in operating room
  - Assess positioning on surgery table to avoid “trapping” skin under the patient

Halsted’s principles
- Minimize tissue trauma
- Precise hemostasis
- Preservation of blood supply
- Aseptic technique
- Minimal tissue tension
- Accurate tissue approximation
- Obliteration of dead space

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Pre-suturing or skin stretching

- Uses biomechanical properties of creep and stress relaxation
- Relies on tension mattress sutures across cutaneous lesion
- Can reduce force necessary to close wound within 24 hours
- Pads or anchors can be applied to the skin and elastic tension pads secured

Surgical Techniques

Taking the “tension” out of skin closure

General guidance for closure

- Close fascia if possible – additional security
- Engage subcutaneous layer
- Place multiple, evenly-spaced SQ sutures even if continuous is planned
  - This disperses tension and prevents/slows complete dehiscence
- Minor tension
- Vertical preferred over horizontal mattress
  - Far-near-far-far Far-far-near-far are good (or variation)
- If no tension, use standard sutures or staples
Surgical methods of relieving tension

1. Exploit natural mechanisms of stretch
   I. Tension lines
   II. Undermining
   III. Walking sutures
   IV. Releasing incisions
   V. Advanced suture techniques
2. Exploit ability to mobilize skin
   I. Local flaps
   II. Plastys
   III. Axial pattern flaps
   IV. Grafts
3. Secondary intention healing

Harnessing viscoelastic skin properties

- Incision made parallel to line of tension

Undermining skin

**Methodology**
- Using scissors to separate skin of panniculus (or both) from underlying tissue
- Allows for full elastic potential of skin to be utilized
- Must preserve subdermal plexus

**Concerns**
- Creates dead space
- Potential for seroma formation
- Potential for damage to plexi or direct cutaneous vessels
Simple releasing incisions

- Single parallel to wound (perpendicular to the tension) and 1.5x the length of the defect
- Incise about the wound width’s distance away from the wound (creates a bipedicle flap)
- Closure of the 1st wound routinely
- Close the 2nd wound either routinely, in a “Y” or “T”, or allow to heal by 2nd intention

Multiple releasing incisions

- Multiple small incisions parallel to the wound creates numerous small bipedicle flaps
- Allow to heal by 2nd intention
- Close transversely
- Very useful on extremities

Tension relieving suture patterns

- Prevent suture “cut out”
- Aims to evenly distribute tension over larger area
- Placed farther from incision (1-2cm)
  - Mattress sutures
  - Crisscross pattern
  - Far-near-far
  - Far-far-near-near
- Can be removed on third day once collagen realigned
Tension relieving suture patterns

- Vertical mattress
- Horizontal mattress

Z - plasty

- Lengthen or relaxes an incision
- Can be incorporated into or adjacent to a wound
- Central limb of Z is wound or primary incision
- Length is gained along the original length when transposed

V to Y – plasty

- For chronic wounds or areas that primary closure may cause distortion
- Good for eye lid surgery
- V-shaped incision approx. 3cm from wound
- Closed original wound and undermine skin to plasty site
- Closed V into a Y
Add actual case photo
ricvet@me.com, 9/23/2018
Local (sub dermal plexus) flaps

- Partially detached segment of skin
- Pedicle maintains the circulation
- Local flaps derived adjacent to wound bed
- Uses surrounding loose skin from a neighboring area
- Simple and economical
- Classified based on method of transfer

- Rely on preservation of subdermal plexus
- Donor sites should have minimal tension or motion
- Base should be wider than body to avoid narrow pedicle
- LIMIT FLAP LENGTH AS MUCH AS POSSIBLE ONLY TO PRODUCE TENSION FREE CLOSURE
- Two flaps may be better than one

**ADVANCEMENT FLAP**

- Advance in a forward direction
- Developed based on the lines of LEAST tension
- Examples include: single pedicle, bipedicle and V to Y
- Flap length should be ≤2 x width
- Limited by availability of loose skin close to the defect
- Flap has to stretch over the defect and some retraction of the flap should be anticipated

**TRANPOSITION FLAP**

- Rotate or pivot
- Developed parallel to lines of greatest tension
- Examples include: 90 degree transposition (most useful), rotation or interpolation flaps
Advancement flap – single pedicle

Bipedicle advancement flap (H-plasty)
Local/Subdermal plexus flaps

- **Rotational flap** – best for triangular defects
- Make an incision at edge of wound
- Elevate and rotate (instead of advancing) across at an angle
- Burrow’s triangle – eliminate “dog-ears”
- Double on two sides (similar to H-plasty)

**Transposition**
- Similar but flap perpendicular to wound edge is elevated
- 3-4 times width
Axial pattern flaps

- Peninsula or island of skin with a reliable, named, known direct cutaneous vascular supply

- Caudal superficial epigastric flap is most versatile and is a great flap to learn to start using flaps
Caudal superficial epigastric

- Mammary glands 2-5 in the canine (2-4 feline)
- In the male, medial incision must incorporate base of prepuce to save the vasculature
- External pudendal artery emerges through inguinal ring
- Able to rotate up to 180°
- Dissect to level of external rectus under supramammarius muscle
- +/- drain under recipient site (not under donor)
- Close recipient and donor sites
Does every wound need surgical closure?
- Not necessarily
- Contamination
- Tissue viability
- Tension
- Anesthetic safety
- Cost
Complex area surgical solutions

- Flank fold advancement flap
- Axilla (lateral thoracic APF) or inguinal (Deep circumflex iliac APF)
- Thoracodorsal APF
- Caudal superficial epigastric APF
- Deep circumflex iliac APF

Hunt et al VS 2001

Post operative management of skin tension

- Think about: IMMOBILIZATION
  - Bandage – conventional
  - Splint
  - NWB bandage
  - Carpal flexion
  - Velpeau
  - Spica
  - Modified- Robinson
  - Ehmer