Surgical Considerations in Lower Extremity Amputation

Kyle M Schweser, MD

Associate Professor
University of Missouri

Disclosures

- Consultant
  - ODI
  - Synthes
  - KCI

Objectives

- Understand the indications for lower extremity amputation
- Understand the principles and goals of lower extremity amputation
- Review specific levels of amputation and important considerations for each

Indications

- Traumatic
- Infection
- Peripheral Vascular Disease
- Neurological
- Burns/soft tissue defect
- Congenital deformity
- Tumors

Trauma

- 130,000 new amputation/year
  - 15% are trauma related
  - Young males

- 16 million people with an amputation
  - 45% trauma

Trauma

- Acute trauma
- Chronic trauma

Trauma

- Acute trauma
- Chronic trauma

How Do We Make Our Decisions?

- Plantar sensation?
- Injury severity?
- Cost?
- Outcomes?
- Gut feeling?

Trauma

- LEAP
  - 569 patients
  - Prospective study
  - Amp vs limb salvage
  - 2 and 7 year data
  - Male (77%), white (72%)
  - Uneducated, poor, no insurance, heavy drinkers

LEAP

- Absent plantar sensation
  - Does not mean amputation
  - Over 50% of salvages regained sensation by 2 years
  - Salvage had similar rates of sensation at 2 years
    - Regardless of presentation

LEAP

- Mangled Extremity Severity Score
  - Historically >8=amputate
- Scoring systems NOT predictive of successful limb salvage

LEAP

- Amputations more cost effective
  - 2 year cost
    - Salvage $81,316
    - Amputation $91,106
  - Lifetime projection
    - Salvage $163,282
    - Amputation $509,275

LEAP

- People do better with an amputation
  - No difference in the Sickness Impact Profile
  - At both 2 and 7 years

LEAP

- Salvage does have higher
  - Depression
  - Anxiety
  - PTSD
  - Rates of complications

How Do We Make Our Decisions?

- Overall clinical picture
- Patient social situation
- Patient desired outcomes/expectations

Indications

- Infection
  - Diabetes
- Peripheral Vascular Disease
  - Diabetes (71%)
  - 80% of lower extremity amputations
- Neurological
  - Neuropathy (diabetes)
  - Contractures

Indications

- Burns/soft tissue defects
- Congenital deformities
- Tumors
  - Goal=Clear margins

Goals

- Initial
  - Debride to healthy tissue
  - Preserve soft tissue
  - Preserve length
  - Balance muscular forces

Goals

- Eventual
  - Early return to function
  - Painless residual limb
  - Prevention of contractures
  - Mobility vs stability

Goal

- Do it right the first time

Goals

- Debride to healthy tissue
  - Easiest part
  - May require multiple surgeries

Goals

- Preserve Soft tissue
  - Viable tissue
  - Atypical flaps

Goals

- Preserve length
  - Dependent on level
  - Important for function
  - Important for prosthetics

Goals

- Consider length
  - Dependent on level
  - Important for function
  - Important for prosthetics

Goals

- Balance muscle forces
  - Prevent unopposed forces
    - Issues with prosthetics
    - Ulcers
    - Pain

General Amputation Principles

- Skin
- Muscle
- Nerves
- Blood Vessels
- Bone

Skin

- Painless, pliable, nonadherent scar

- Scar placement and prosthetic wear
  - Viable level
- Coverage:
  - Flap coverage
  - Skin graft

Muscle

- Myofascial closure
  - Minimal muscle stabilization
- Myoplasty
  - Opposing muscle groups
- Myodesis
  - Attached to bone
- Tenodesis
  - Tendon attached to bone

Nerves

- Avoiding painful neuromas
  - Separate from vessels
    - Pain generator
  - Traction on nerve and sharply transect
    - Retracts to safety
  - Nerve preparation
    - Ligation
    - Injection
    - Transfer

Blood Vessels

- Suture ligate major vessels

- Full-thickness skin flaps
  - Minimize wound necrosis

- Hemostasis prior to closure
  - Drains

Bone

- Minimize sharp edges
  - Beveling/filing
- Narrow metaphyseal flare/condyles
- Cap intramedullary canal
  - Minimize bleeding
- Minimize periosteal stripping
  - Exostosis

Level of Amputation

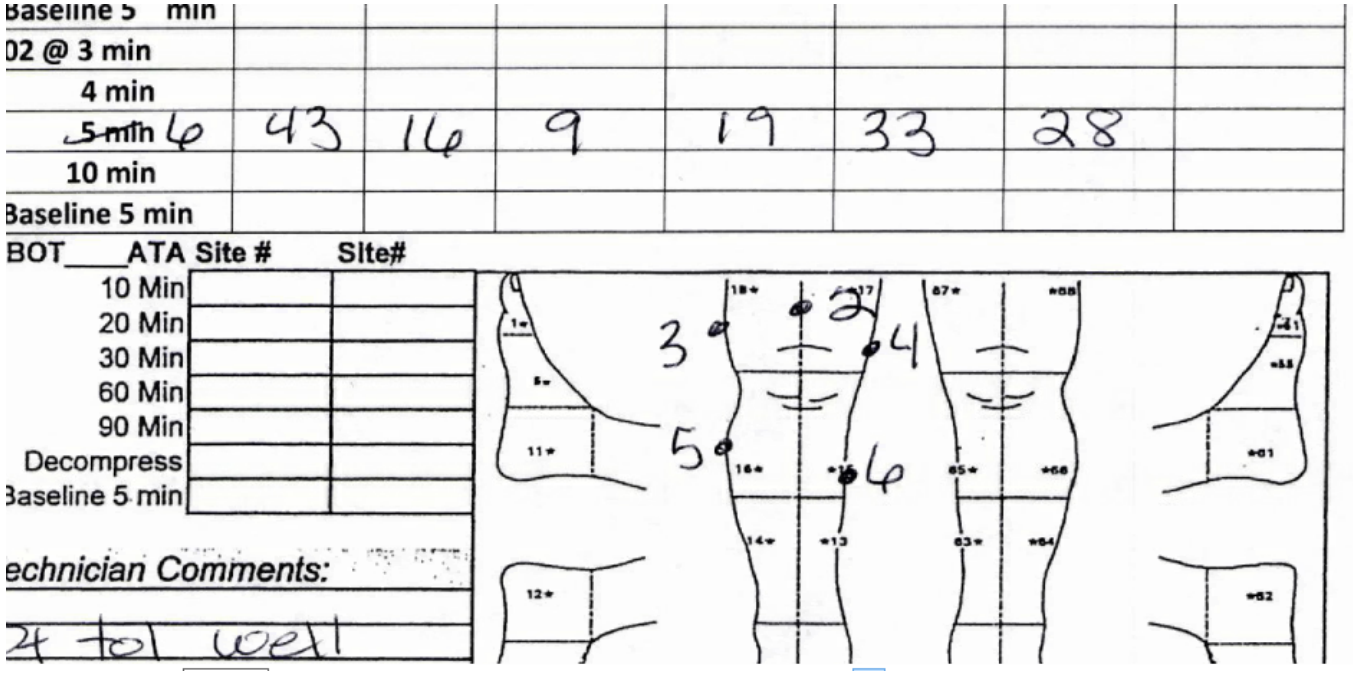
- Factors
  - Soft tissue
  - Blood flow
  - Functional requirements

Level of Amputation

- Soft tissue
  - Trauma
  - Infection
  - Previous surgeries

Level of Amputation

- Blood flow
  - Traumatic
  - Vascular disease



Baseline 5 min							
02 @ 3 min							
4 min							
~~5 min~~ 6	43	16	9	19	33	28	
10 min							
Baseline 5 min							

