

# "PRIME PRINCIPLES" IN THE SURGERY OF REPAIR

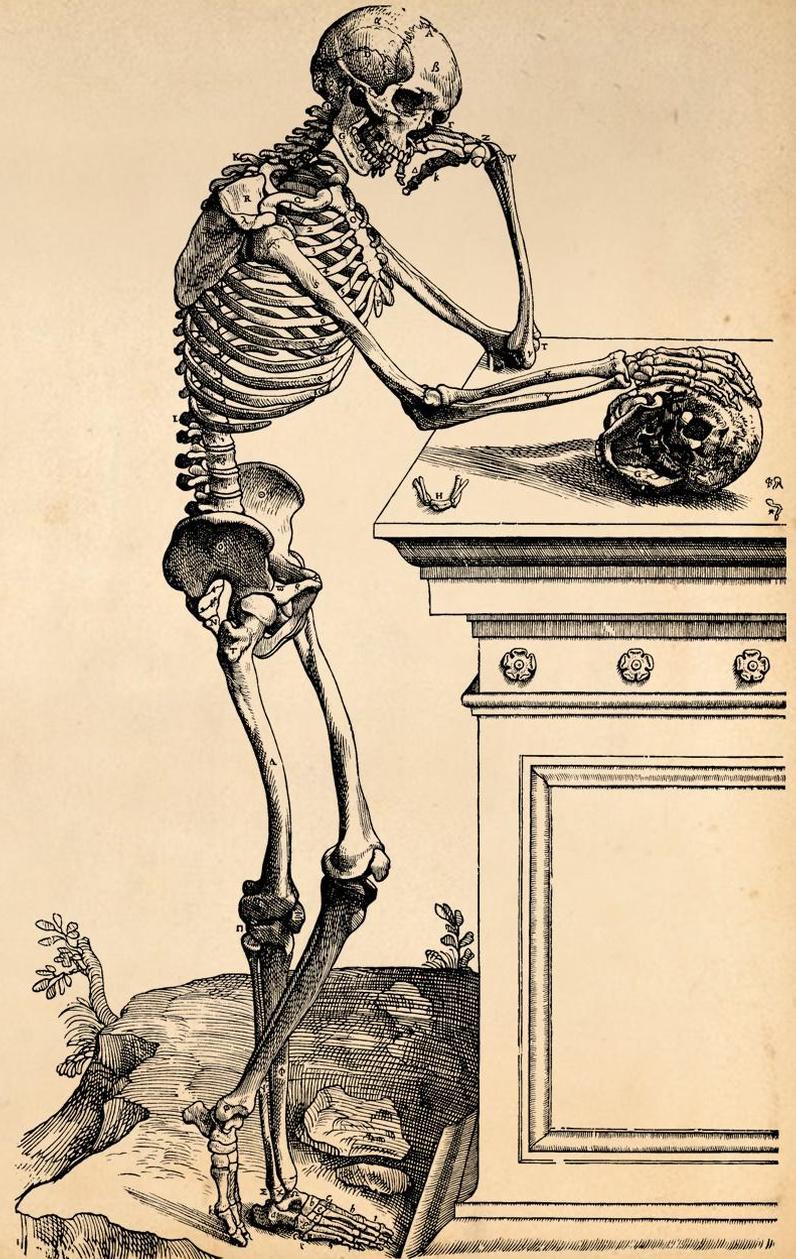
## QUINTESSENTIAL STRATEGIES AND TACTICS GOVERNING EFFECTIVE RESULTS

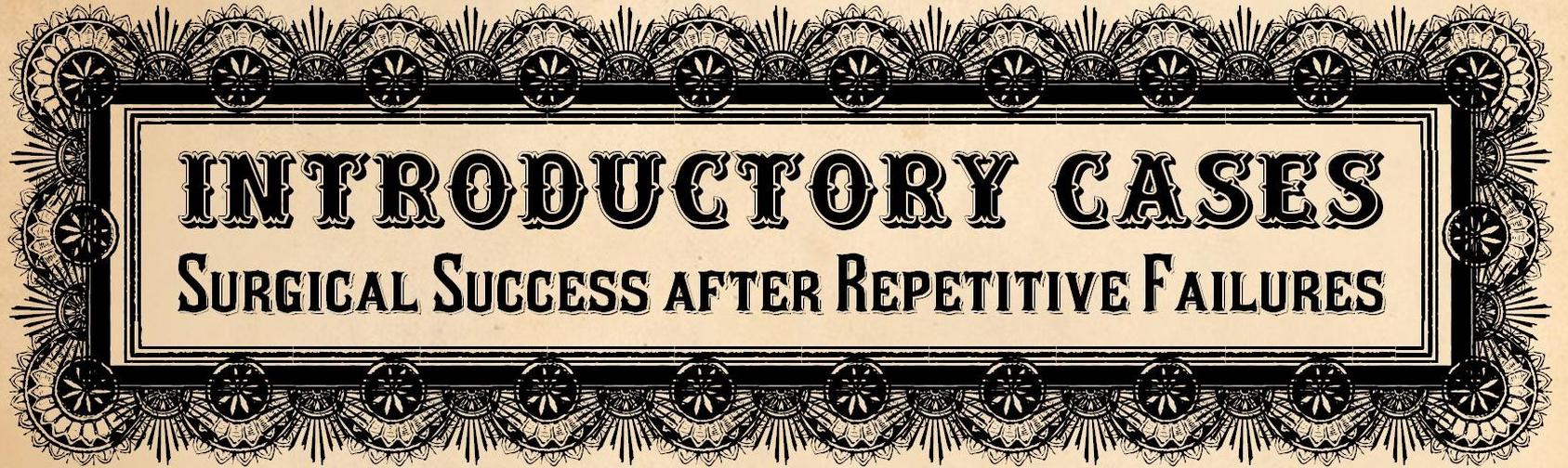
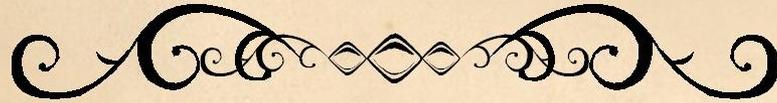
### CRITICAL CONCEPTS IN SURGERY & PATHOLOGY

Marc E. Gottlieb, MD, FACS  
Phoenix, Arizona

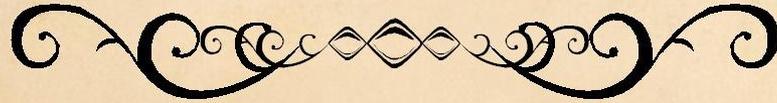
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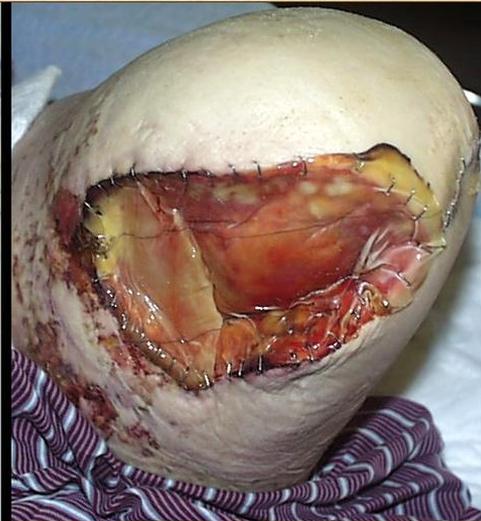




**INTRODUCTORY CASES**  
**SURGICAL SUCCESS AFTER REPETITIVE FAILURES**



64 M,  
aorto-iliac aso-pvod



42 F,  
dm, aso-pvod hands

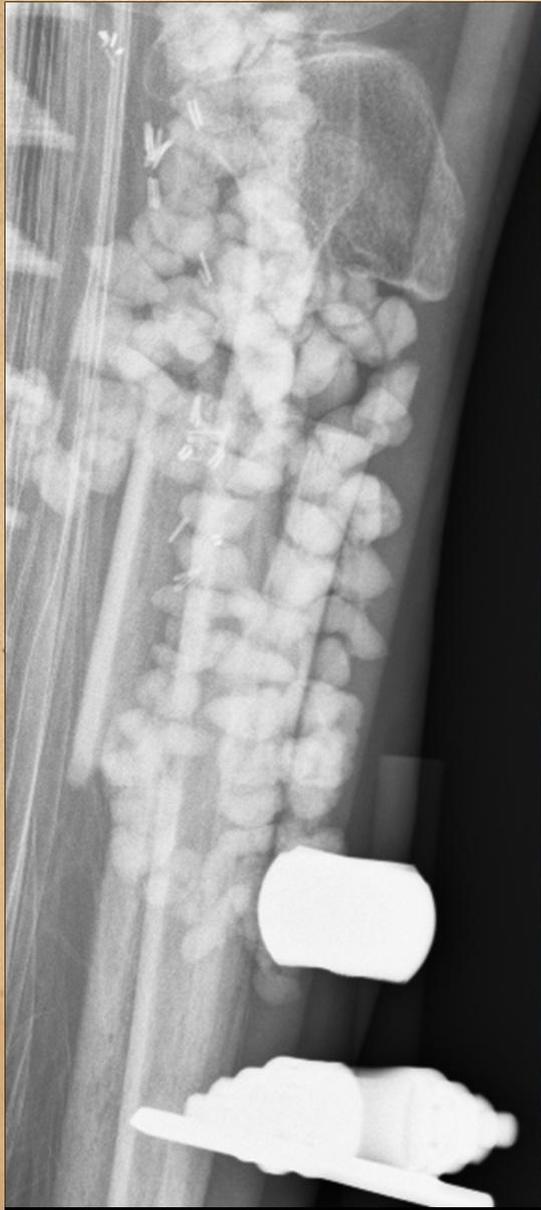




49 M, back trauma, arthrosis, abscess



74 F, multiple hernia, abscess, e-c fistula



17 F, tibia non-union after trauma

ARIMEDICA

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PRINCIPLES OF GOOD RESULTS  
IN  
COMPLEX (& ALL) CASES

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STRATEGIC CONCEPTS IN  
SURGERY OF REPAIR

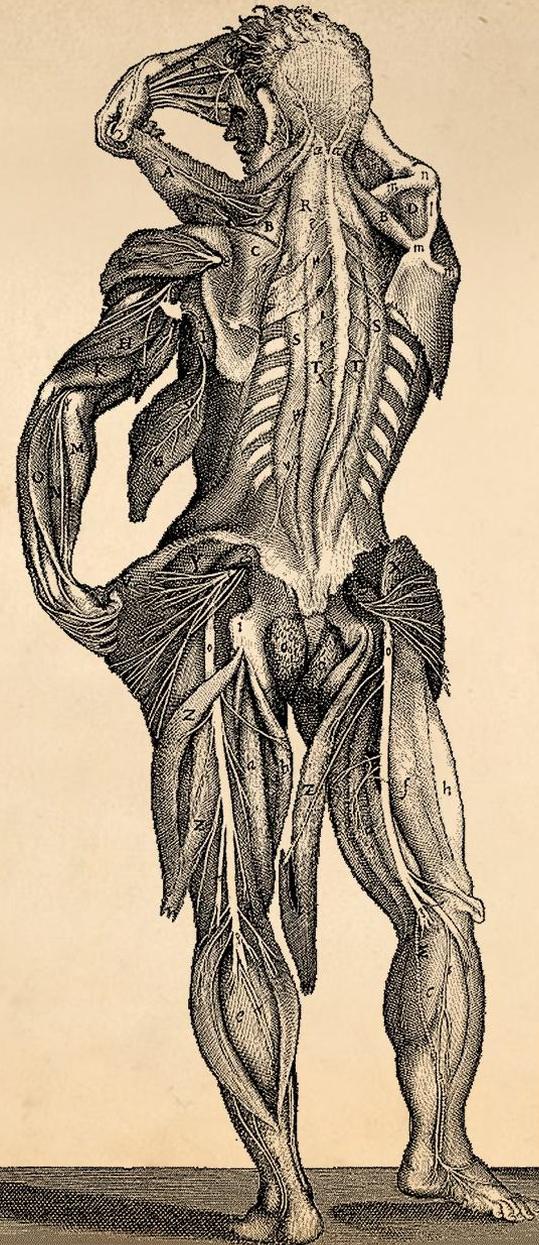
ARIMEDICA

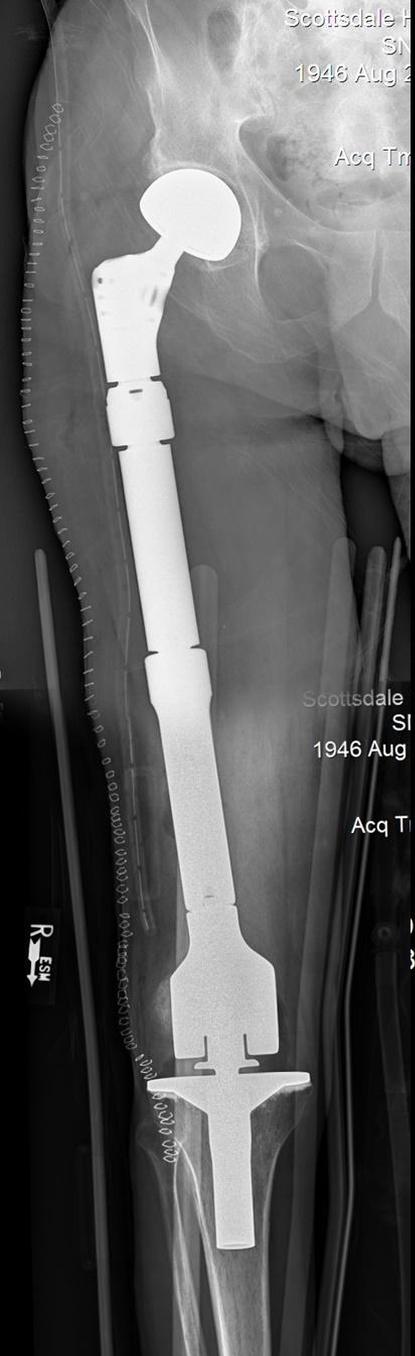
ALPHA PRINCIPLE

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65 M, osteosarcoma femur

56 M, TKA after trauma

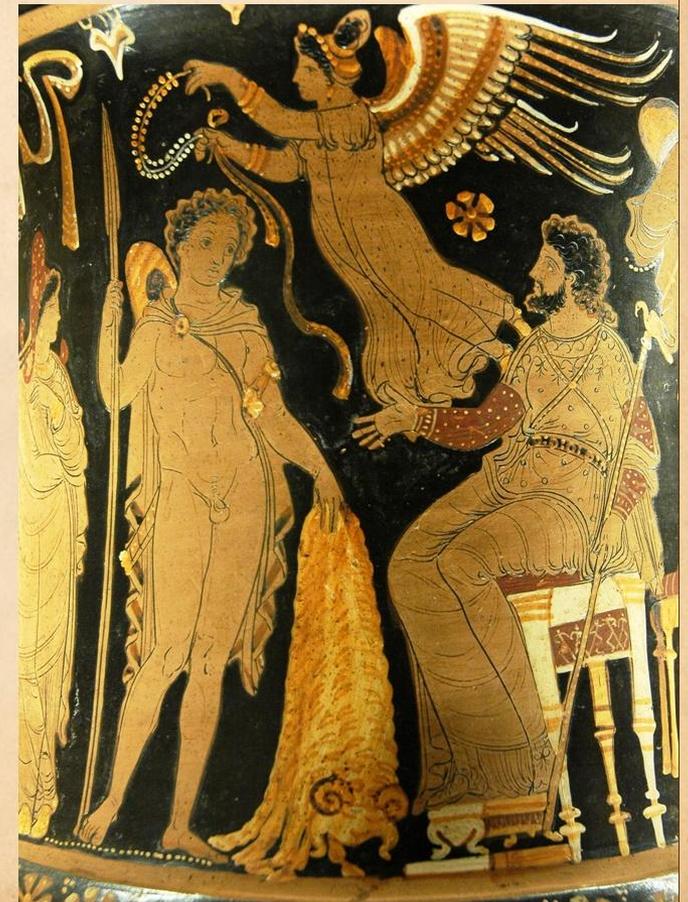
17 F, TKA after trauma

66 F, tumor resect THA, late failure



## MAGIC STITCHES

The cotton fiber sews my britches,  
 And baseball weaving throws my pitches.  
 Synthetic blends make costume kitsches,  
 While fate spins yarns by mythic witches.  
 Floss and fabric create with stitches,  
 But ne'er in there are magic stitches.



*Morai*  
*The Three Fates*  
*Clotho, Lachesis, and Atropos*  
 1558  
 by Giorgio Ghisi  
 (Mantua, 1520–1582)

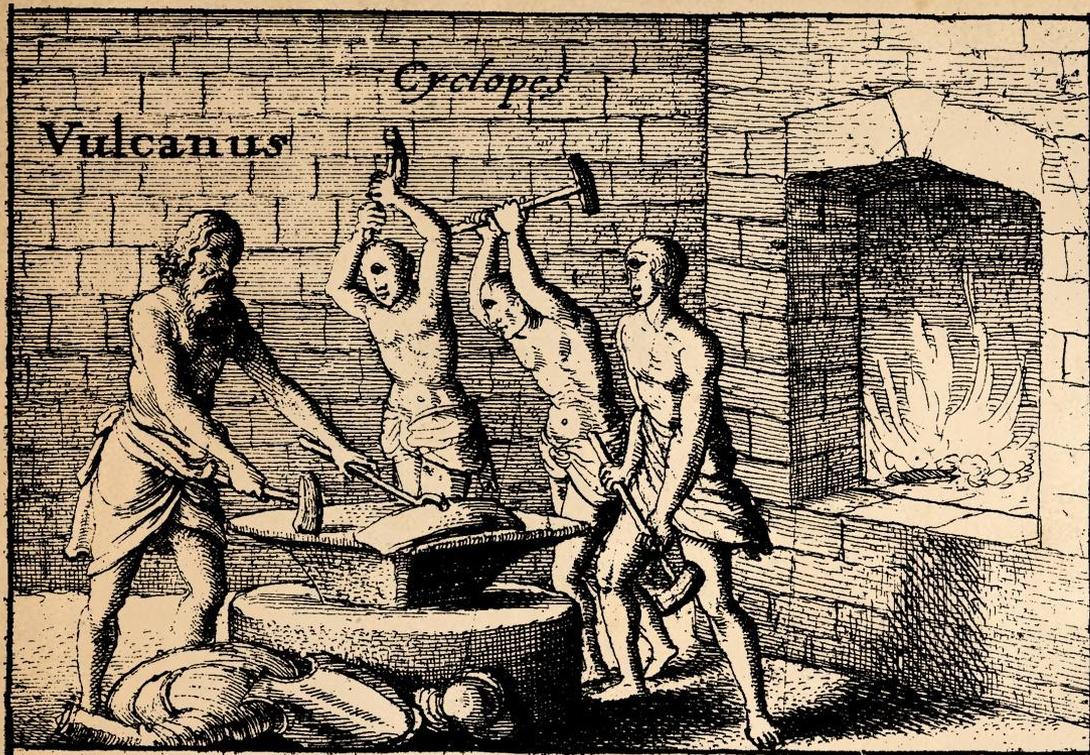
*Jason presenting the Golden Fleece to Pelias*

c 340 -  
 330 BCE  
 Taranto, Italy.  
 Apulian  
 red figure  
 painting on  
 calyx krater  
 by the  
 "Underworld  
 Painter".

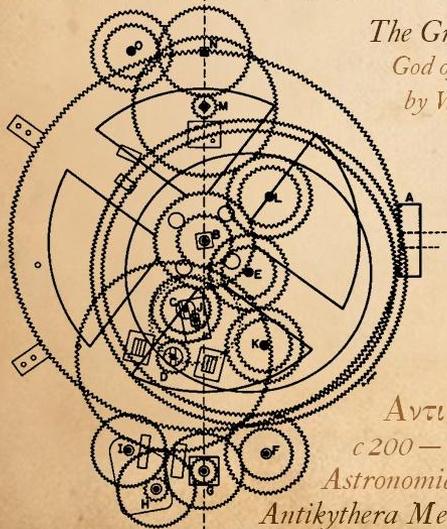


From ropes and jute to make strong hitches  
 That pull a truck from roadside ditches,  
 To feathery wisps like plumed ostriches  
 Of gold lamé from Argonaut riches,  
 Cloth and ribbon the eye bewitches,  
 But naught I've seen of magic stitches.

With woven gauze to dress my itches,  
 And fabric splints that quell my twitches,  
 Sutures strong for surgical niches,  
 Like silk and gut to fix my glitches,  
 These strings and threads our craft enriches,  
 But I do not have magic stitches.



*The Greek Gods. Vulcan. (Hephaestus Ἥφαιστος)  
 God of blacksmiths, craftsmen, artisans, sculptors, metals  
 by Wenceslaus Hollar (Prague, London, 1607-1677)  
 c 1660 - 1670*



*Αντικύθηρα  
 c 200 – 100 BCE  
 Astronomical clock  
 Antikythera Mechanism*

*Themis Θέμις  
 (First Pythia  
 at Delphi)  
 Attic red-figure  
 kylix.  
 440 -  
 430  
 BCE*



*Aegus at the  
 Oracle*



*Minerva  
 (Athena Ἀθηνᾶ)  
 Goddess of enlightenment,  
 knowledge, education,  
 learning, wisdom.  
 c 1640  
 by Claude Mellan  
 (France, 1598 - 1688)*



*The School of Athens (Scuola di Atene), 1509-1511, by Raphael (Raffaello Sanzio da Urbino, Italy, 1483-1520), in the Vatican.*

# Surgery of Repair & Reconstruction

## ACUTE CARE versus REPAIR SURGERY

drain, debride  
relieve, stabilize  
excise, remove  
preserve, cure

repair  
rebuild  
reconstruct  
rehabilitate

get through skin and fascias to  
operate on visceral structures

work on the skin and fascias  
( & stromal features of viscera)

## BIOLOGICAL PARADIGMS of REPAIR SURGERY

- 0 - Basic Care (*in support of natural contraction*)
- 1 - Repair
- 2 - Grafts
- 3 - Flaps
- 4 - Regenerative Matrices (*wound healing independent*)

## TIMING and STAGED RECONSTRUCTION

**Staged reconstruction.**

*Incremental successful procedures.*

**Principle of too much too soon too often.**

*Destroyer of good health & good results.*

**Law of inevitable countability and accountability.**

*Judgment and choices to allocate procedures done.*

**All wounds must be properly prepared prior to any closure.**

*The Alpha ◀Αα▶, the Aleph ▶ℵ▶, the Prime ▶1▶.*



A α



1° STRATEGIC PRINCIPLE  
DO NOT CLOSE UNTIL ALL IS CORRECT



Σ



**18 days  
15 failed procedures**

**DOING  
too much  
too soon  
too often.**

**Too much too soon too often.**  
*Destroyer of good results.*

**Law of inevitable countability.**  
*Allocate procedures wisely.*

**Staged — reconstruction.**  
*Incremental successful procedures.*

**Prep & control prior to closure.**  
*The Alpha, The Prime.*  
*Prepare then repair.*  
*Control then close.*  
*Proper intervals.*  
*Not concurrent.*

**Good results are a virtue.  
Quick results are irrelevant.**

**Doing too much too soon too often.**



**Staged reconstruction.**



# INFARCTION & DEHISCENCE - EXTRINSIC INJURY & PERTURBATION

## ISCHEMIA-DEVASCULARIZATION

Bad flaps  
Degloving-shear  
Avulsion-amputation  
Stasis, low flow, thrombosis  
Arterial & venous devascularization

## TRAUMA-INFECTION

Tissue loss  
Tissue injury-damage  
Thrombosis-inflammation  
Bioburden  
Abscess-infection



# NECROSIS & ULCERATION - INTRINSIC PATHOLOGIES & PATTERNS

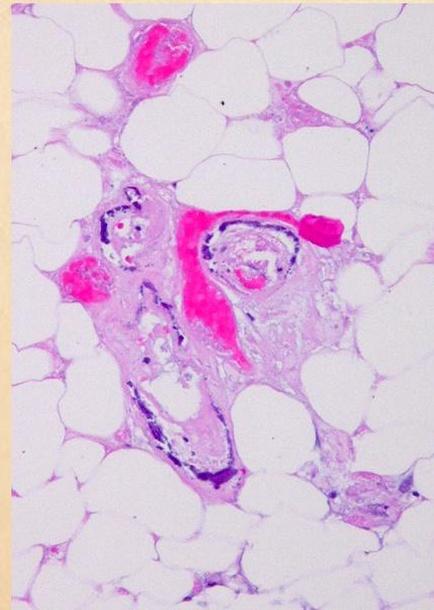
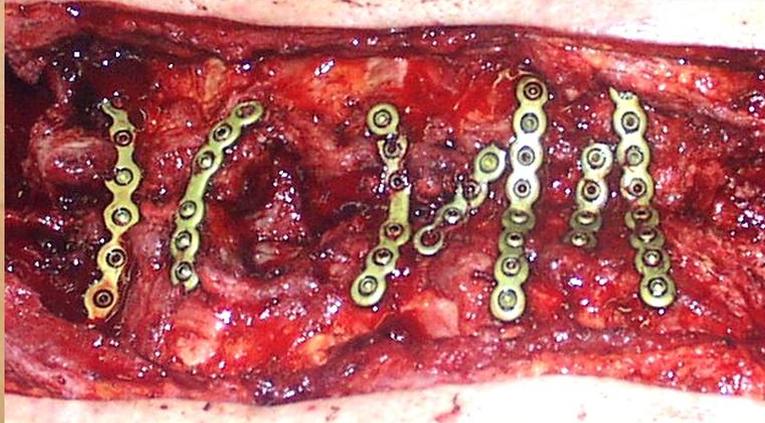
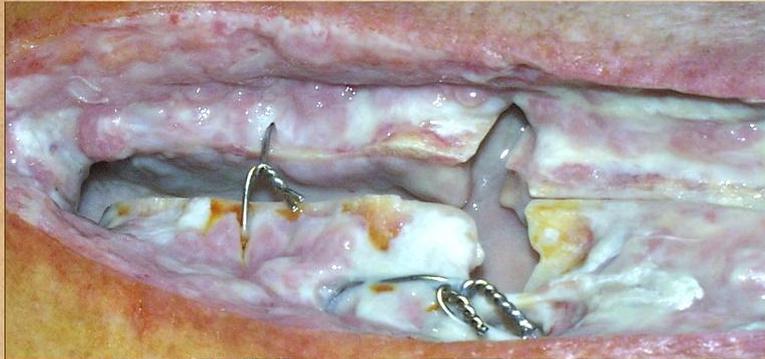
## THROMBO-INFARCTIVE

Macro-occlusive  
Micro-occlusive  
Micro-angiopathies  
Hemopathologies  
Hypercoagulable / Coagulopathic

## INFLAMMATORY-LYTIC

Inflammatory  
Autoimmune  
Atopic, Suppurative  
Connective Tissue Disorders  
Lymphoreticular / Reticuloendothelial





PARATHYROID HOR @ 472Hf  
CALCIUM FOR PTH @ 8.9

73 M, sternal dehiscence after coronary bypass

51 F, calcific microarteriopathy of hyperparathyroidism



62 M, trauma, aso-pvod



82 F, radiation injury



Αα |  
αλφα |

Thou shalt not close  
until all is perfect.



*Separate*  
repair & reconstruction  
*from*  
debridement & control.

**DO NOT DO**  
too much  
too soon  
too often.

Quintessentiality of  
patience, prudence,  
planning, proper care.



“DON'T CLOSE PUS”

**SCAR TREK**



**THE PRIME  
DIRECTIVE.**

Αα  
αλφα

Thou shalt not close  
until all is perfect.

  
*Separate*  
repair & reconstruction  
*from*  
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**DO NOT DO**  
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Quintessentiality of  
patience, prudence,  
planning, proper care.

  
“DON'T CLOSE PUS”

Ββ  
βήτα

**MANDATORY**  
for successful repair:

Tissue-to-Tissue  
Coaptation

  
Tissue Interface  
Stability Without  
Shear or Distraction

1α

Repair & Reconstruction  
Strategic planning

**WHEN**

2β

Repair & Reconstruction  
Tactical execution

**HOW**

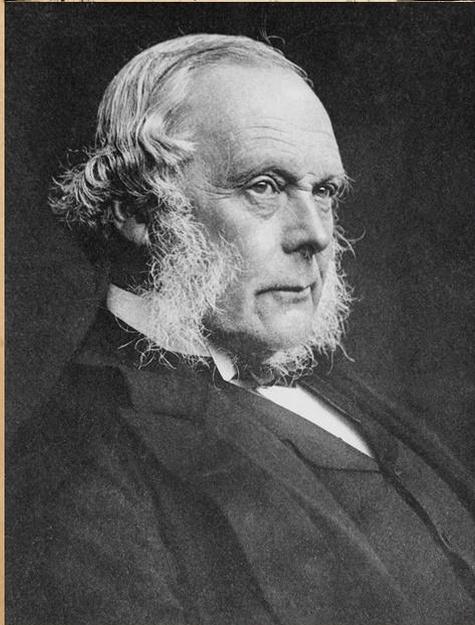
WOUND GEOMETRY &  
MECHANICS



Vos Creditis ad eum fabel.  
 quod scilicet vobiscum scilicet  
 de fide de contagione  
 et auctoritate scilicet dicitur  
 Cadaveris fuit et a frigidis  
 gleich wie der Corvus auf der Höhe  
 Ah Creditis, aber nicht dort hin  
 Dann Rom, regnat die Fabel.

Quis non deberet scire cythere,  
 que sine fidei alio proferri  
 quia loquatur ad vultu et flos  
 und deus est con confilium  
 Womancher Credit ohne zweifel  
 das im tentur ein dharbartel  
 Maripinum hoch seine Hüll  
 und aurum die gebote joch

Wiedung wider den Tod zu Rom Anno 1656  
 Die gahnde Doctores Medici daga zu Rom, man flehden an die gahnde  
 fabel zu lesen, die zu curieren und fragen, sich wider den Tod zu fuchen, an langes Leben zu  
 werten, nach die Ansechtlichkeit zu laren, fuden, lügen, baten sie große Verhoffung, die Willen wie  
 Namenen langes Schnabel, welche die Speerey, in der Hand, welche mit Hand schuhen  
 und verleben ist, an langes Leben und darmit bitten sie, was man thun, lano gebühret solt.



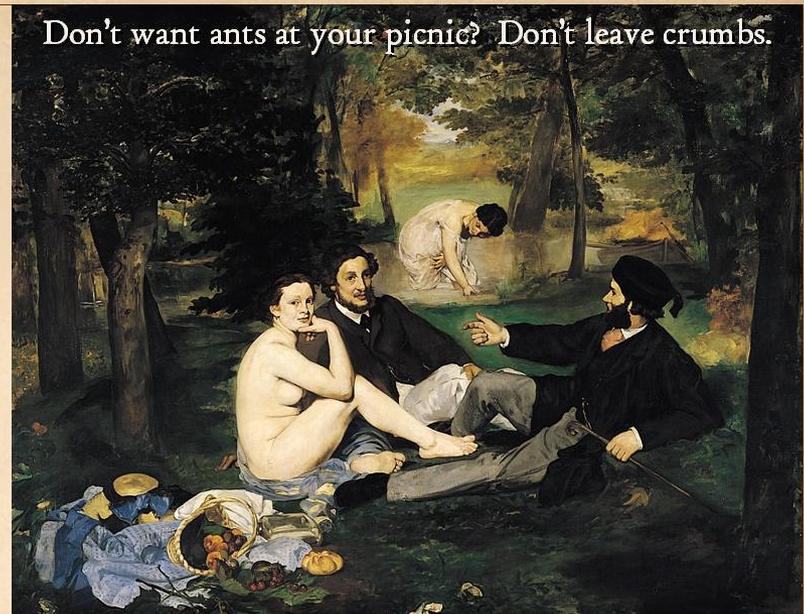
Sir Joseph Lister, 1827-1912, carbolic antiseptics, 1867.

ALPHONSO & IMOGENE AN IDYL OF HENRY'S CARBOLIC SALVE.

ALPHONSO LOVED DEARLY THE BLITHE IMOGENE WHOSE FACE WAS THE FAIREST THAT EVER WAS SEEN, BUT WHEN HE PROPOSED, "ALAS", IMOGENE SAID "I WOULD GLADLY ACCEPT AND WITH THEE WOULD WED BUT WITH UGLY ERUPTIONS YOUR FACE IS SO SCARRED THAT ALL MY LIFE'S FUTURE, WITH YOU WOULD BE MARRIED UNLESS YOU REMOVE THEM, SO IF ME YOU'D HAVE YOU MUST CURE THEM WITH HENRY'S CARBOLIC SALVE.

ALPHONSO & IMOGENE AN IDYL OF HENRY'S CARBOLIC SALVE.

ALPHONSO THIS REMEDY TRIES — AND AGAIN POPS THE QUESTION — NOR DOES SO IN VAIN HENRY'S CARBOLIC SALVE HAS SWART HIS FACE CLEAN OF EVERY UNSIGHTLY SPOT THAT WAS SEEN AS A COMPOUND FOR HEALING IT'S SPEEDY AND SURE AND FOR BURNS, CUTS AND BRUISES, READIEST CURE.



Don't want ants at your picnic? Don't leave crumbs.

DIATRIBE on the MISUNDERSTANDING & MISAPPROPRIATION of INFECTION to deny, eschew, disavow, blame, obfuscate, and misdirect responsibility for the proper practices and procedures of patient care & effective outcomes. FUD mongering.

HENRY'S CARBOLIC SALVE,

The Most Powerful Healing Agent Ever Discovered.

HENRY'S CARBOLIC SALVE	HEALS	BURNS
HENRY'S CARBOLIC SALVE	CURES	SORES.
HENRY'S CARBOLIC SALVE	SALVE	ALLAYS PAIN.
HENRY'S CARBOLIC SALVE	CURES	ERUPTIONS.
HENRY'S CARBOLIC SALVE	HEALS	PIMPLES.
HENRY'S CARBOLIC SALVE	HEALS	BRUISES.

ASK FOR HENRY'S AND TAKE NO OTHER

BEWARE OF COUNTERFEITS.

Henry's Carbolic Salve, c 1890, patent medicine germ killer and cure-all.



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**PRINCIPLES OF GOOD RESULTS  
IN  
COMPLEX (& ALL) CASES**

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**TACTICAL CONCEPTS IN  
SURGERY OF REPAIR**

**E-DS-M-I**

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Four Horsemen of the Apocalypse, 1498, by Albrecht Dürer, (Nuremberg, 1471-1528).