BOT___ATA Site # Site#

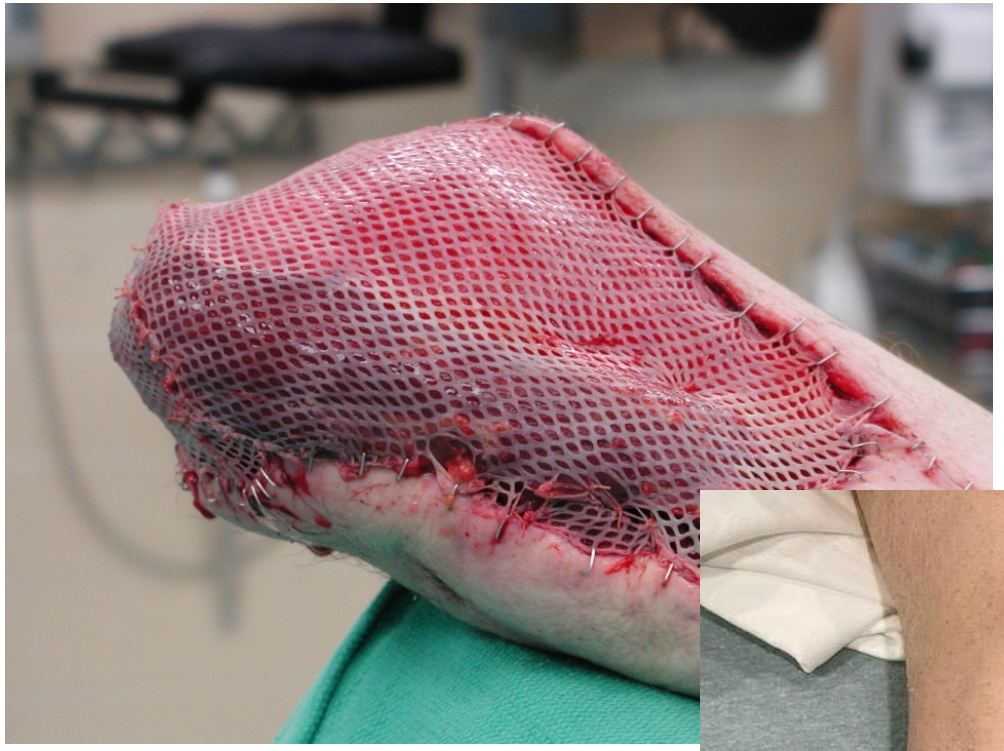
10 Min		
20 Min		
30 Min		
60 Min		
90 Min		
Decompress		
Baseline 5 min		

Technician Comments:

24 tol well

Level of Amputation

- Functional requirements
  - Young, healthy
    - Preserve length
    - Be aggressive
      - Flaps
      - Skin grafts
  - Sick, low demand
    - Consider prosthetic odds
    - Preserve length for sitting
    - Goal is one surgery
  - Bilateral
    - Consider atypical amps



Level of Amputation

- Metabolic Demand
  - Proximal = increased demand
  - Exception—Syme
- Must evaluate the patient
  - Diabetic with bilateral BKA won’t do well

Metabolic Demand

- Syme - 15%
- Transtibial
  - Traumatic - 25% average
  - Vascular - 40%

Metabolic Demand

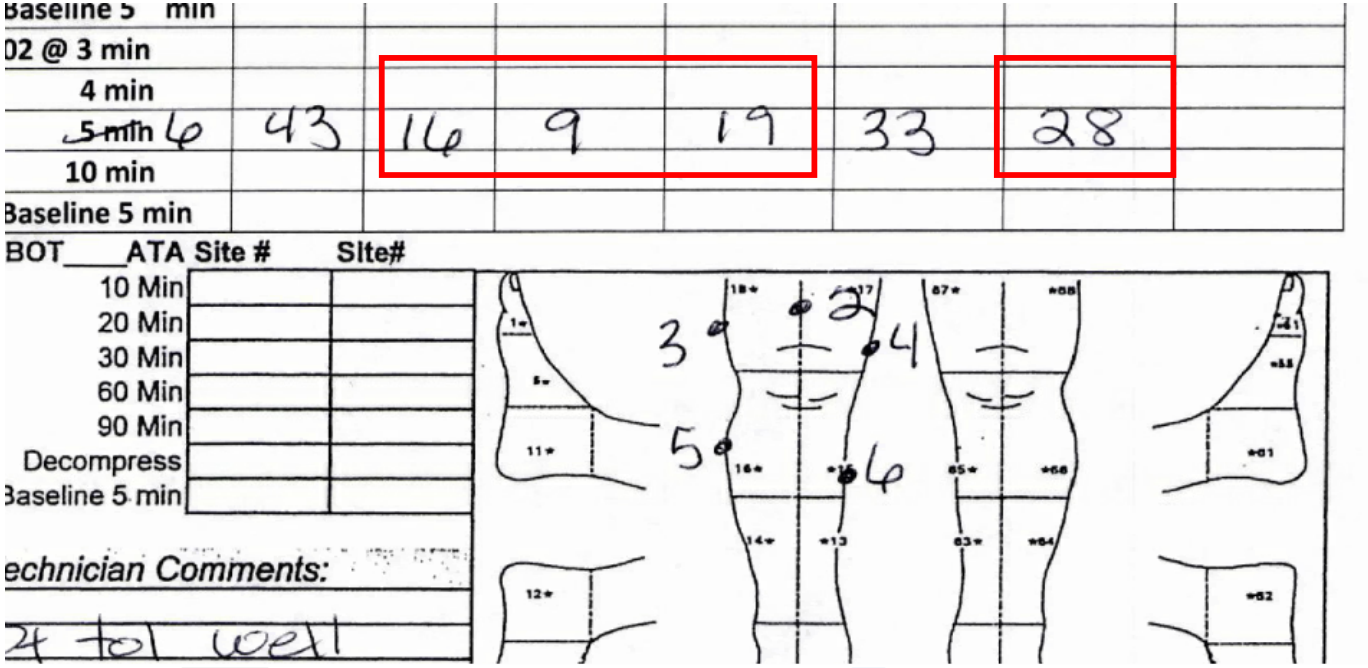
- Transfemoral
  - Traumatic - 68%
  - Vascular - 100%
- Thru-knee amputation
  - Varies based on patient habitus
  - Between transtibial and transfemoral

Metabolic Demand

- Bilateral amputations
  - BKA + BKA - 40%
  - AKA + BKA - 118%
  - AKA + AKA - >200%

Preoperative Evaluation

- Nutrition labs
  - Albumin > 3 g/dL
  - Total lymphocyte > 1500/mm3
- Transcutaneous Oxygen
  - > 30 (45 ideal)
- Toe pressure
  - > 40 (< 20 absolute contraindication)
- ABI
  - > 0.45



Levels of Amputation

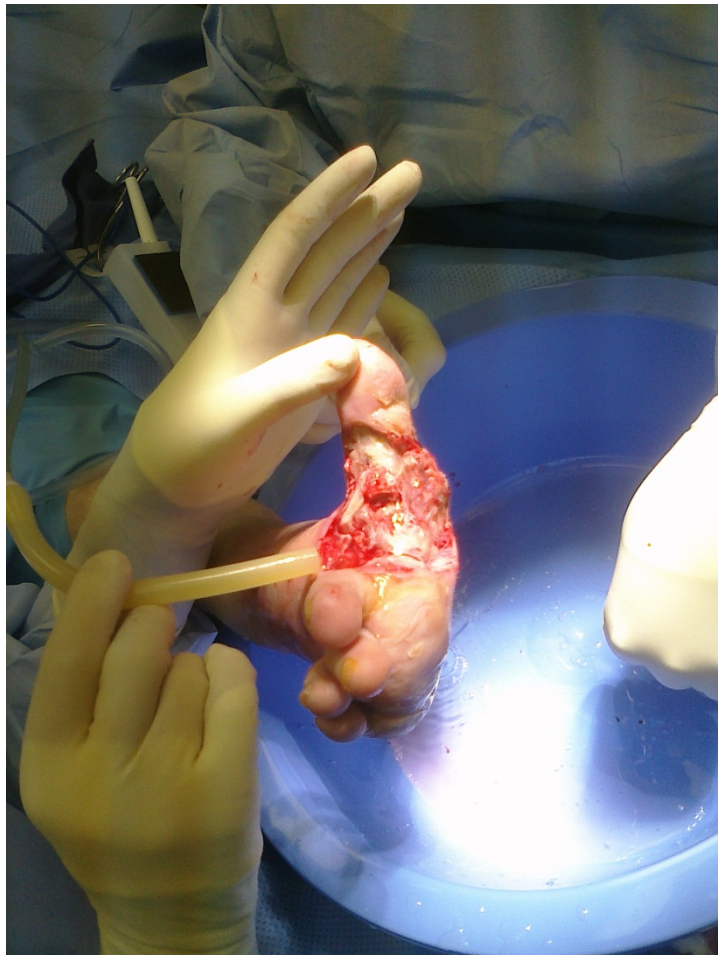
- Toe
- Ray resection
- Partial forefoot
- Transmetatarsal
- Symes
- Modified Symes
- BKA
- Through knee
- AKA
- Hip Disarticulation
- Hemipelvectomy