# Apocalypse

αποκάλυψη  
αποκάλυψις

Conquest

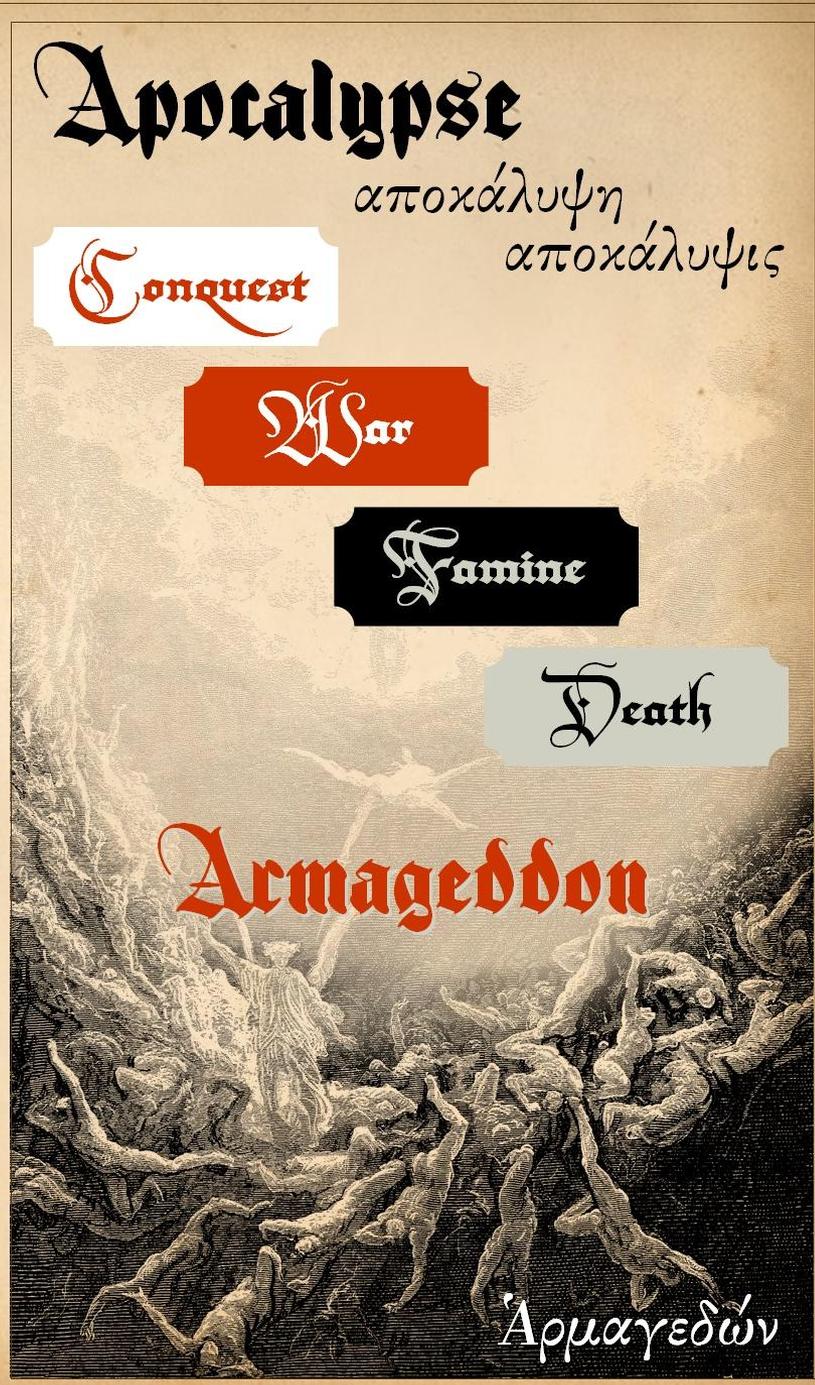
War

Famine

Death

Armageddon

Άρμαγεδών



The Final Judgement, 1865, by Gustave Doré, (France, 1832-1883).



1  
White - Conquest

**EDEMA**

2  
Red - War

**DEAD SPACE**

3  
Black - Famine

**MOTION**

*and mechanics*

4  
Pale - Death

**INFLAMMATION**

*and ischemia*

ИВНДЕ ИСКОНЬ БЪЛЗ ИСЕДАН НАНЕ ИМЪАШЕ ЛУКЪ ИДАНЪС . ПТЬ ЕМУ ВЪНЪ  
 ИИЗЫНДЕ ПОБЪДАГАН ИДАПОБЪДАНТЪ ИИЗЪИДАГ ДРУГИИ КОНЬ РЫЖЪ  
 СЕДАЩЕМУ ИАНЕ ДАНОБЫСТЪ ВЪАТИ МНОЗЪ ШЪСМАА ИДАБЪИЕТЪ ДРУГЪ  
 ДРУГАИДА БЫСТЪ ЕМУ . Е ВЕЛИКІИ ИВНДЪ ИСКОНЬ ВОРОНЪ ПСЕДАН ИАНЕ  
 ИМЪАШЕ МЕРЛО ВРЪКЕ СВОЕЙ МЕРА ПШИНЦЫ ЗАДИНА ИТРИ МЕРЫ ДАМЪ  
 ИИЗАДИНАН Е ЛСА ИВНАИ ПЪВРАИ ИВНАИ ИСКОНЬ БЪЛЗ И СЕДАН И СМРТЪ ИА . Э .

# Negative Effects of the Four Apocalyptic Wound Adversaries

## EDEMA

leukocyte concentration and activation  
dermatitis & panniculitis

effects of inflammation  
inhibition of wound dynamics  
weakening of structure

hydraulic and volumetric effects  
brawny edema, fibrosis, liposclerosis

### WOUND DYNAMICS & FAILURE

$\alpha$  Beta Principle – the “When” of Wound Closure

## DEAD SPACE

loss of tissue-to-tissue contact  $\diamond$  impaired adhesion  
wound surface inflammation  $\diamond$  wound stiffness

fluid accumulation  
unmitigated dead space = abscess  
wound bursitis  $\diamond$  adverse effects of inflammation

loss of stability  
shearing and motion  $\diamond$  serosal metaplasia

### WOUND GEOMETRY & MECHANICS

$\beta$  Beta Principle – the “How” of Wound Closure

### WOUND GEOMETRY & MECHANICS

$\beta$  Beta Principle – the “How” of Wound Closure

loss of tissue-to-tissue contact  $\diamond$  unstable coaptation  
wound bursitis  $\diamond$  adverse effects of inflammation  
impaired adhesion

adverse effects of tension & bending  
rupture and dehiscence

adverse effects of shear  
serosal and synovial metaplasia

## MOTION

### WOUND DYNAMICS & FAILURE

$\alpha$  Beta Principle – the “When” of Wound Closure

final common pathway of wound failure  
consequence of the other factors

interplay with thrombosis  
arbiter of necrosis and ulceration  
active destructive of wound and stroma

inhibitory of the repair process  
long term sequelae if unabated (auto-immunization)

## INFLAMMATION

Playground,  
engraving  
c 1860.



E-DS-M-I

EDEMA

DEAD SPACE

MOTION

INFLAMMATION

John William Draper, M.D.

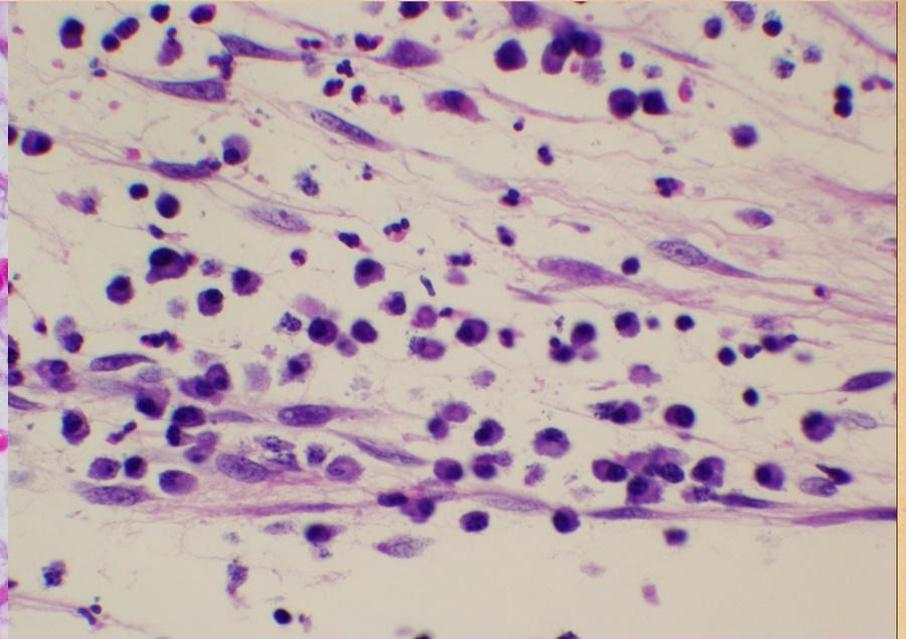
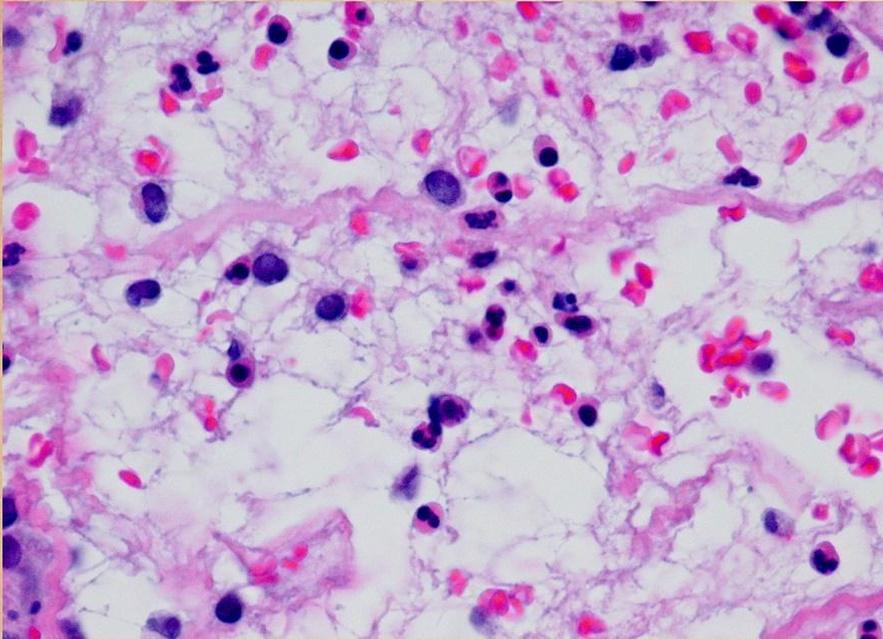
1811-1882, New York

*"Human Physiology, Statical and Dynamical, or a  
Treatise on the Conditions and  
Course of the Life of Man."*

1856

Engraving from photomicrograph.





## Effects & Complications of Edema

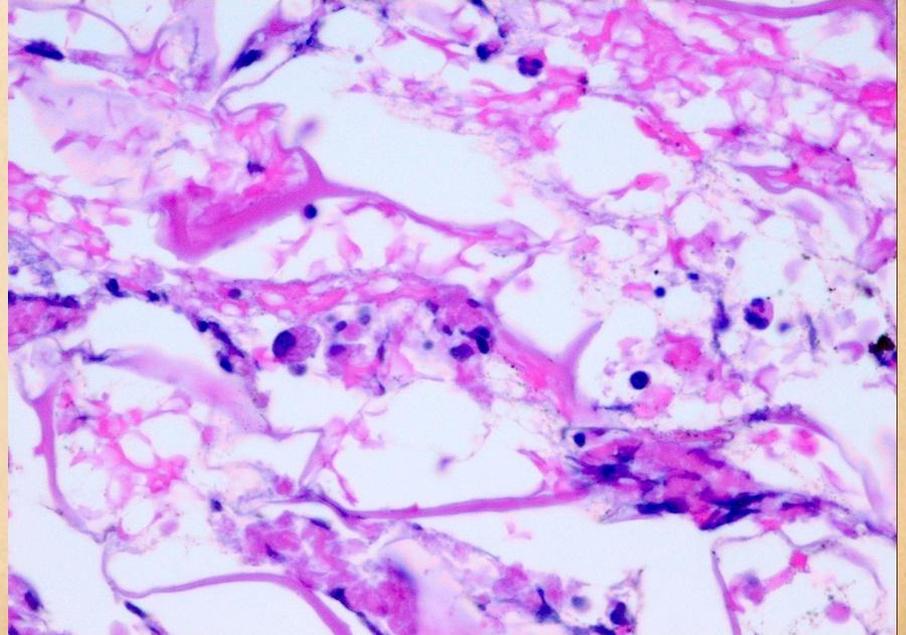
leukocyte concentration and activation  
dermatitis & panniculitis

protease activity  
lysis and weakening of tissues  
impaired fixation strength  
suture laceration

wound module reduction  
impaired epithelialization

hydraulic effects & dehiscence  
transudates, seroma, loss of contact

brawny edema, fibrosis, liposclerosis





## PARAMOUNT IMPORTANCE OF EDEMA CONTROL

Edema control facilitates  
all other wound healing  
events and interventions.

**Edema control alone will  
cure and close many wounds.**

### Methods of Edema Control

compression wrapping  
multi-layer compression wraps  
compression garments & sleeves  
(*LaPlace's Law  $T=Pr$* )

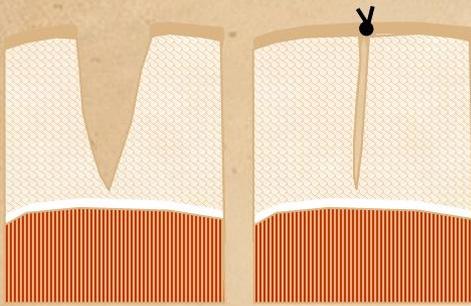
elevation  
orthotics

active compression devices  
activity and mobility  
splinting  
negative pressure  
edema therapies

control inflammation  
control disease

cardiopulmonary optimization  
renal and hepatic management

hygroscopic dressings  
[diuretics]



## PROLOGUE TO DEAD SPACE & MOTION



**MANDATORY**  
for successful repair:

**TISSUE-TO-TISSUE COAPTATION**

**TISSUE INTERFACE STABILITY**  
Without Shear or  
Distraction



**DEAD SPACE CONTROL**

Positive pressure from without.  
Negative pressure from within.



Gather and bind space.  
Fill the space.  
(flaps, biomatrices, cement)



Controlled sustained drainage.



Wound remodeling.  
Proper dissection &  
preemptive avoidance.

E-DS-M-I

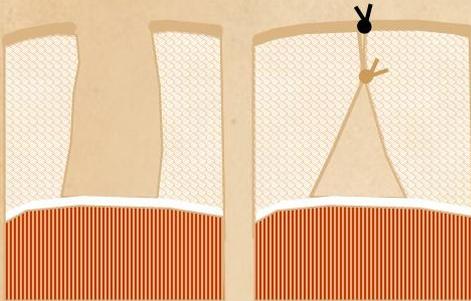


EDEMA

DEAD SPACE

MOTION

INFLAMMATION



Αα  
αλφα

Repair & Reconstruction

Strategic planning

**WHEN**

edema  
inflammation

# WOUND GEOMETRY & MECHANICS

**MANDATORY**  
for successful repair:

**Tissue-to-Tissue Coaptation**

**Tissue Interface Stability**  
Without Shear or Distraction

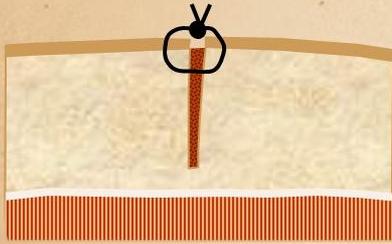
Ββ  
βήτα

Repair & Reconstruction

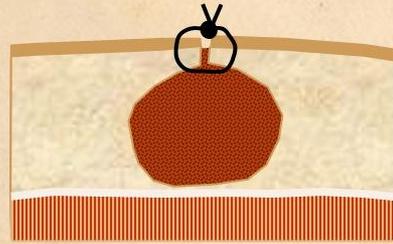
Tactical execution

**HOW**

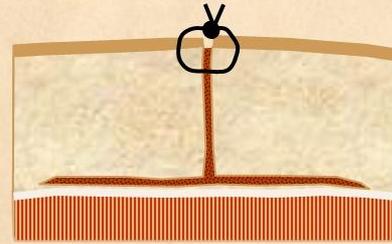
motion  
dead space



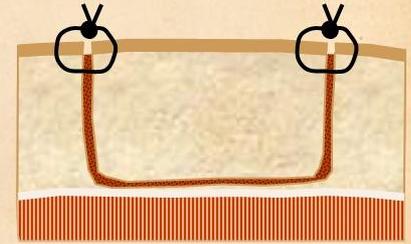
*nominal dead space*



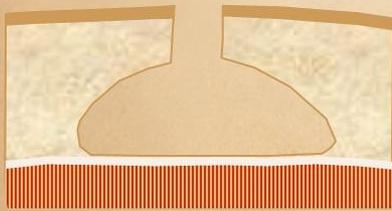
*overt dead space*



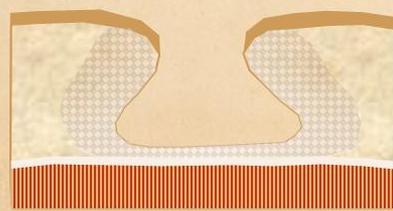
*latent dead space, shear*



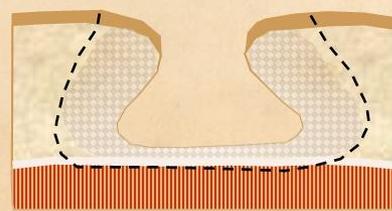
*latent dead space, shear*



*cavitary defect after pathology*



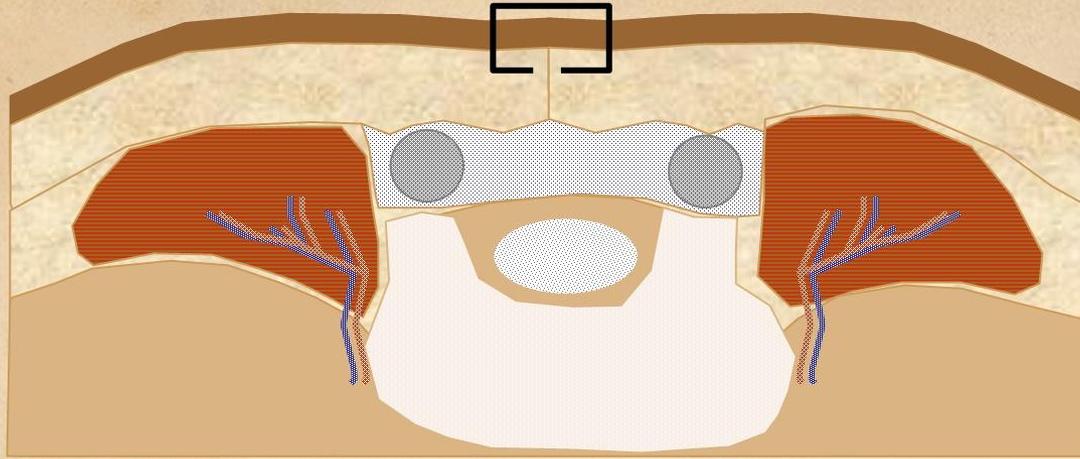
*chronic scar & contracture, stiff*



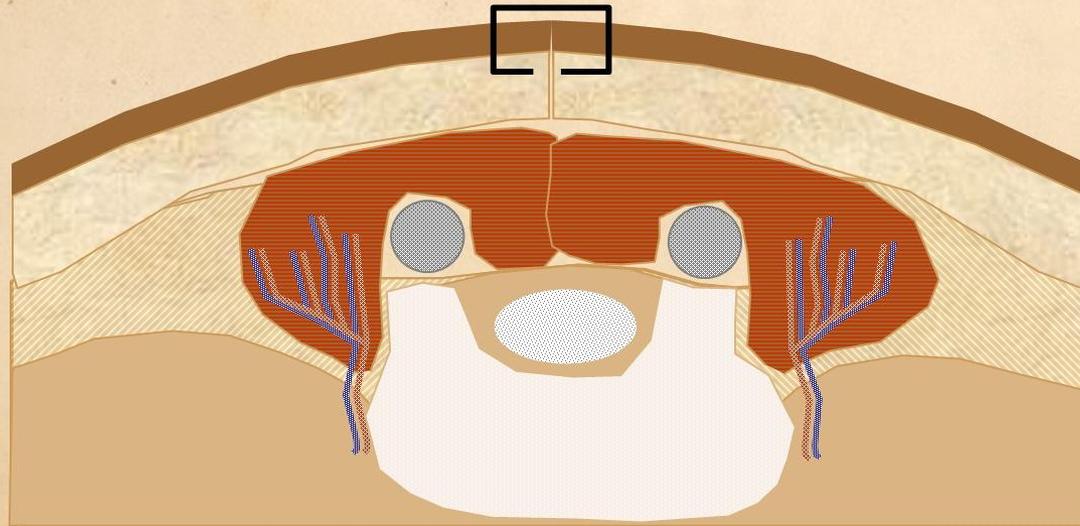
*excise scar to restore compliance*



*what next ?*



## **DEAD SPACE**

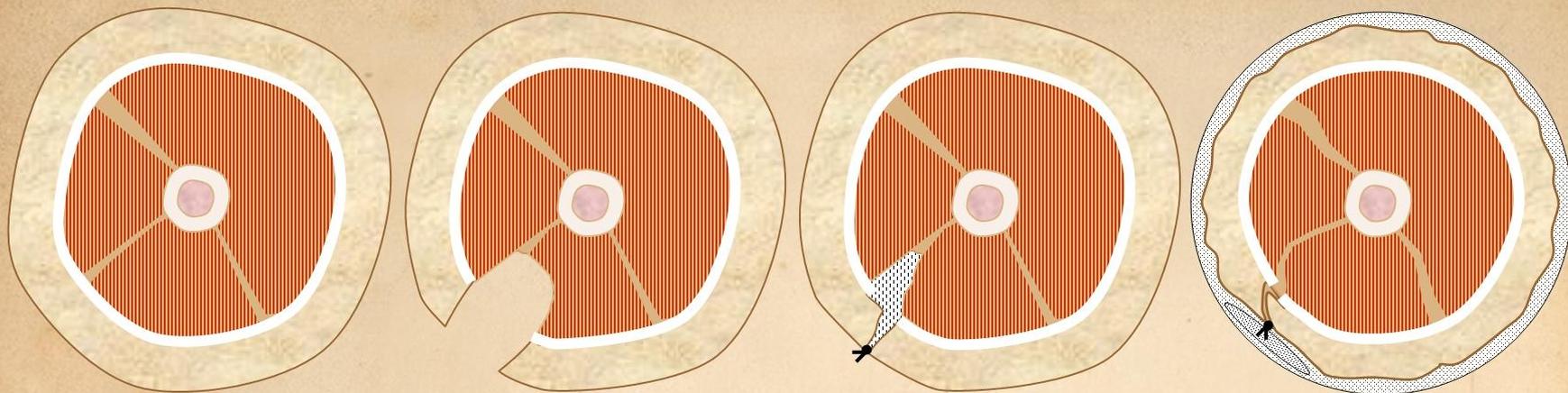


**Unmitigated dead space = Abscess.**

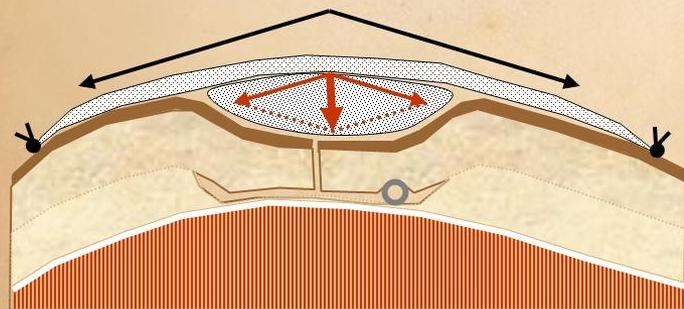
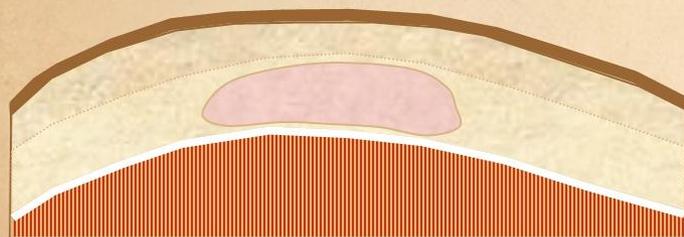
**Fill it in or drain it, lest the wound become a swamp.**

# Tissue-to-tissue coaptation.

# Tissue interface stability without shear, distraction, or separation.

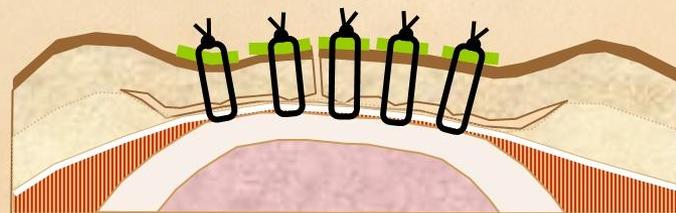


*circumferential compression wrapping*



*compression dressings*

In concave areas,  
fill and elevate the  
external hollow with  
bolsters, wadding,  
molds, moulages,  
plugs, stents.



*mattress sutures*

## DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.

NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.  
FILL THE SPACE.  
(E.G. FLAPS, BIOMATRICES, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.  
PROPER DISSECTION & AVOIDANCE.

## IMPORTANCE OF POSITIVE PRESSURE

High pressures and extreme mechanical stability make this the standard for the extremities (by compression wrapping) & for smaller defects (by "tie-overs"), either by itself, or especially over flaps and grafts.

Concurrent control of edema confers those benefits as well.

### Methods of Positive Pressure

circumferential  
compression wrapping

multi-layer  
compression wrapping

compression  
garments & sleeves

(LaPlace's Law  $T=Pr/n$ )

tie-over and  
compression dressings  
bolster, stent, moulage  
npwd over convex surface

splints and orthotics  
mattress suturing

### Pros

collapses dead space  
high force & pressure  
mechanical stability  
minimizes surface area  
for contained volume  
minimizes motion  
& inflammation  
edema control  
good for convex surfaces  
ideal for extremities



### Cons

cumbersome fixation  
for trunk, pelvis, scalp  
limitations in concave areas  
unsuited for neck & orbit  
attention to distribution  
& LaPlace principles  
tourniquet effects & edema  
pressure and ischemia,  
especially in vasculopathies



## IMPORTANCE OF SUCTION & CLOSED NEGATIVE PRESSURE

Ability to eliminate fluids and prevent loss of tissue contact makes this a mandatory modality for many procedures.

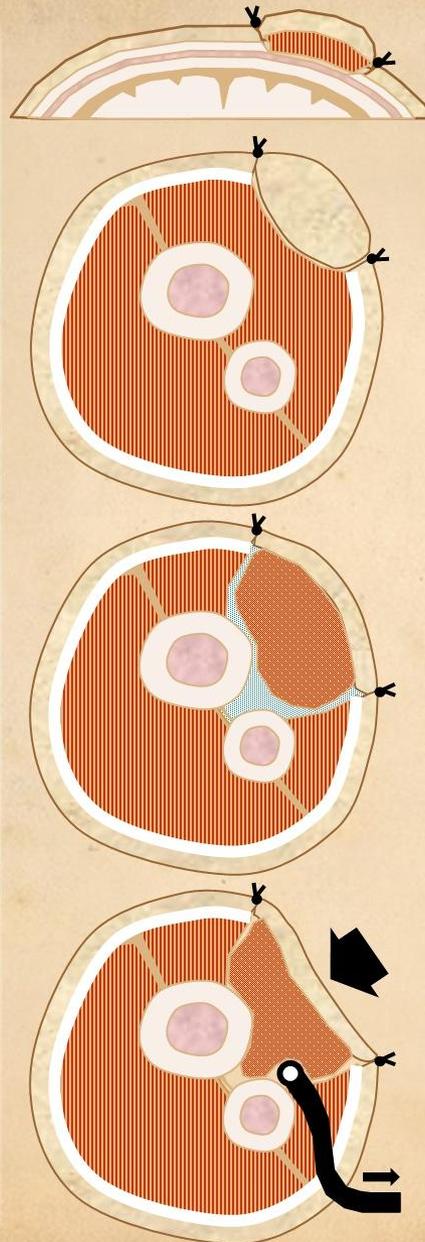
It can control real dead space, and it is the prime method of eliminating latent dead space.

### Pros

- collapses dead space
- controls fluids and latent dead space
- preserves tissue contact
- suitable for all areas & simple to implement
- vital adjunct to other modes

### Cons

- low pressure
- poor mechanical stability
- limited effectiveness by itself for extreme concavity or rigid spaces
- can clot or occlude
- critically dependent on a sealed wound without air leak (air leaks easily managed with external negative pressure wound device)



## DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.

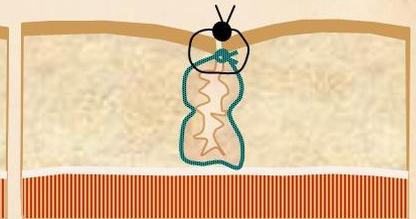
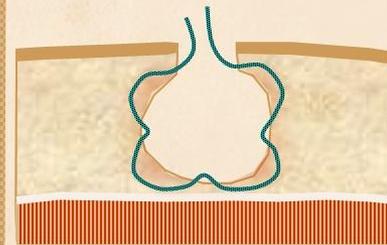
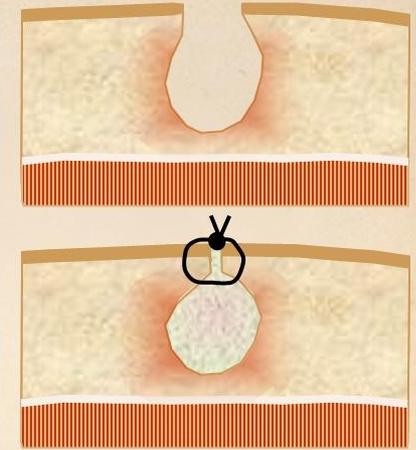
NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.

FILL THE SPACE.  
(FLAPS, BIOMATRICES, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.  
PROPER DISSECTION & AVOIDANCE.



## GATHER & BIND

**Pros** obviates drains  
obviates flaps  
good for small wounds

**Cons** unsuited for stiff wounds  
& complex geometries

## DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.

NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.

FILL THE SPACE.

(FLAPS, BIOMATRICES, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.  
PROPER DISSECTION & AVOIDANCE.

**Tissue-to-tissue coaptation.**

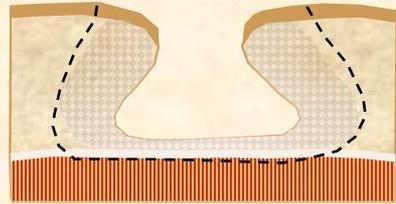
**Tissue interface stability without shear, distraction, or separation.**



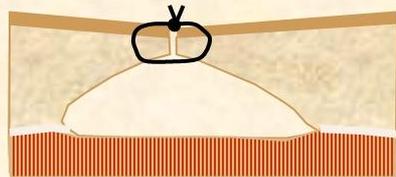
*chronic scar & contracture, stiff*



*stiffness prevents reduction*



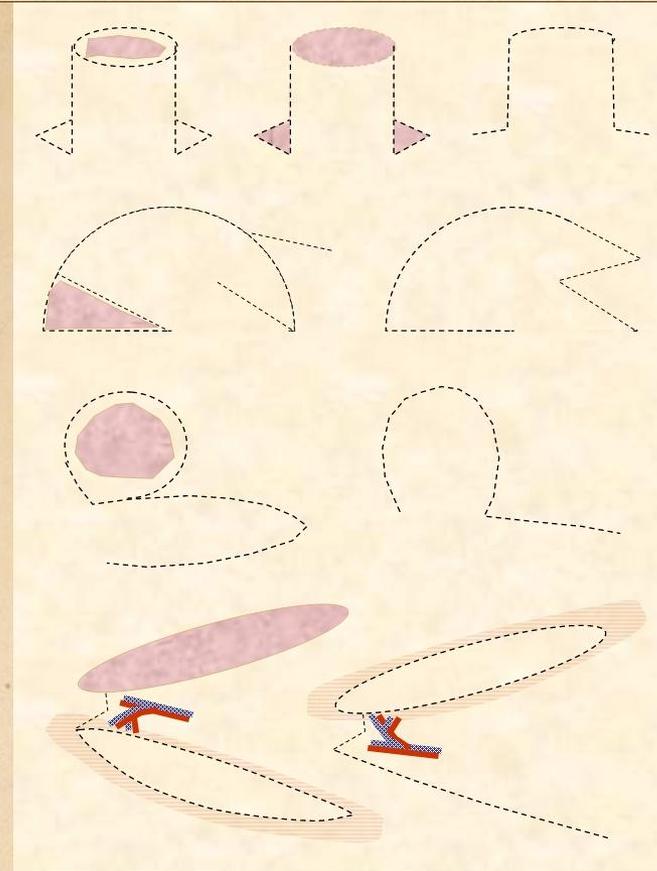
*excise scar to restore compliance*



*direct closure – drumskin effect*



*what next ?*



**DEAD SPACE CONTROL**

POSITIVE PRESSURE FROM WITHOUT.  
NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.

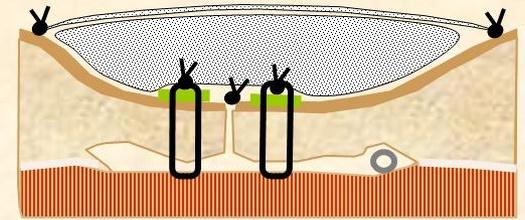
**FILL THE SPACE.**

(FLAPS, BIOMATRIX, CEMENT)

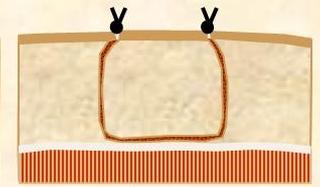
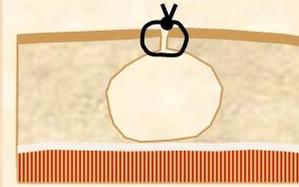
CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.