Toe

- Interphalangeal
  - Leave cartilage
  - Trim condyles
- Transect tendons and nerves
  - Do not sew tendons together
- Great toe
  - Leave 1cm
  - Foot balance and function

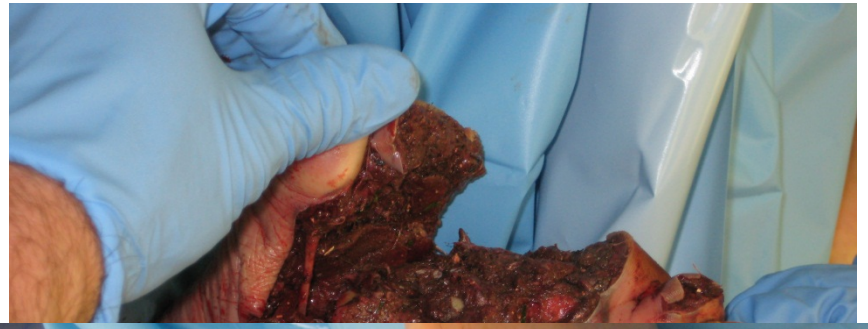
Ray Resection and Partial Foot

- Includes toe and part of metatarsal
- Preserve 1st MT length
  - Orthosis
  - Foot balance
- Avoid sharp bony prominences
- Multiple lateral rays



Transmetatarsal

- Considered
  - 2 or more medial rays
  - More than one central ray
- Preserve length
- Maintain arch and metatarsal cascade
- Avoid Achilles contracture
  - Achilles lengthening



Transmetatarsal

A

B

C

D

E

Ng et al. JAAOS 2010

Negatives for Transmetatarsal

- Foot balance
- Prosthetic fit
- Wound healing
  - 33% primary wound closure
  - 56% may require revision to higher level

Diabetics and Foot Amps

- 75% get revised by 9 months
  - 87% revised to BKA

Symes

- Ankle disarticulation

- Required
  - Viable heel pad

- Modifications
  - Malleoli excision
  - Incision

Symes

Benefits

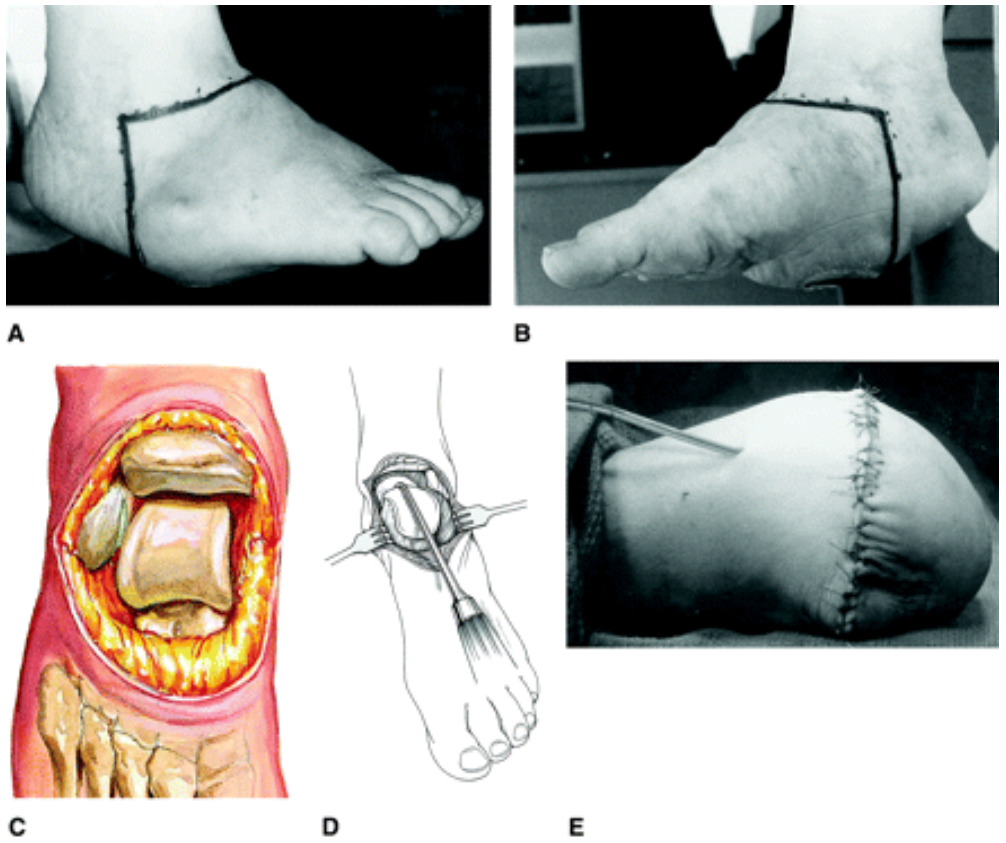
- Longer limb/less energy
- High level walkers
- End bearing for obese patients
- Ambulate without prosthesis
- Less metabolic demand than midfoot

Negatives

- Wound healing
- Heel pad instability
  - Major issue
- Can’t really walk barefoot

Symes

- Must preserve posterior tibial arterial supply



Ng et al. JAAOS 2010

Other Foot Amps

- Pirogoff
  - Remove all but calcaneus
  - Fuse calcaneus to tibia
  - No need for prosthesis
- Chopart
  - Leaves talus and calcaneus
  - Requires tendon transfers
  - Requires achilles lengthening
  - Poor prosthetic options
- Lisfranc
  - Leaves all tarsal bones
  - Preserve base of 5th
  - Requires tendon transfer
  - Same metabolic demand of BKA

Below Knee Amputation

- Most common
- Longer is better
  - Soft tissue
  - 8-12 cm from ground for most high-impact prosthetics
- Minimum to utilize BKA prosthesis
  - 2.5 cm per 30cm pt height
  - 5cm distal to the tubercle

Below Knee Amputation: Techniques

- Long posterior myocutaneous flap
- Modify skin flaps based upon available skin
- ID neurovascular structures
- Isolate fibula and transect 1.5cm above tibia