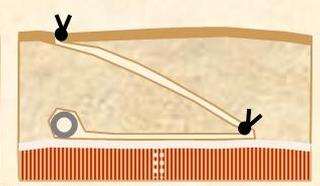
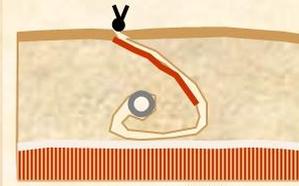
PROPER DISSECTION & AVOIDANCE.



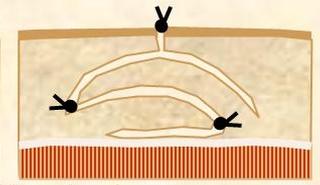
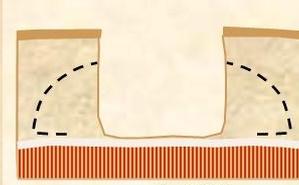
*pos-neg pressure modalities inadequate*



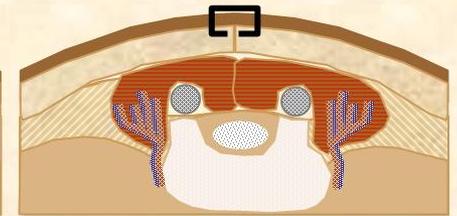
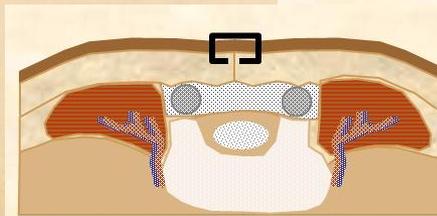
*fill void with transposed flaps*



*infolding and interleaving 1*

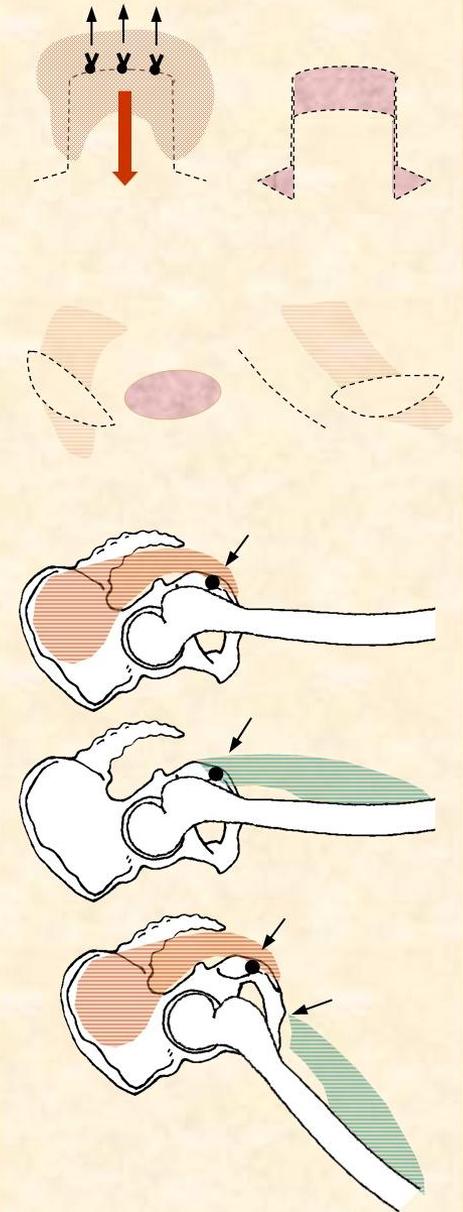
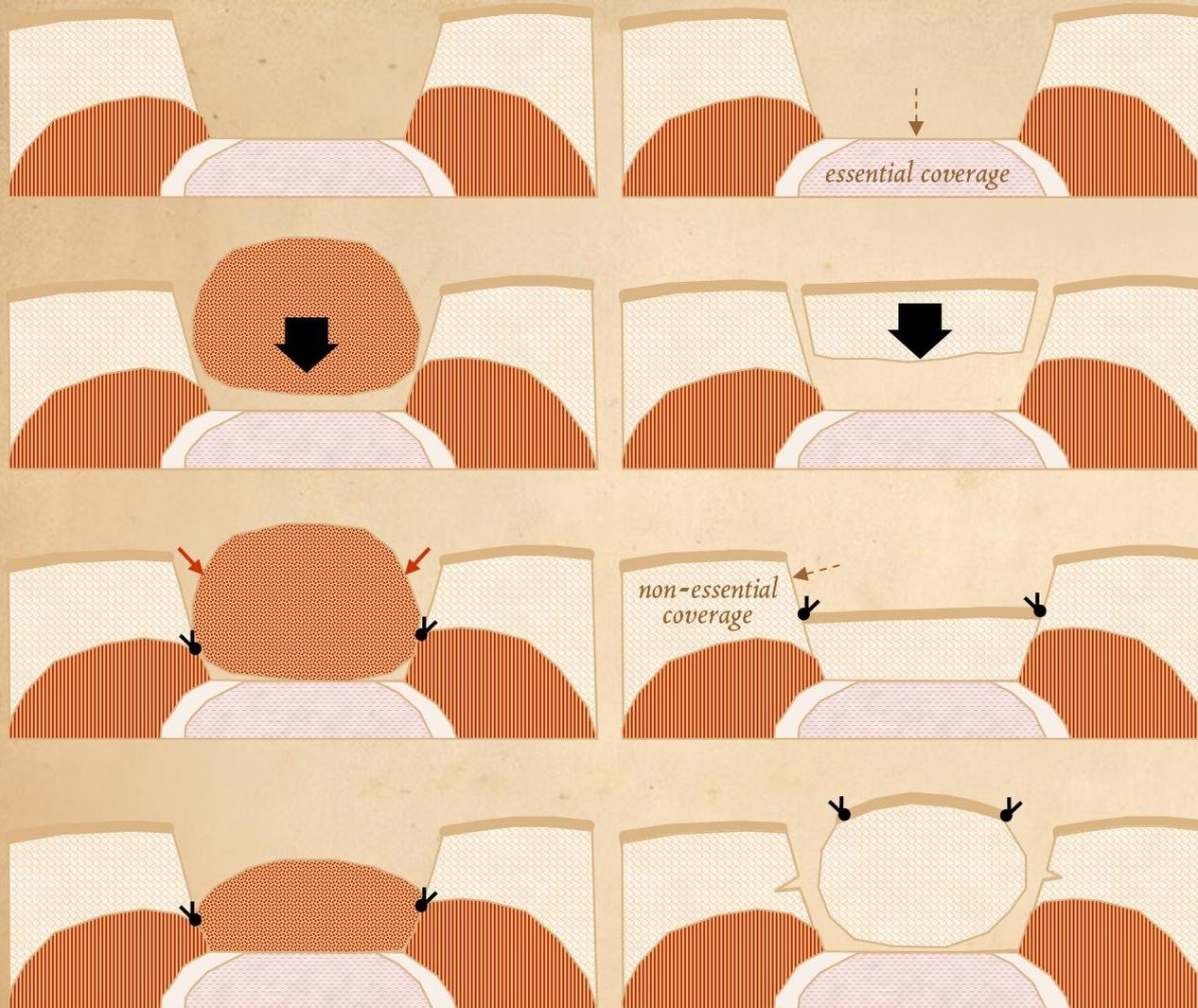


*infolding and interleaving 2*



**Tissue-to-tissue coaptation.**

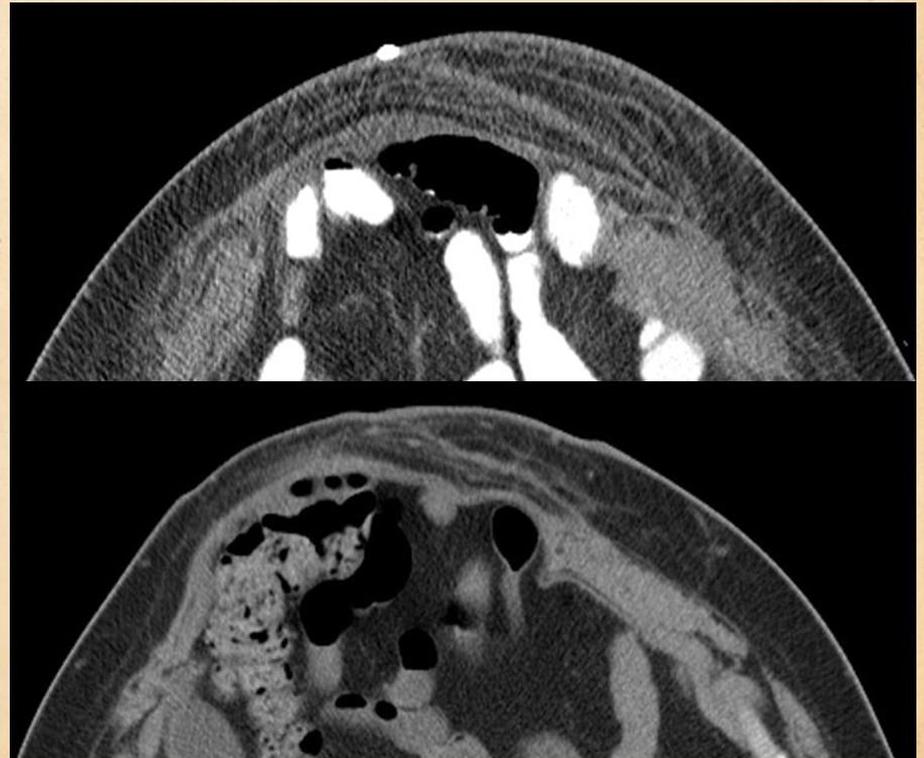
**Tissue interface stability without shear, distraction, or separation.**



**Filling Space with Flaps  
Technicalities & Pitfalls**



58 F, sarcoma resection and THA



abdominal wall reconstruction, interleaving flaps

67 F, sarcoma resection and radiation

## IMPORTANCE OF FILLING THE DEAD SPACE

When collapsing deadspace is impossible but the wound must be closed, then filling the space is mandatory.

Done properly, it assures tissue-to-tissue contact and is the most dependable route to a good result.



### Pros

eliminates voids · eliminates “unsatisfied” surfaces

flaps & matrices: definitive fix once healed

alloplastic fillers: solve untenable situations

complemented by the other deadspace modalities

### Caveats

no cons, just details · art and rules of “flapology”

staged reconstruction often required

highly dependent on technique

risks and caveats of all flaps

### DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.

NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.

**FILL THE SPACE.**

(FLAPS, BIOMATRIX, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.

PROPER DISSECTION & AVOIDANCE.

Fillers in lieu of living autogenous flaps:

regenerative biomatrices

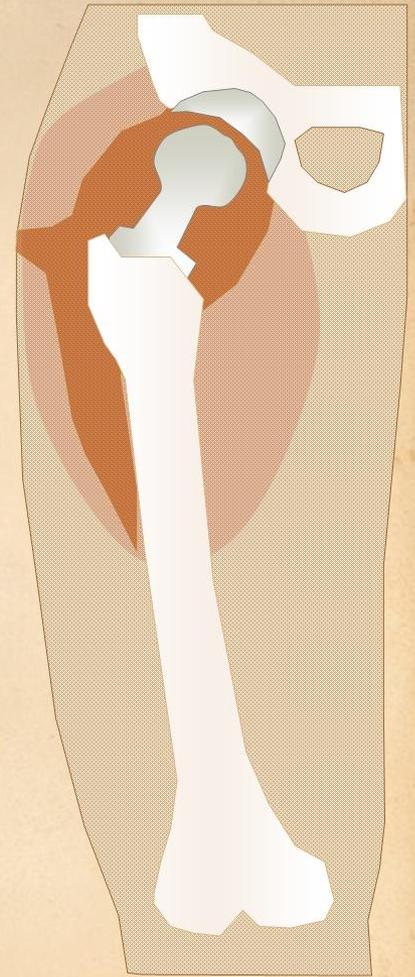
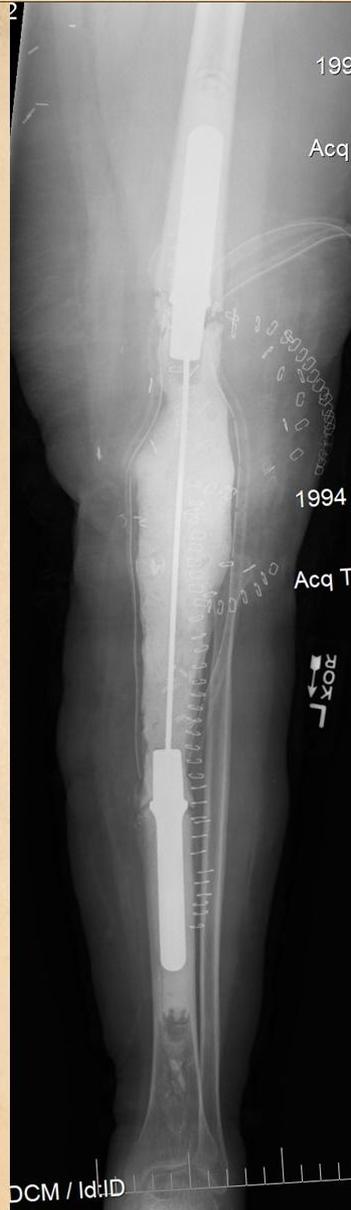
*solid & sheet*

*putty & flowable*

acrylic cement (with abx)

bone grafts, auto, allo,  
and alloplastic





44 M, tibia defect after necrotizing fasciitis

17 F, tibia defect after trauma

44 M, calcaneal defect after trauma

## CONTROLLED SUSTAINED DRAINAGE

Establish permanent gravity dependent drainage.

Ideally, create a wound ostium that cannot contract and close.

Indicated when inflammation and bioburden persist in dead spaces that cannot be eliminated or in alloplastic materials or implants that cannot be removed.

It is a capitulation to difficult circumstances where long term management of a problem is preferable to a definitive fix, or where a definitive fix is not technically possible.

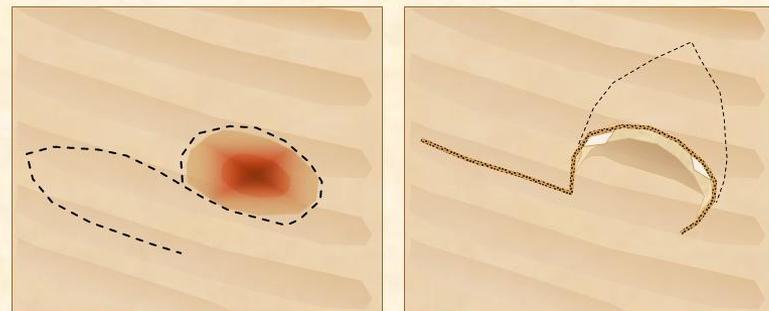
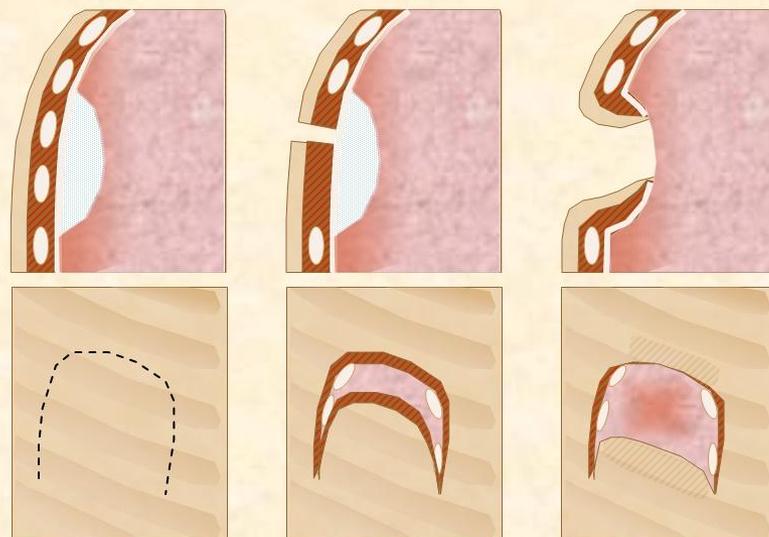
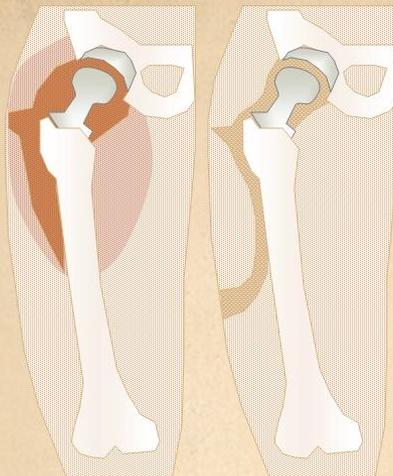
This strategy mandates long term management, oftentimes adjuvant therapies such as antibiotics, and sometimes periodic wound remodeling.

### Examples

**infected arthroplasties**  
(most commonly *THA's*)

**empyema**  
(*Clagett, Eloesser, etc.*)

**pelvic exenteration**  
**and radiation**



### DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.  
NEGATIVE PRESSURE FROM WITHIN.

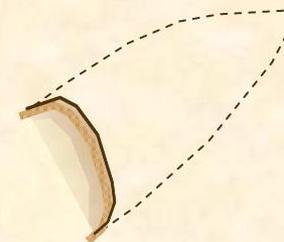
GATHER AND BIND SPACE.  
FILL THE SPACE.  
(FLAPS, BIOMATRIX, CEMENT)

CONTROLLED SUSTAINED  
DRAINAGE.

WOUND REMODELING.  
PROPER DISSECTION & AVOIDANCE.

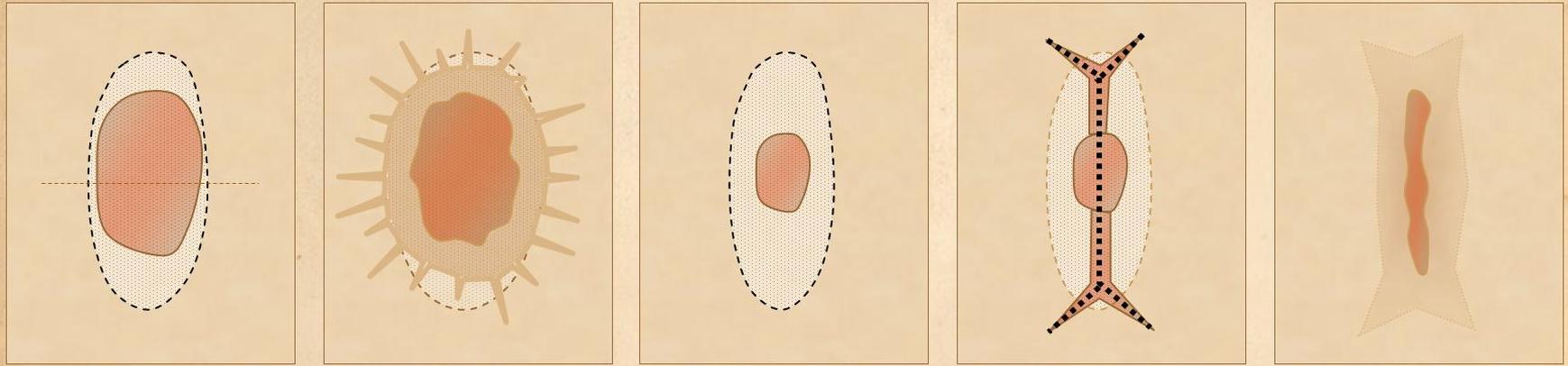
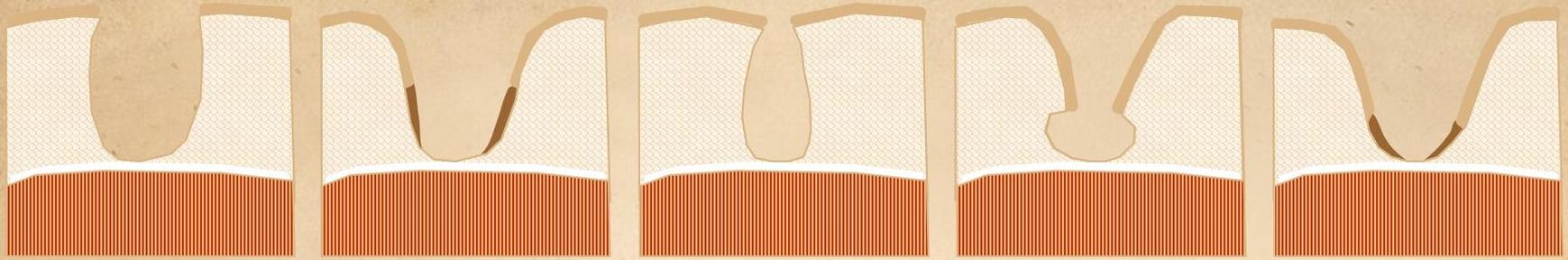


*Eloesser flap and variations.*



**Tissue-to-tissue coaptation.**

**Tissue interface stability without shear, distraction, or separation.**



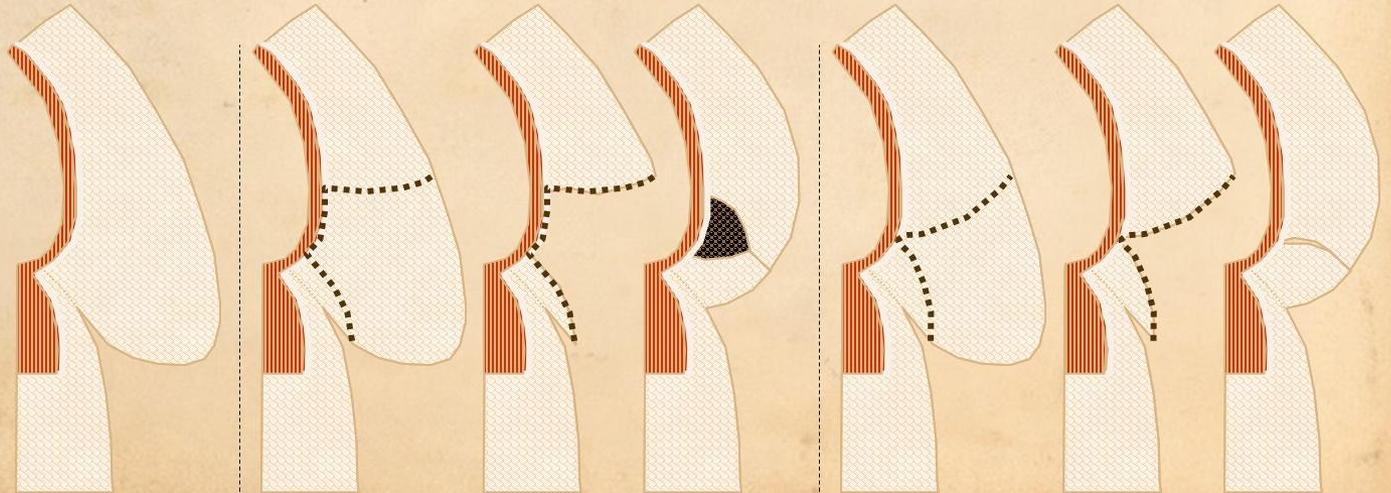
**DEAD SPACE CONTROL**

POSITIVE PRESSURE FROM WITHOUT.  
NEGATIVE PRESSURE FROM WITHIN.

GATHER AND BIND SPACE.  
FILL THE SPACE.  
(FLAPS, BIOMATRIX, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

WOUND REMODELING.  
PROPER DISSECTION &  
PREEMPTIVE AVOIDANCE.



# WOUND REMODELING & PREEMPTIVE AVOIDANCE

Wound remodeling directly addresses the adverse mechanics of scar and the constraints of an unfavorable wound geometry.

*“An ounce of prevention is worth a pound of cure.”*

## WOUND REMODELING

Altering or correcting wound mechanics and geometry to facilitate or obviate adhesion, contraction, and epithelialization.

### METHODS

excise constraining scar

increase perimeter and perimeter-to-area ratio by multangular incisions

simplify manifold geometry by multangular incisions (“saucerization”)

relax wound by incisions or flaps

Obviate wound and dead space by closure with grafts, with or without flaps to selective areas

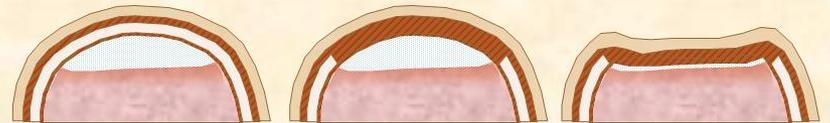
## DEAD SPACE CONTROL

POSITIVE PRESSURE FROM WITHOUT.  
NEGATIVE PRESSURE FROM WITHIN.

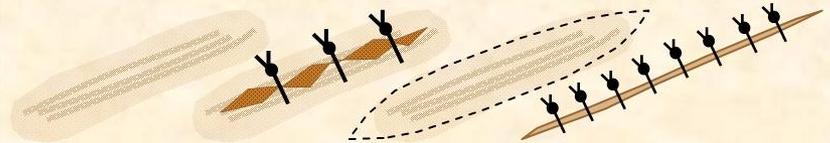
GATHER AND BIND SPACE.  
FILL THE SPACE.  
(FLAPS, BIOMATRIX, CEMENT)

CONTROLLED SUSTAINED DRAINAGE.

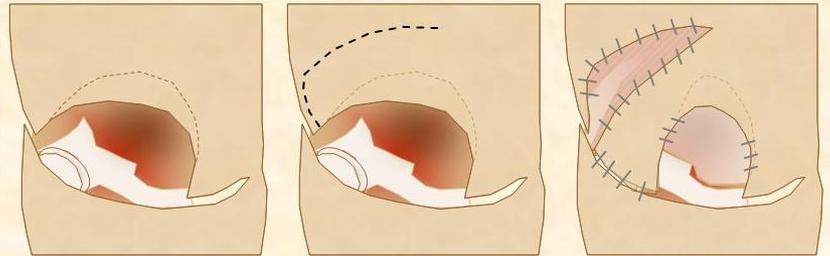
WOUND REMODELING.  
PROPER DISSECTION &  
PREEMPTIVE AVOIDANCE.



*Remodel wound and geometry by thoracoplasty (with or without space filling flaps).*



*Remodel and preempt by excising old scars and restoring compliance.*



*3D-to-2D conversion with grafts and selective flaps.*

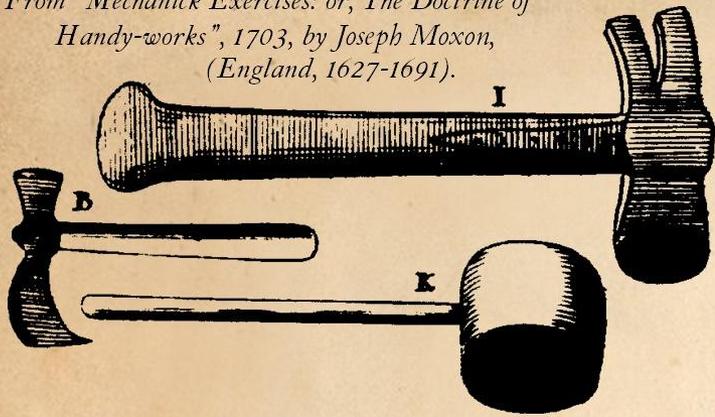
Closing skin over geometrically and mechanically complex spaces may look good from the outside, but the wound surfaces do not share the same view.

**Total skin closure over a complex wound is never a priority, and oftentimes it is an impediment to a good result, oftentimes the cause of a bad result.**

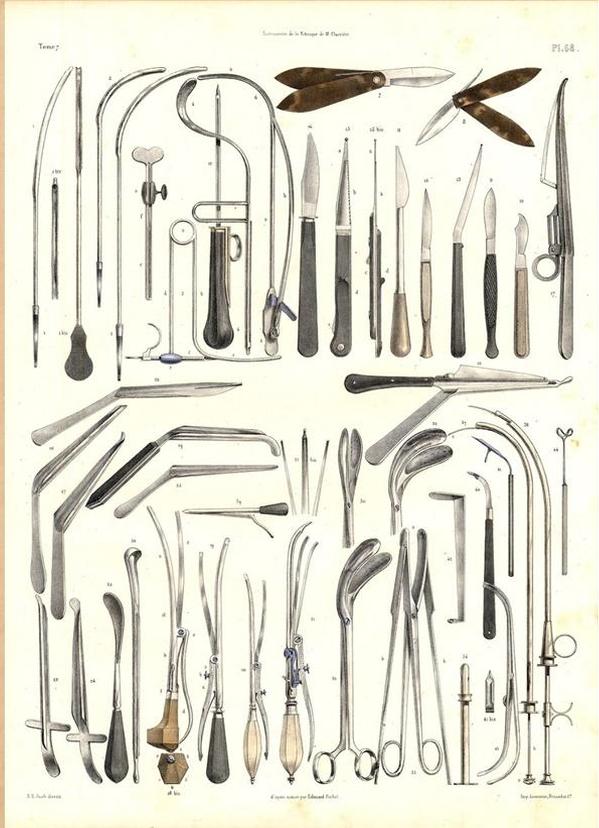
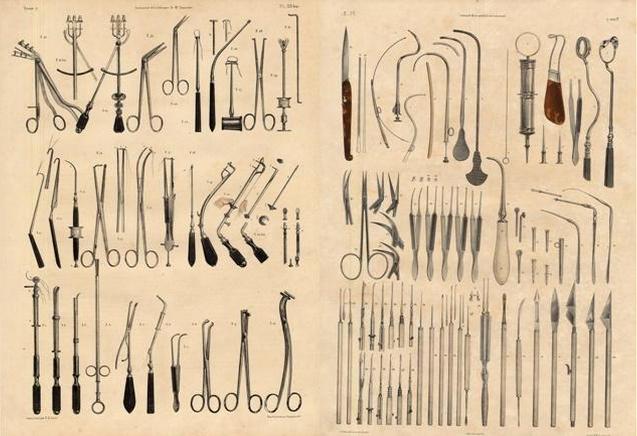
Wound closure is always the goal, but closing skin per se is never a priority. Closure must be done in each individual location or domain of the wound each according to its own needs.

**MAKE THE SKIN FIT THE WOUND, NOT VICE VERSA.**

From "Mechanick Exercises: or, The Doctrine of Handy-works", 1703, by Joseph Moxon, (England, 1627-1691).



Tools from preeminent Swiss surgical instrument maker Joseph-Frédéric-Benoît Charrière (1803-1876), Lithographs by Nicolas-Henri Jacob (1782-1871) for "Traité complet de l'anatomie humaine" (1832-1851), Authored by French physician & anatomist Jean-Baptiste Bourguery (1797-1849).



# Clinical Sampler - Situations to Consider

WITH RESPECT TO CONTROLLING DEAD SPACE.



**Chronic fibrotic traumatic hematoma of hip.**

**(Morel-Lavallee)**

*Stiff tissues cannot mold or contract.*



**Chronic pelvic wound after exenteration and radiation.**

**(Rigid anatomy)**

*Solid surfaces cannot contract.*



**Mid tarsal exenteration for trauma or Charcot.**

**(Caveats of motion & load)**

*Constrained space, bending.*



**Proximal femur resection for Charcot or osseous abscess.**

**(Girdlestone)**

*Shearing, tension, unconstrained loads.*



**Pilonidal or post-pilonidal inter-gluteal sinus.**

**(Rigidity plus shear)**

*Constrained & rigid, cannot contract.*



**Groin necrosis following femoral artery surgery.**

**(Risk devascularized flaps)**

*Essential coverage, limited anatomy.*



**Thoraco-mediastinal defect after thymectomy & radiation.**

**(Critical essential coverage)**

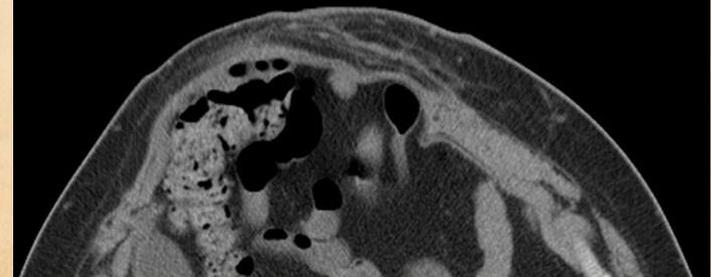
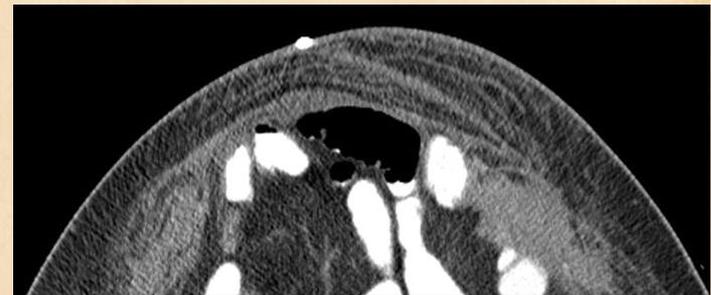
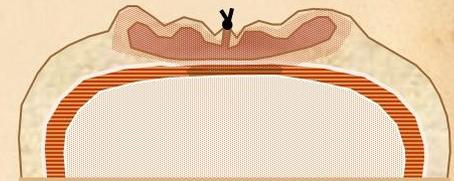
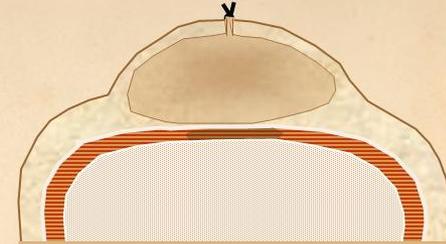
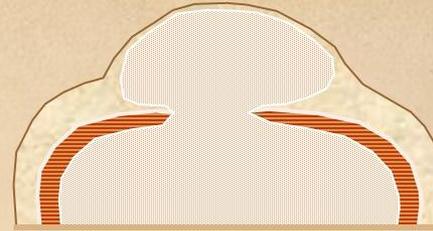
*Essential coverage, ventilatory shear.*

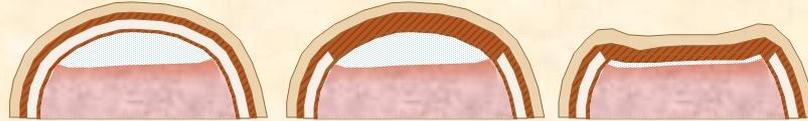
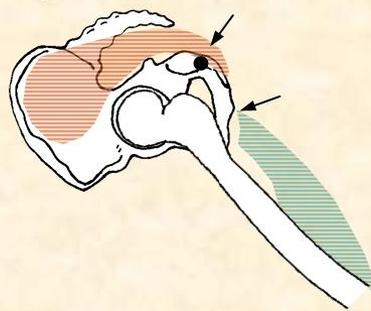
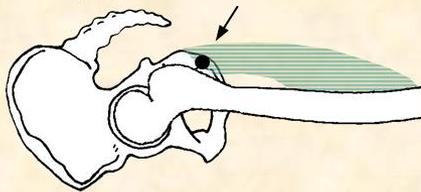
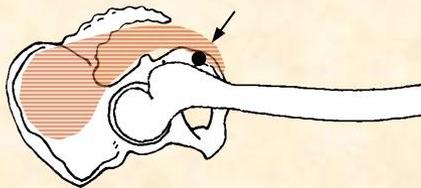
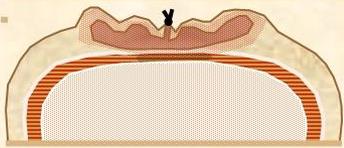
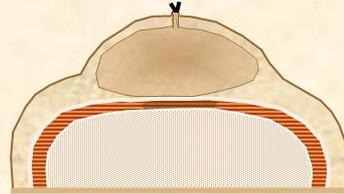
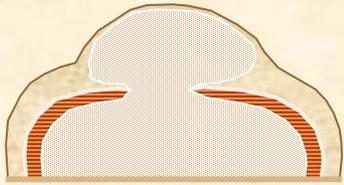


**Chronic axillary wound after lymphadenectomy & radiation.**

**(Motion vs functional shoulder)**

*Constrained space, tension, damaged flaps*





Natural anatomy  
meant to shear

**Musculoskeletal**  
Joints  
Tendons  
Bursas

**Coelomic viscera**  
Heart  
Lung  
Bowel

Wolf's Law,  
generalized

Mesenchyme subject to chronic  
or repetitive stress will react  
or differentiate to minimize  
strain due to that stress.