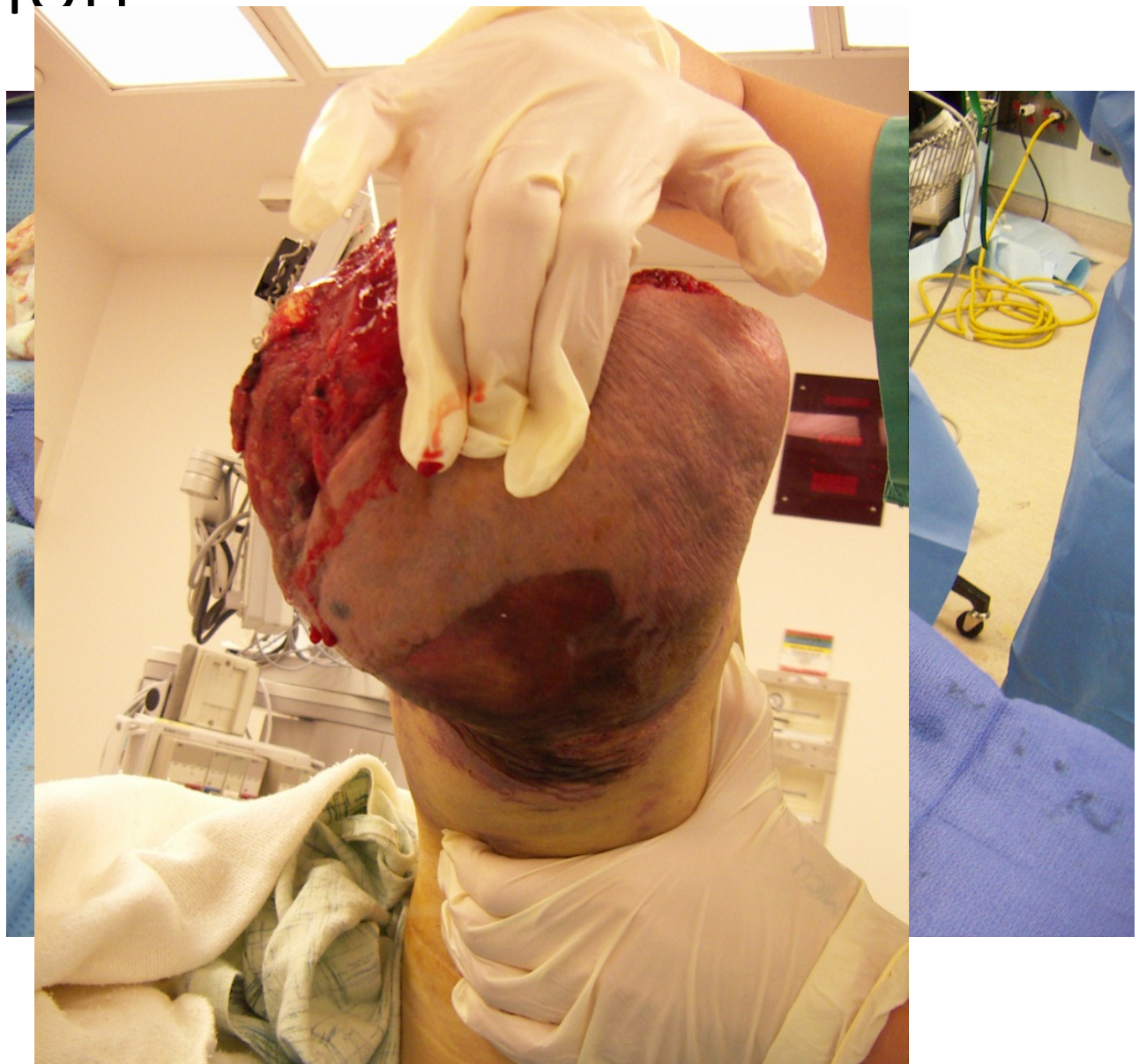
Below Knee Amputation: Techniques

- Tibial cut
- Bevel bone cuts
- Ligate vessels and transect nerves
- Myodesis vs. myoplasty

Below Knee Amputation

Staged

- Traumatic or infection
- Guillotine
  - Allows soft tissues and bone to declare



Ertl Procedure

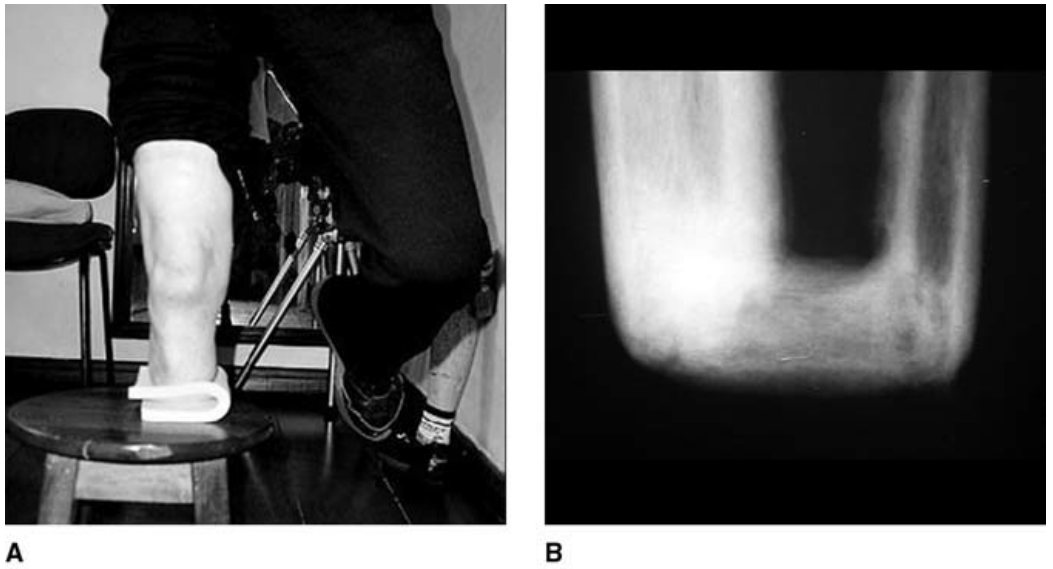
- Tibiofibular synostosis
- Indication
  - Young
  - Proximal tib/fib instability
  - High activity level


L
EEW


L
EEW

Technique

- Fibula cut at same level
- Leave medial periosteal hinge
- Connect to tibia
  - Metal
  - Suture