Mesenchyme subject to chronic  
or repetitive strain will react  
or differentiate to minimize  
stress due to that strain.

**WOLF'S LAW HAS PROFOUND IMPLICATIONS FOR  
THE BIOLOGY OF THE MESENCHYME.**

In the musculoskeletal system, it regulates  
embryogenesis, pathology, response to  
injury & healing, and the strategies  
and methods of clinical care.

It governs tissue response  
to mechanical force:

*tension - distraction*  
*compression*  
*shear*

Wounds can fail acutely due to excessive  
force (dehiscence, rupture, etc.), but they also  
fail due to a Wolf's Law response to abnormal or  
unconstrained motion even when force is low, failure  
from two mechanisms, inflammation & tissue metaplasia.

E-DS-M-I

EDEMA

DEAD SPACE

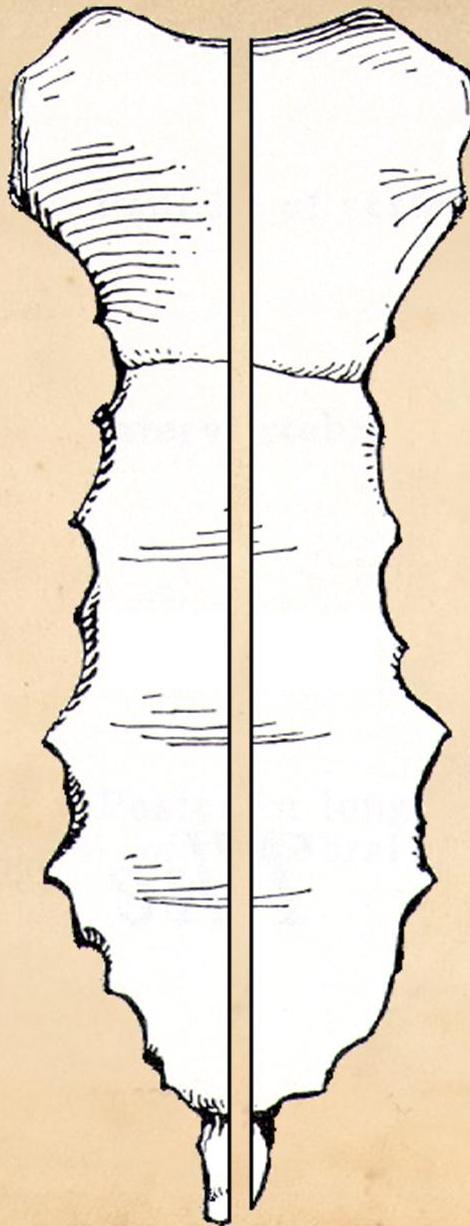
MOTION

INFLAMMATION

EXPIRATION  
OUT



INSPIRATION  
IN



**OUT**



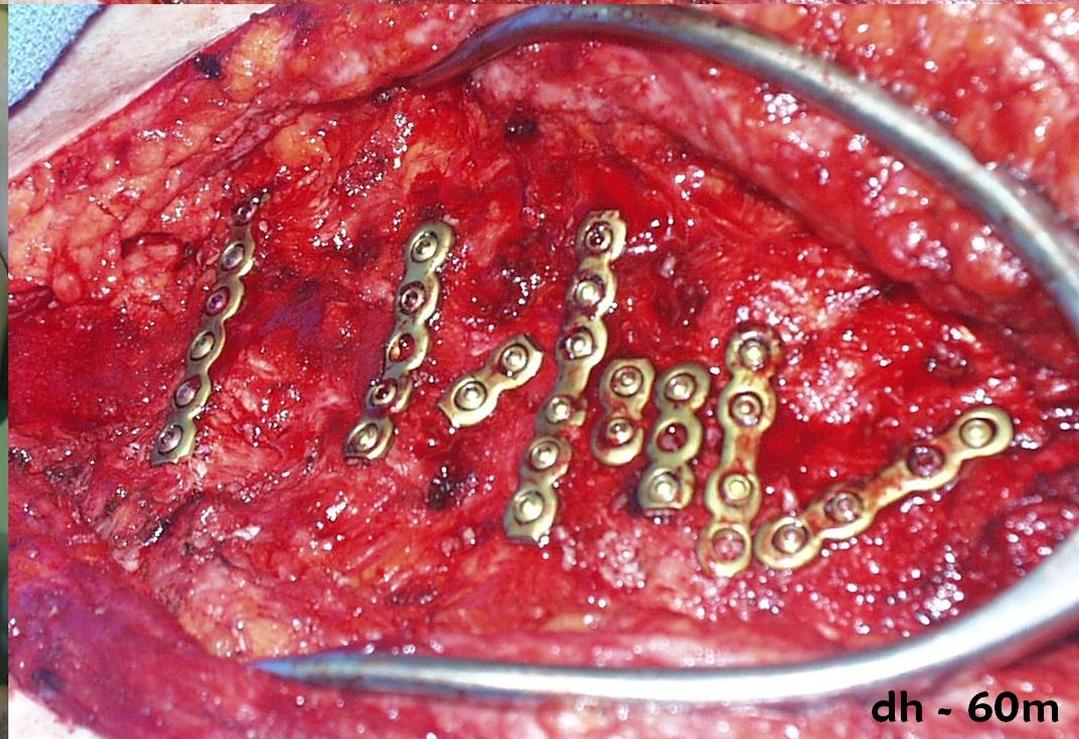
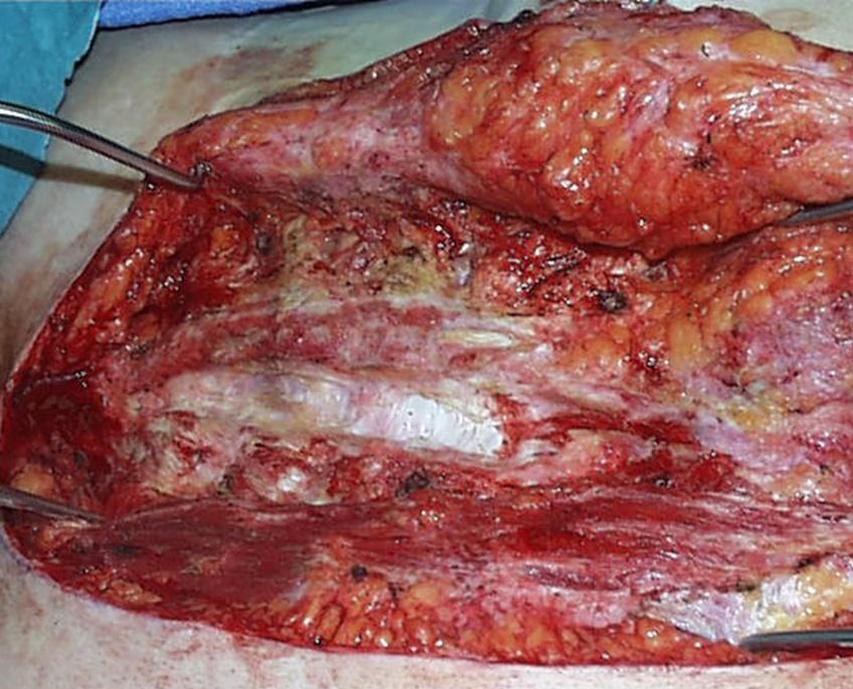
**IN**



# Strains on the sagittal (median) sternotomy – versus – stress or load.

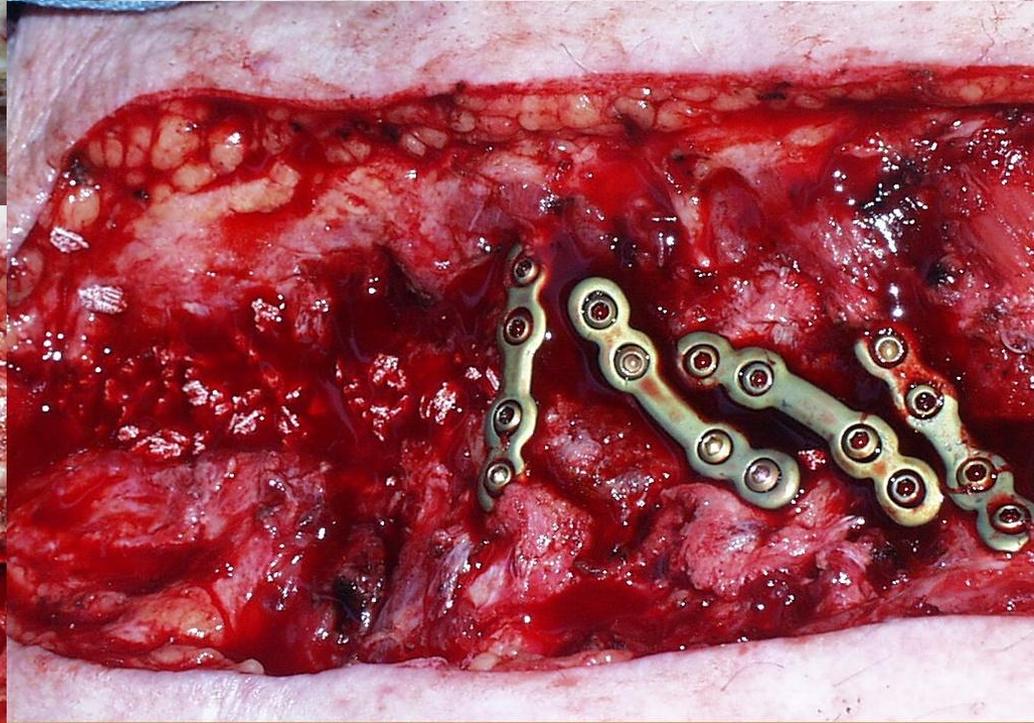
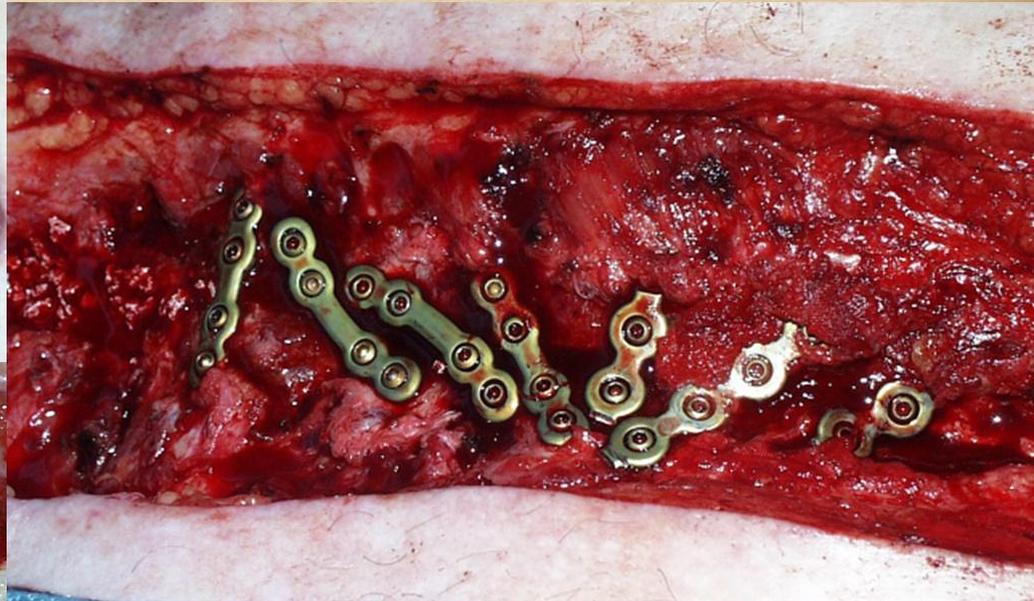
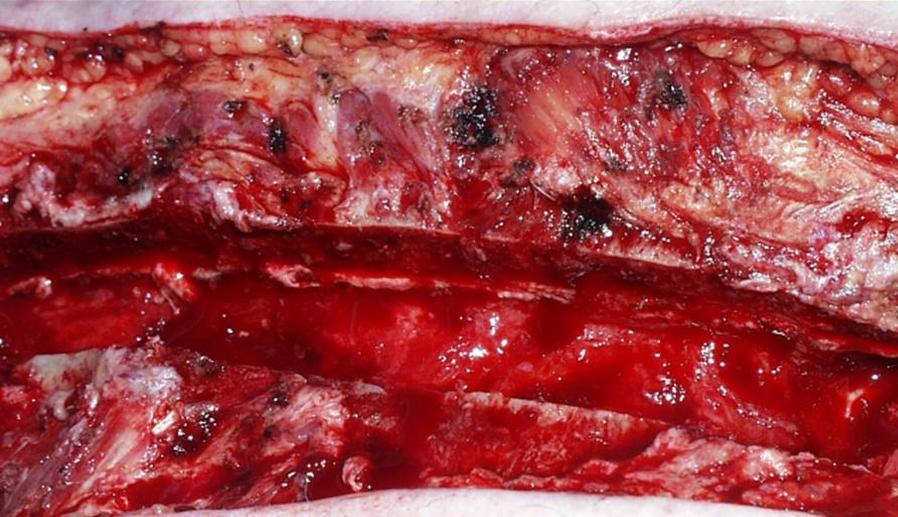
 <b>BENEFICIAL</b>  <b>NEUTRAL</b>  <b>ADVERSE</b>		Cephalocaudal Axis Rotation (roll)	Dorsoventral Axis Rotation (yaw)	Transverse Axis Rotation (pitch)	Cephalocaudal Translation (vertical)	Dorsoventral Translation (anteroposterior)	Transverse Translation (horizontal)
<b>SYMMETRIC</b>	Tidal volume active inspiration	 <b>COMPRESSION</b>	 N/A	 N/A	 N/A	 N/A	 <b>COMPRESSION</b>
	Tidal volume passive expiration	 <b>MILD TENSION</b>	 N/A	 N/A	 N/A	 N/A	 <b>MILD TENSION</b>
	Vital capacity active inspiration	 <b>COMPLEX / TNSN</b>	 <b>COMPLEX / TNSN</b>	 N/A	 N/A	 N/A	 <b>COMPLEX / TNSN</b>
	Vital cap. active expiration & cough	 <b>TENSION</b>	 <b>COMPLEX / TNSN</b>	 N/A	 N/A	 N/A	 <b>TENSION</b>
	Positive pressure ventilation	 <b>TENSION</b>	 N/A	 N/A	 N/A	 N/A	 <b>TENSION</b>
	Costal muscles	 <b>COMPLEX</b>	 N/A	 N/A	 N/A	 N/A	 <b>COMPLEX</b>
	Diaphragm	 <b>COMPRESSION</b>	 <b>COMPLEX</b>	 N/A	 N/A	 N/A	 <b>COMPRESSION</b>
<b>ASYMMETRIC</b>	Paradoxical or asymmetrical vent.	 <b>SHEAR</b>	 <b>SHEAR / TNSN</b>	 <b>SHEAR</b>	 N/A	 <b>SHEAR</b>	 <b>TENSION</b>
	Abdominal muscles	 <b>TNSN / SHEAR</b>	 <b>COMPLEX</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>TENSION</b>
	Paraspinal muscles	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>TENSION</b>
	Neck and head muscles	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>NEUTRAL</b>	 <b>SHEAR</b>	 <b>NEUTRAL</b>	 <b>NEUTRAL</b>
	Shoulder muscles & upper extremity	 <b>TNSN / SHEAR</b>	 <b>TNSN / SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>SHEAR</b>	 <b>TENSION</b>
	Extrinsic load chest wall (ribs)	 <b>CMPRS / SHEAR</b>	 <b>CMPRS / SHEAR</b>	 <b>SHEAR</b>	 N/A	 <b>SHEAR</b>	 <b>COMPRESSION</b>
	Extrinsic load chest wall (sternum)	 <b>SHEAR</b>	 N/A	 <b>SHEAR</b>	 N/A	 <b>SHEAR</b>	 N/A

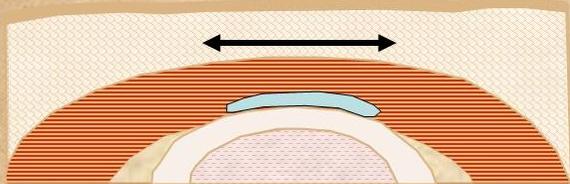
Sternal pseudarthrosis, chronic, closed



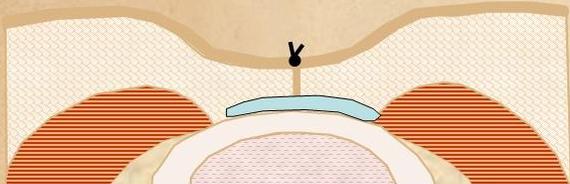
dh - 60m

Sternal pseudarthrosis, subacute, open

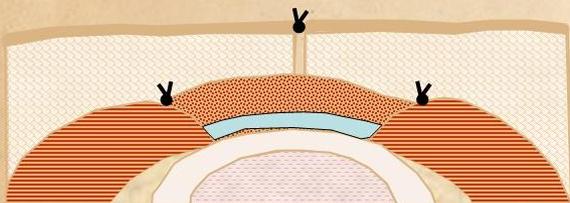




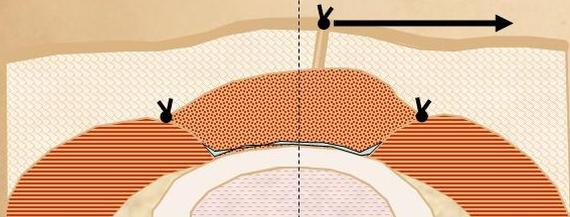
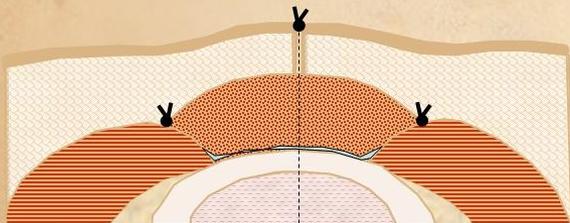
*natural bursa in area of tangential shear*



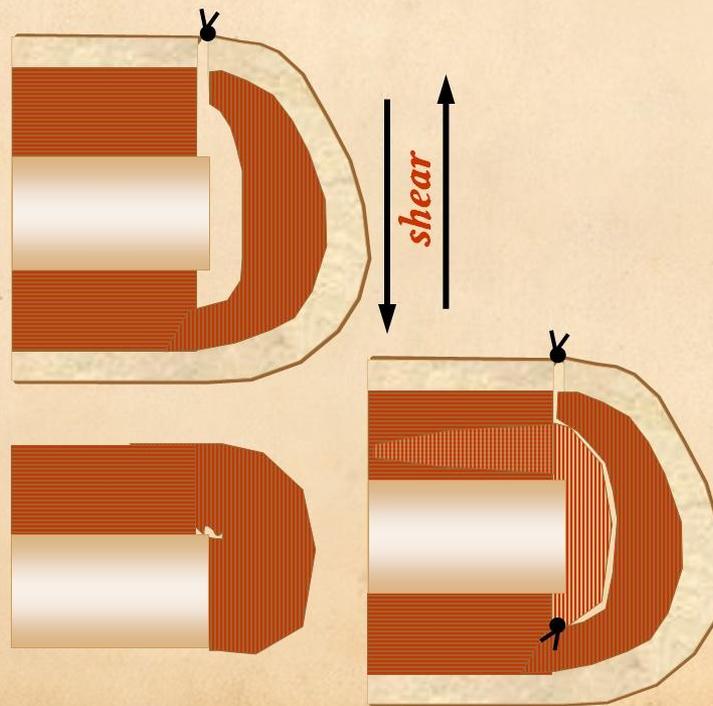
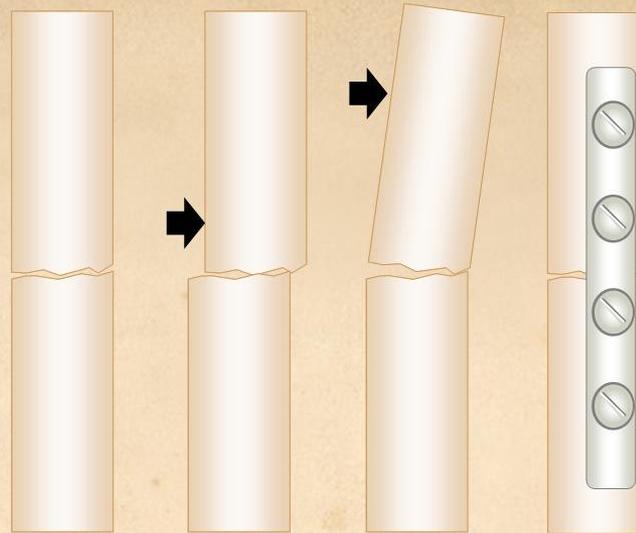
*post-resection bursa prone to seroma and bursitis*



*post-resection thin flaps help but not perfect*



*post-resection bulky flaps absorb all shear strain*



*supplemental drains and splints*

# Common Scenarios – Shear & Tension

**Wound bursitis**  
**Synovial and serosal metaplasia**  
**Rupture-dehiscence from tension**  
**= Failed wound and repair**

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<b>SITUATION</b>	<b>SOLUTION</b>
<b>Empyema</b>	<b>Drains, pleurodesis, thoracoplasty</b>
<b>Pilonidal</b>	<b>Infold flaps, regenerative matrices</b>
<b>Coccygectomy</b>	<b>Do not resect tip of coccyx</b>
<b>Sternal non-union</b>	<b>ORIF</b>
<b>Any non-union pseudarthrosis</b>	<b>Splints, ORIF</b>
<b>Pectoralis &amp; latissimus donor sites</b>	<b>Drains, shoulder immobilizer</b>
<b>Open olecranon bursa</b>	<b>Z-plasties, Splints</b>
<b>Flaps across joints</b>	<b>Proper flaps, splints</b>
<b>Flaps across ischium and hip</b>	<b>Drains, splints</b>
<b>Flaps over sacrum</b>	<b>Drains, mattress sutures, bulky flaps, sand bed</b>

## WOUND MECHANICS AND GEOMETRY

### MISCELLANEOUS PRINCIPLES

Natural joints and tendons are engineered for motion. Bursas or surgery, trauma, and disease are not and are prone to inflammation and rupture.

Bone and joint principles of rigid tissues apply to soft tissues equally – they are all mesenchyme, with the same natural rules.

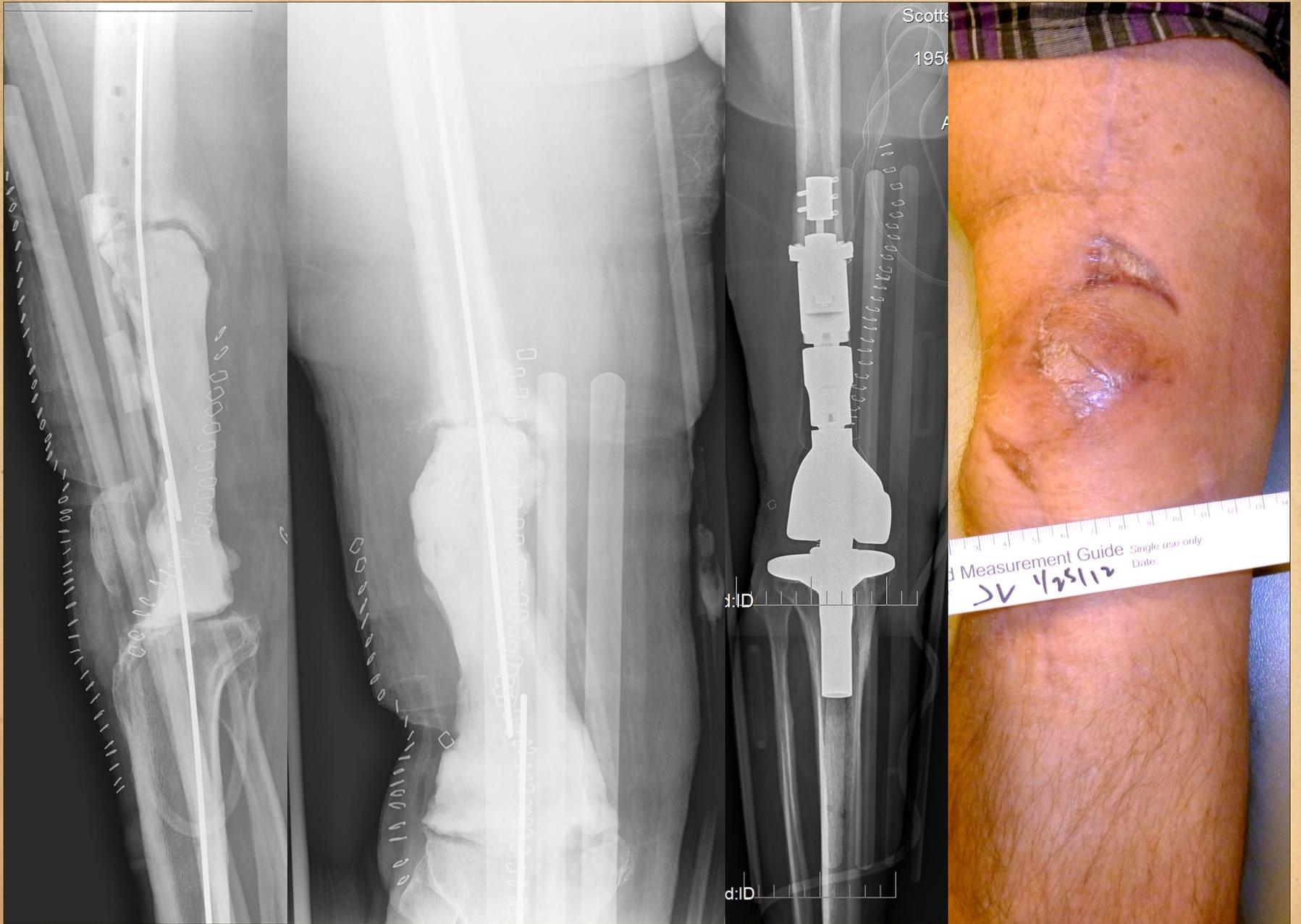
Control abnormal motion by splints, hardware, or whatever means apply to each situation.

Wounds heal by contraction, but rigid surfaces cannot contract – engineer the repair accordingly.

Accommodate shear internally by minimizing surface area for volume, or maximizing volume for area.

Avoid discongruency of wound surfaces. Keep surface and volume congruent.

Bandaging, compression, splints, “cylinderization”.



56 M, TKA after trauma

## WOUND MECHANICS AND GEOMETRY

### MISCELLANEOUS PRINCIPLES - MORE

Tension & bending = bad. • Shear = bad.  
Accommodate accordingly.  
Compression = good.

Attention to net mechanics and geometry.  
Avoid shear and internal deformation.

Put shear into soft tissues, and  
take it away from rigid objects.

Maximize contact area of repair.  
Avoid stress concentration.

Avoid the asymmetric wound  
Avoid the high modulus wound.

Proper reduction & coaptation.  
Always fill dead space.

Keep wounds open when required  
due to inflammation and disease.

• BUT ALSO •

Keep wounds open when required  
to promote good fixation and stability.

Splints, orthotics, fixation.  
Rest and offloading.

## IMPORTANCE OF MOTION CONTROL

Abnormal unconstrained motion  
causes wound bursitis, serosal  
& synovial metaplasia, and  
a failed wound.

**Tension and shear are  
the main adversaries.**

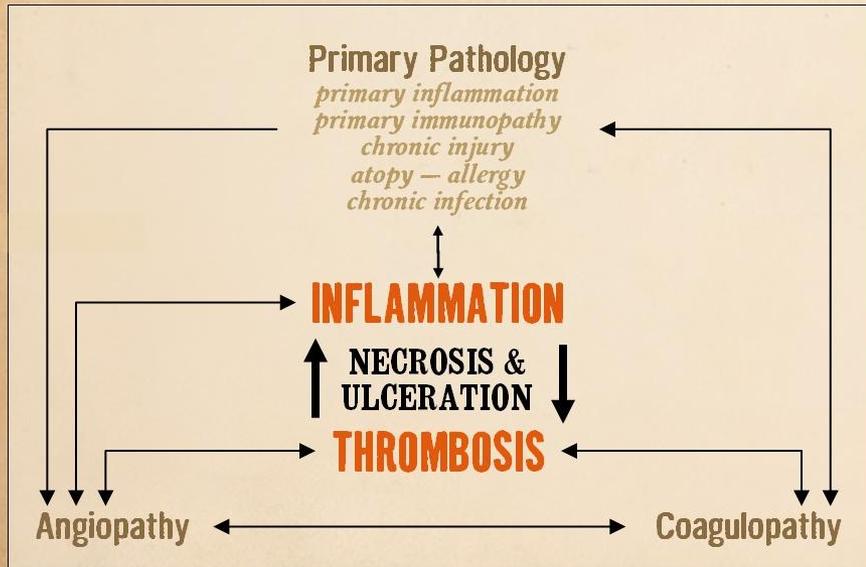
### Methods of Motion Control

proper reduction and coaptation  
proper principles of flaps

splints, casts, orthotics  
pins and temporary fixation  
external fixation  
internal fixation

compression bandaging  
dressings

offloading  
specialty beds  
rest and restricted activities



**INFLAMMATION IS**

more than just a sign to slow down and observe the Alpha Principle,

it is more than just a marker of adverse conditions indicating injury and disease,

it is its own adversity that must be managed,

in part passively by control of disease and avoidance of injury,

and in part actively by suppression of inflammation.

**E-DS-M-I**

**EDEMA**

**DEAD SPACE**

**MOTION**

**INFLAMMATION**

71 M, rheumatoid, Rx = prednisone

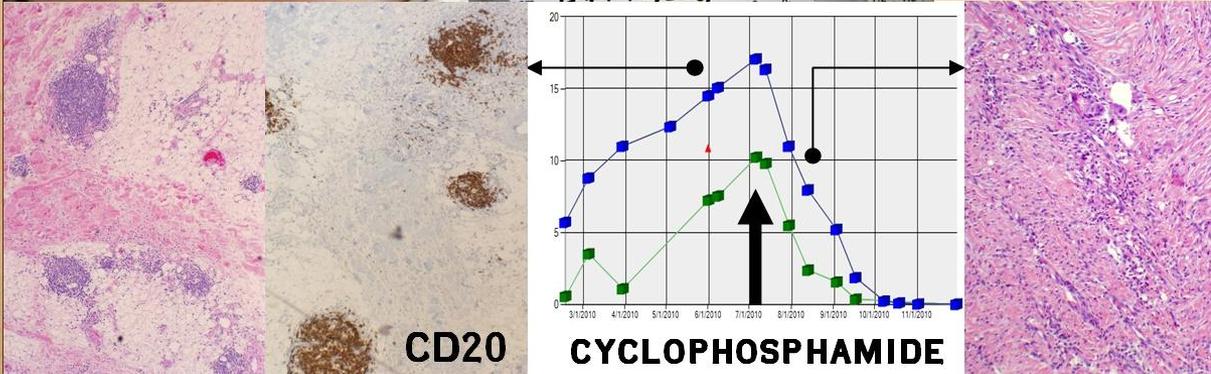
24 F, hypercoagulable, and lupus or mctd variant, Rx = cyclophosphamide



35 M, bullous pemphigoid, wound autoimmunity, Rx = azathioprine



44 F, lupus or polymyositis variant, Rx = cyclophosphamide



## PARAMOUNT IMPORTANCE OF INFLAMMATION CONTROL

Inflammation is the arbiter of adverse events that inhibit wound stability & healing.

Inflamed wounds will not heal, so control is mandatory.

### Methods of Inflammation Control

Alpha Principle  
not too much too soon too often

wound hygiene  
topicals  
debridement & bioburden

avoid further injury  
control primary disease

control edema  
control dead space  
control abnormal motion

steroids  
other anti-inflammatories  
anti-immune therapies

anticoagulation

# WHEN NOT TO OPERATE



## Failed Wounds & Failed Surgery due to Repeated Trauma and Imprudent Care

*Respect the biology of  
injury, inflammation, and wound healing.*

*Practice the virtues of  
patience, prudence, planning, proper care.*

*Do not close, repair, reconstruct  
until circumstances are correct.*

*Care properly for open wounds  
as you wait for control of the disease.*

*When repair goes wrong,  
open and debride promptly, and start over.*



# HOW TO FAVOR GOOD REPAIR

## Bβ

### Four Enemies of Repair

**Edema**  
**Motion**  
**Dead Space**  
**Inflammation**

*Edema and inflammation reflect state of the wound, but also must be actively managed.*

*Motion and dead space can undo any good operation. They must be mitigated or eliminated.*

*These principles apply to each and every operation for surgery of repair and reconstruction.*

*They must be innate and practiced intuitively when tissues and structures are being reassembled.*

*There is no case too small to apply these principles, no case too big to be overwhelmed by them.*



ספר חנוכה