A B

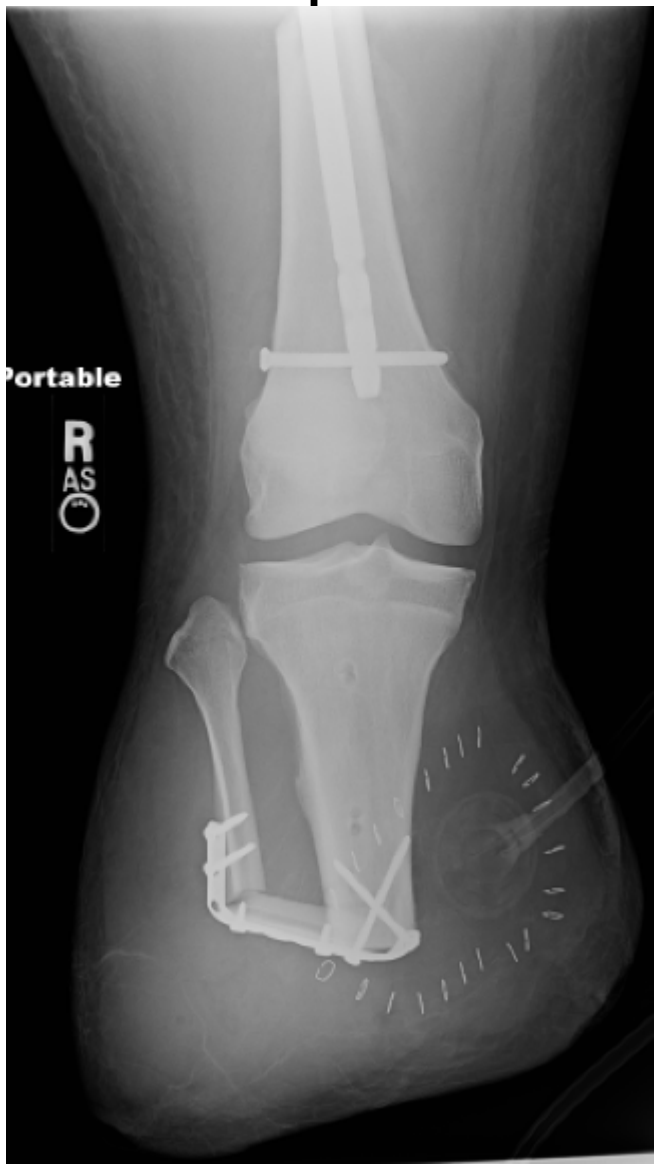
Ng et al. JAAOS 2010

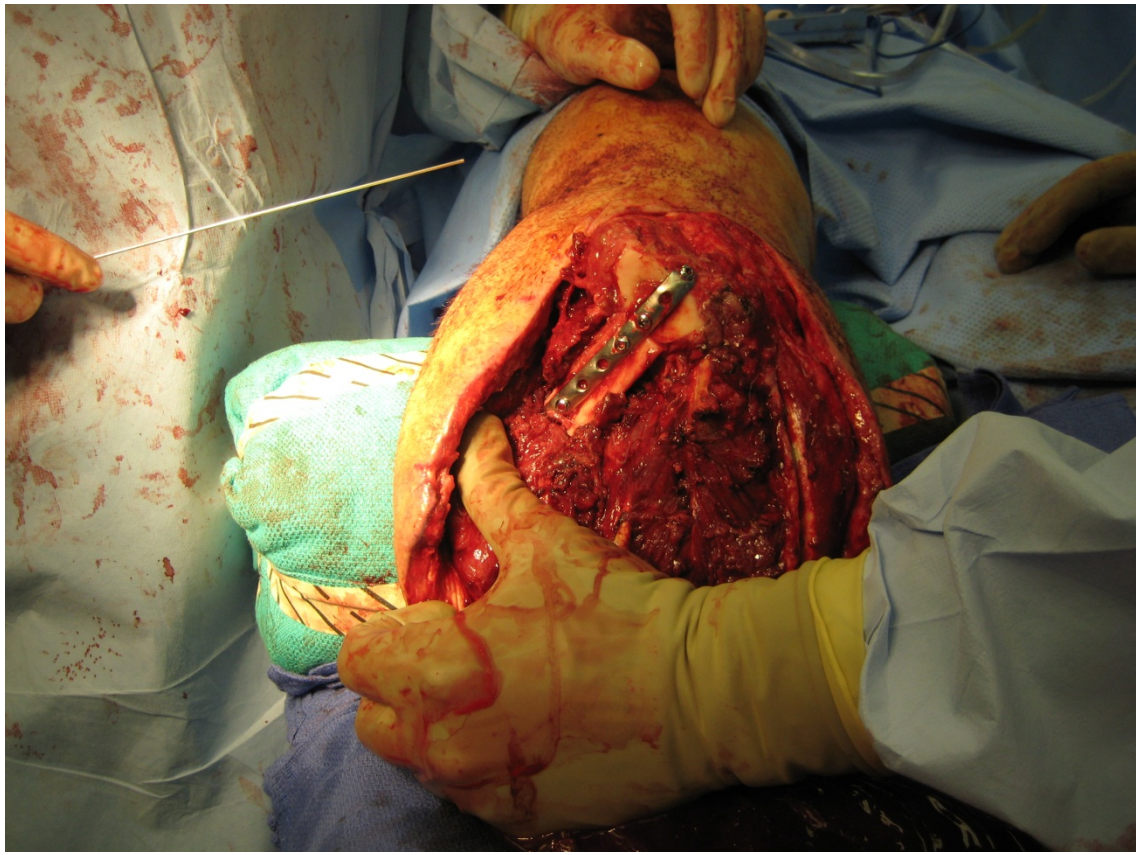
Case Example

- 45y/o s/p MCC
- Police officer
- Right open femur fx
- Right open tib/fib with vascular insufficiency
- Ex-fix
- Multiple debridements
- Progressive necrosis

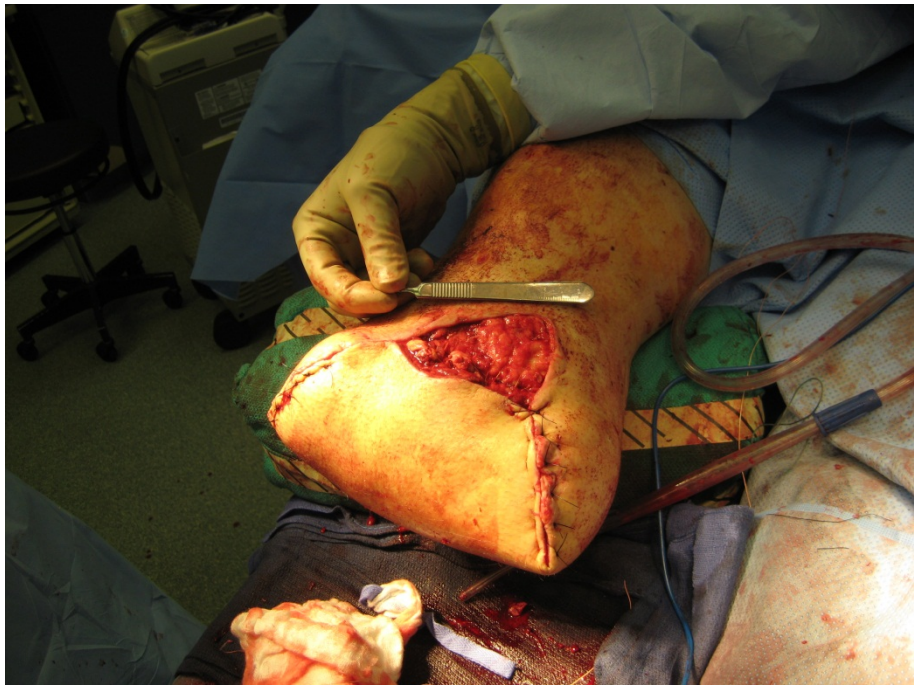
Case Example

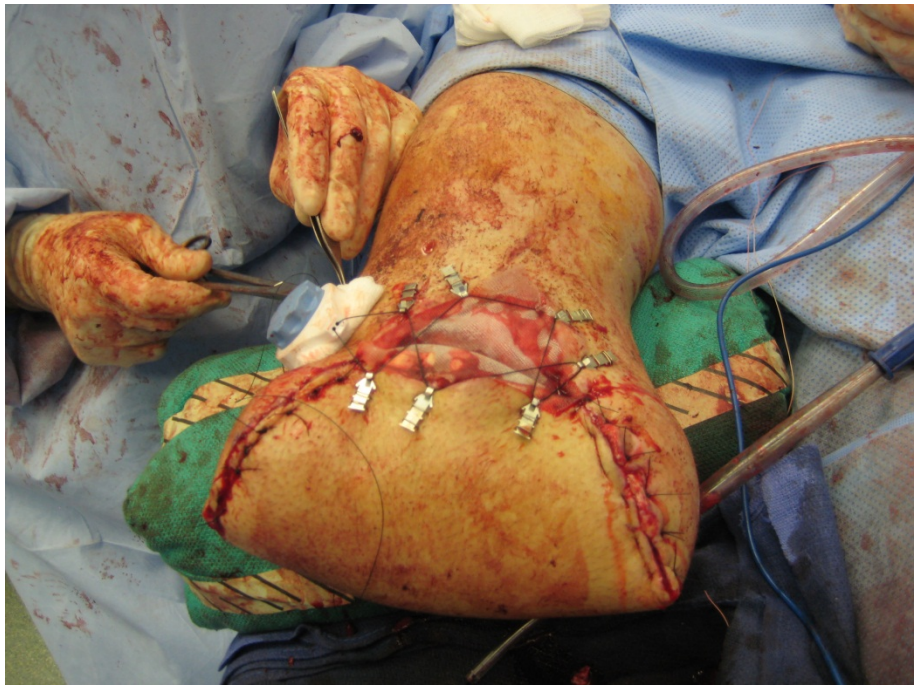
Case Example





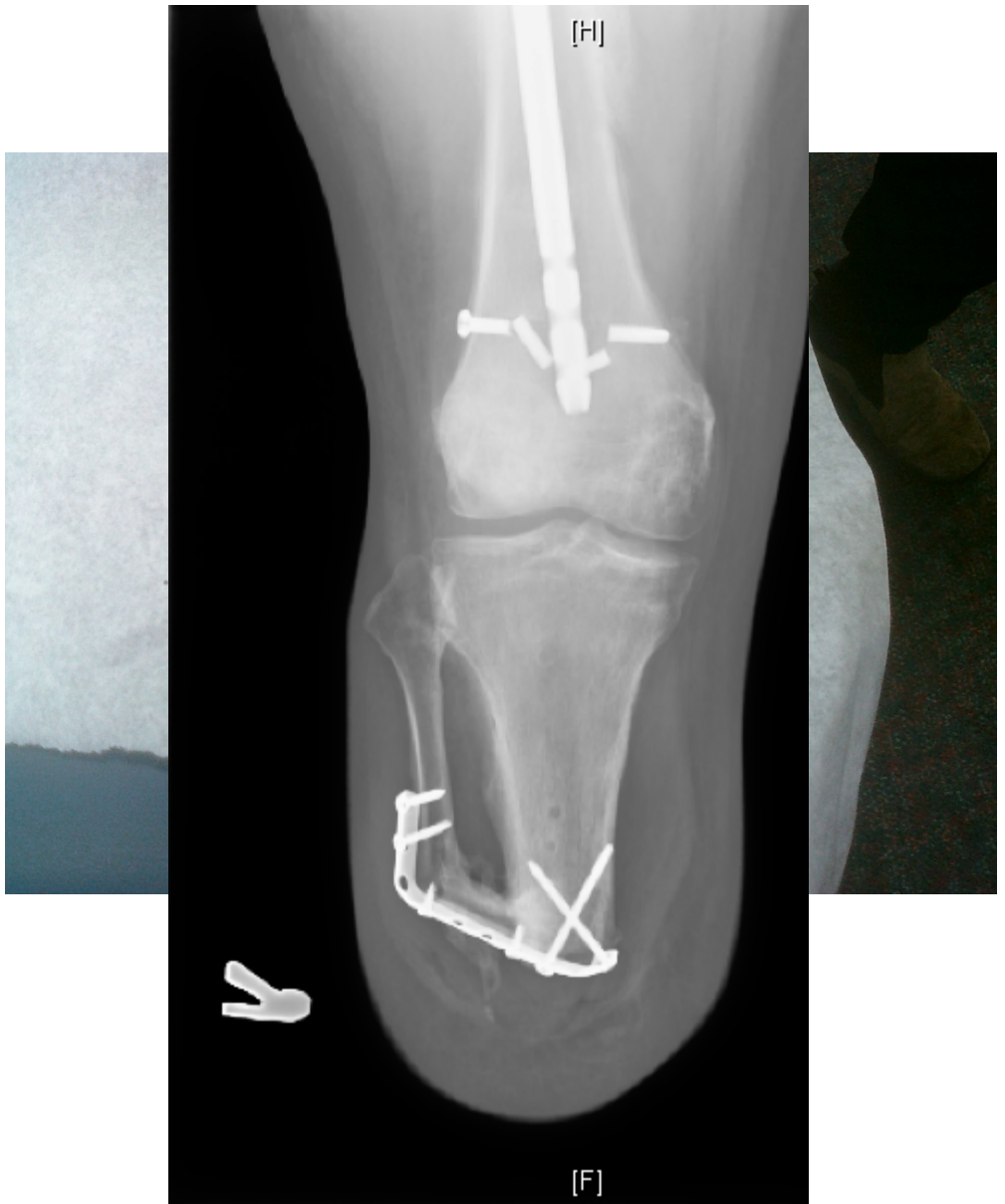
Case Example





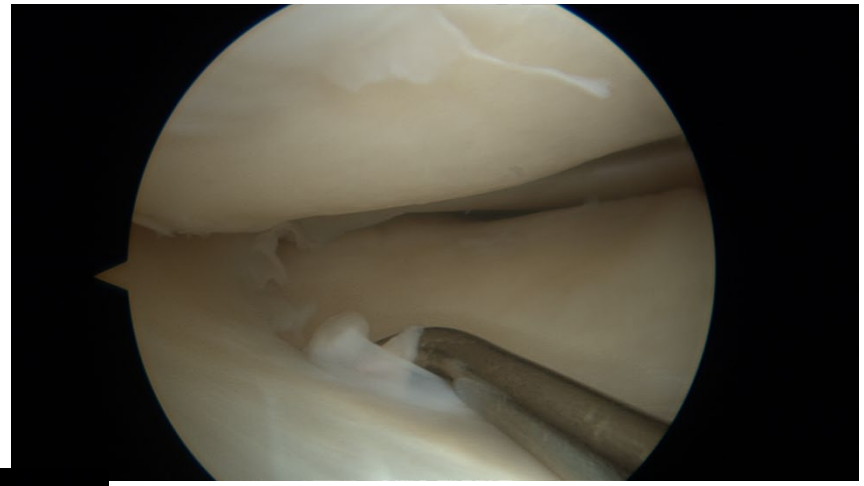
Case Example

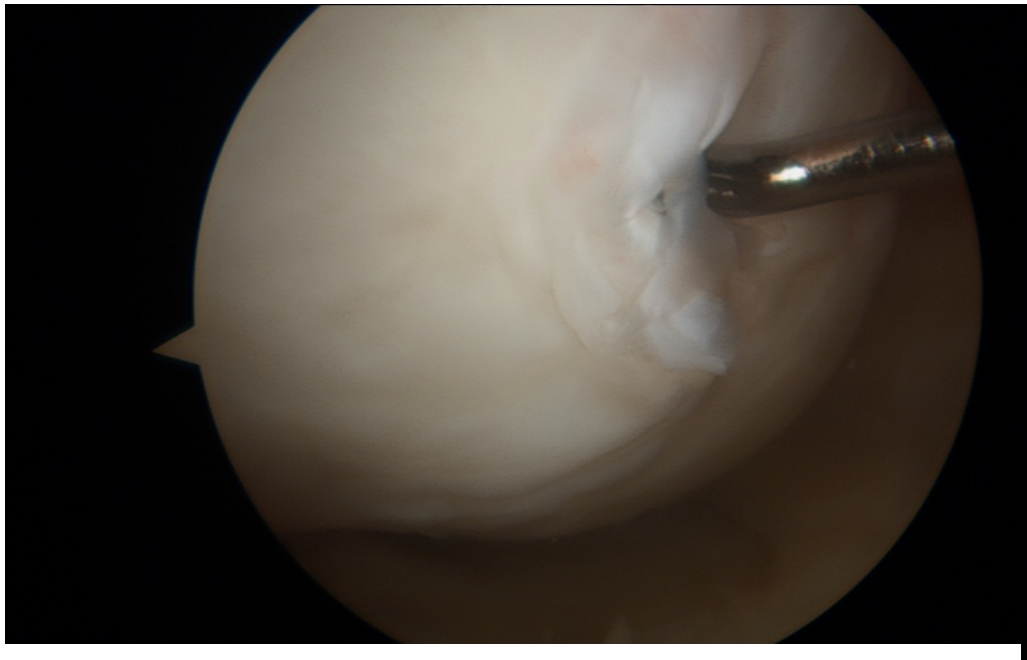
- Femur infected
  - ABX beads
  - IV abx
  - debridements
- 2 STSG
- Suture removal
- 11mo

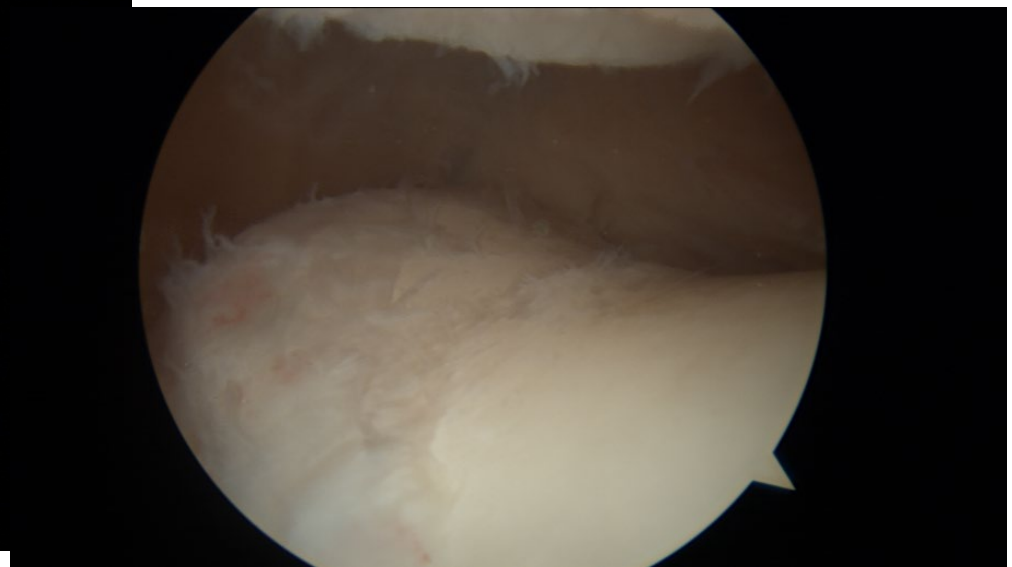


After prosthesis

- c/o knee pain and crepitance







Why not Ertl?

- Outcomes
  - Functional scores = no benefit (Ng et al. JAAOS 2010)
- Increasing risk for:
  - Nonunion
  - Painful hardware
  - Infection

BKA at all costs

- Improved energy expenditure
- Soft tissue reconstruction to maintain length and knee function
  - Skin graft or substitute
  - Muscle flap
- More functional prosthesis

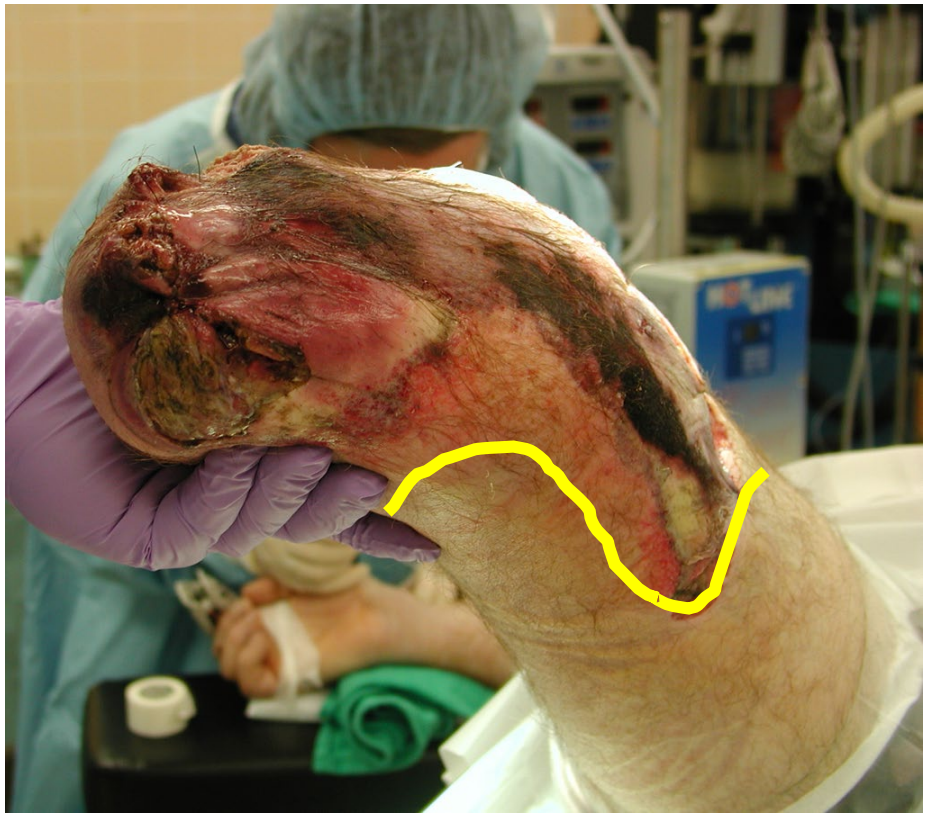
Case Example

- 40y/o male s/p BKA due to mangled lower extremity after go-cart accident

- Within 2 weeks of BKA and DPC
  - Infected
  - Necrotic skin

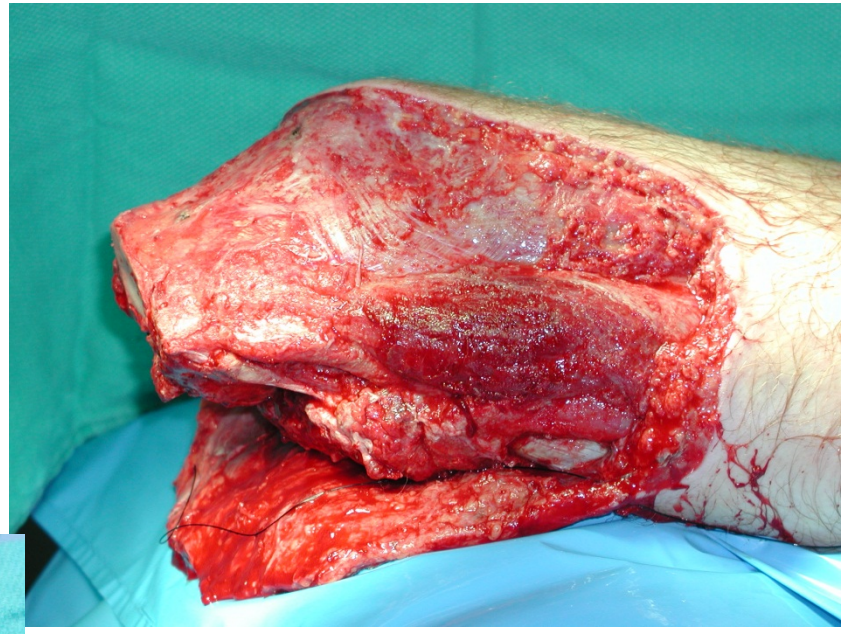
Options

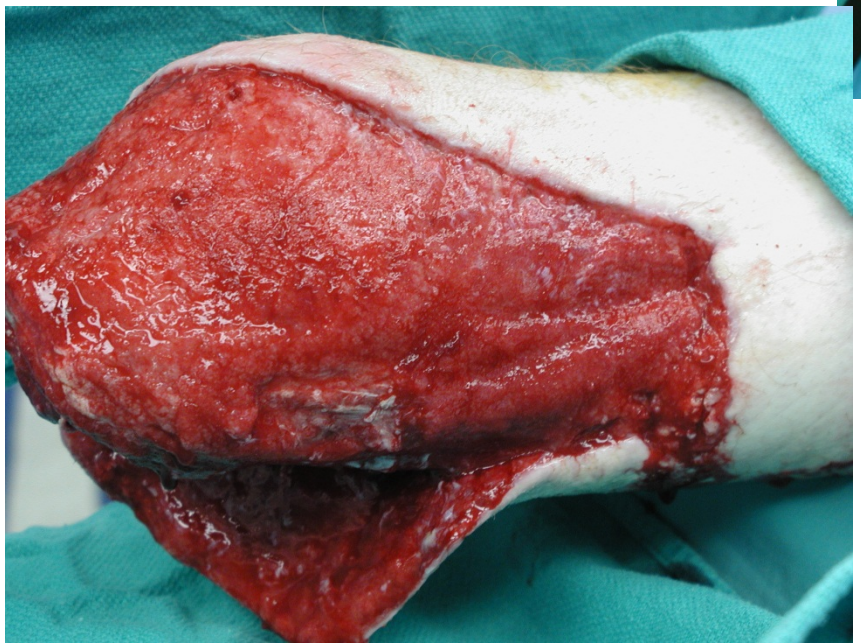
- Revision to AKA
- Reconstruct soft tissue weight-bearing surface



Case Example

- Multiple debridements
- Negative pressure wound therapy (NPWT)

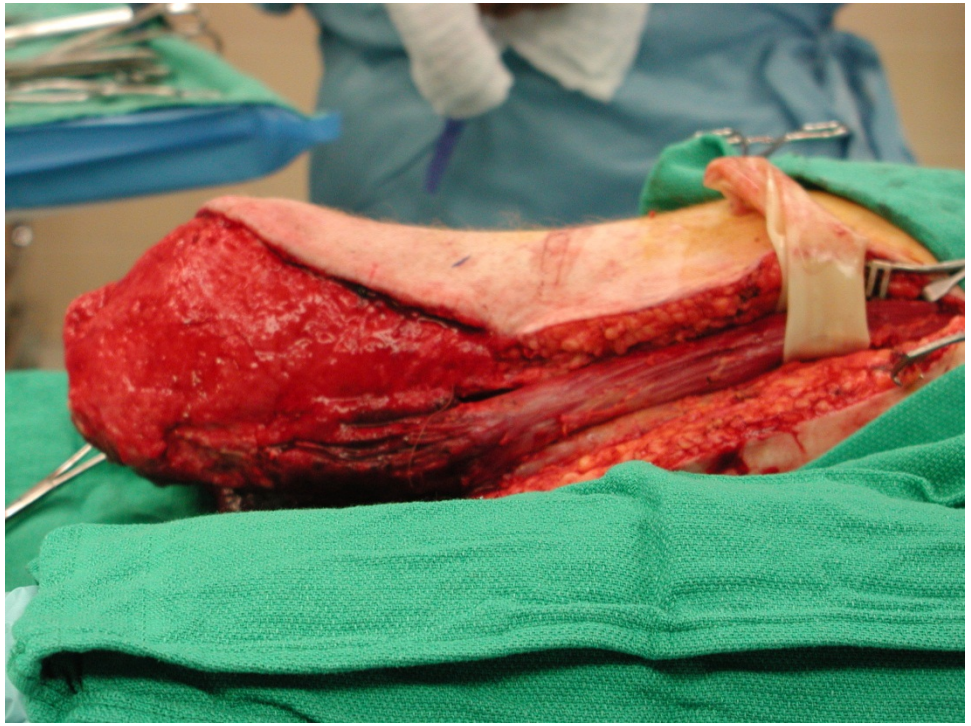




Case Example

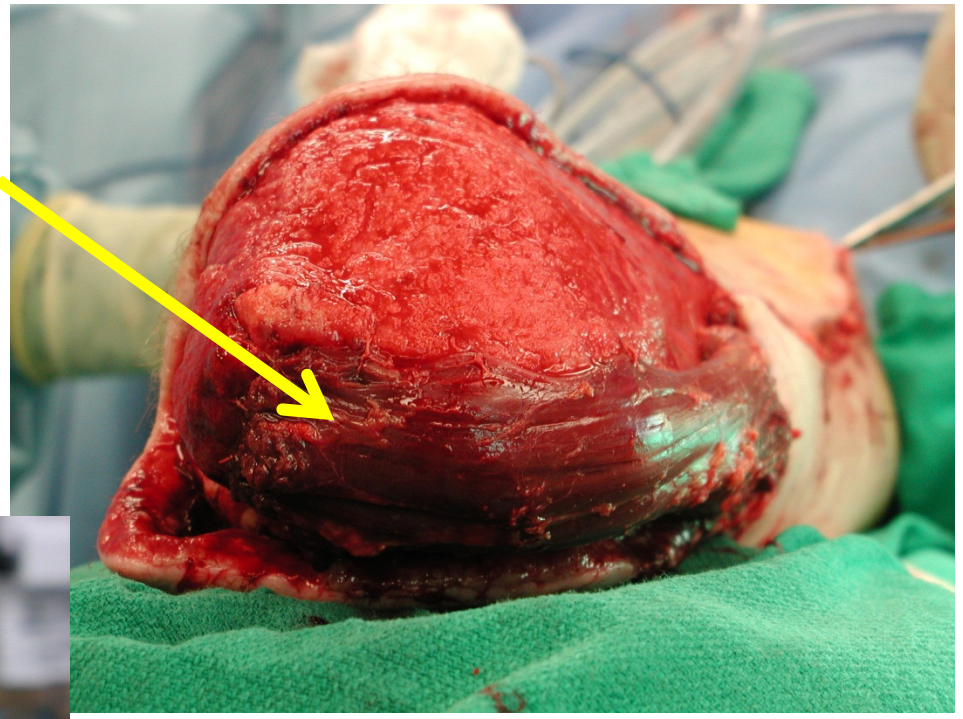
- STSG low probability

- Muscle flap required
  - Gracillis rotation flap



Case Example

- Gracillis covering tibia



- STSG over muscle

Through Knee Amputation/Knee Disarticulation

- Prosthetists
  - Bulbous end
  - Knee axis lower to the ground
  - Self image issues
- End bearing residual limb
- Soft tissue coverage
  - Improved with posterior flap technique

Indications

- Trauma
- Infection
- Dysvascular
- Nonambulatory
  - Risk of knee contractures with BKA
- Unlikely to get into prosthesis with AKA

Through Knee Amputation/Knee Disarticulation

Benefits

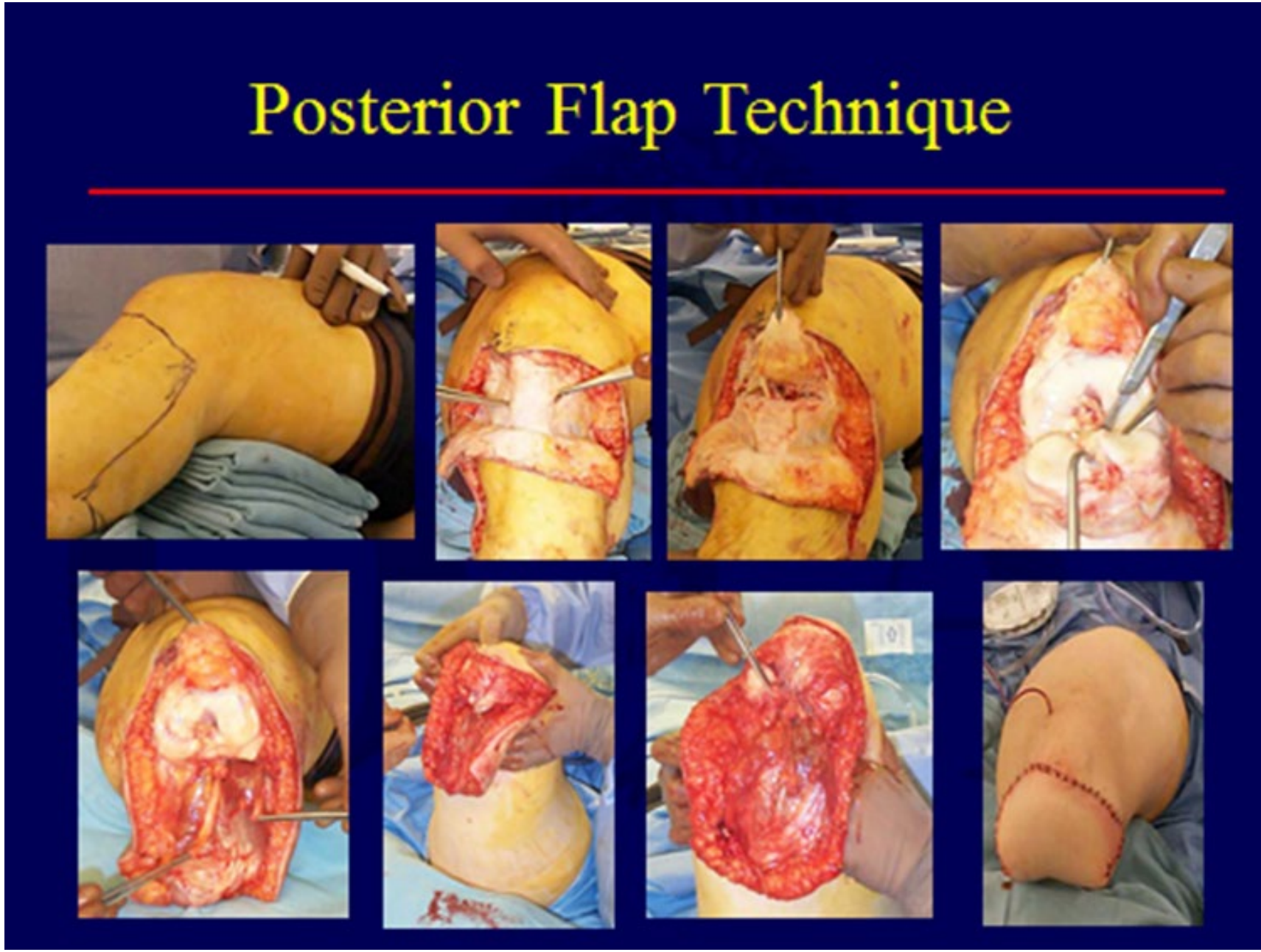
- End bearing surface
- Sitting comfort
- Longer lever arm
- Balanced thigh muscles
- Prosthetic suspension (femoral condyles)

Negatives

- Knee height
- Soft tissue coverage
- Slower walking speeds (BKA)
- Worse performance on SIP (AKA and BKA)

Technique

- Suture patellar tendon to cruciates
- Patella not distal to femur
  - Not a cap



Doug Smith, MD

Through Knee Amputation/Knee Disarticulation

- LEAP study
  - Slowest walking speed
  - Least satisfaction
  - 12/18 no gastroc coverage
  - = poor prosthetic tolerance

Mackenzie et al. JBJS 2004

Above Knee Amputation

- Maintain length
  - 12cm proximal to knee is ideal
- Energy expenditure
  - Increased
- Recurrent infected total knee arthroplasty
  - Alternative = knee fusion

Technique

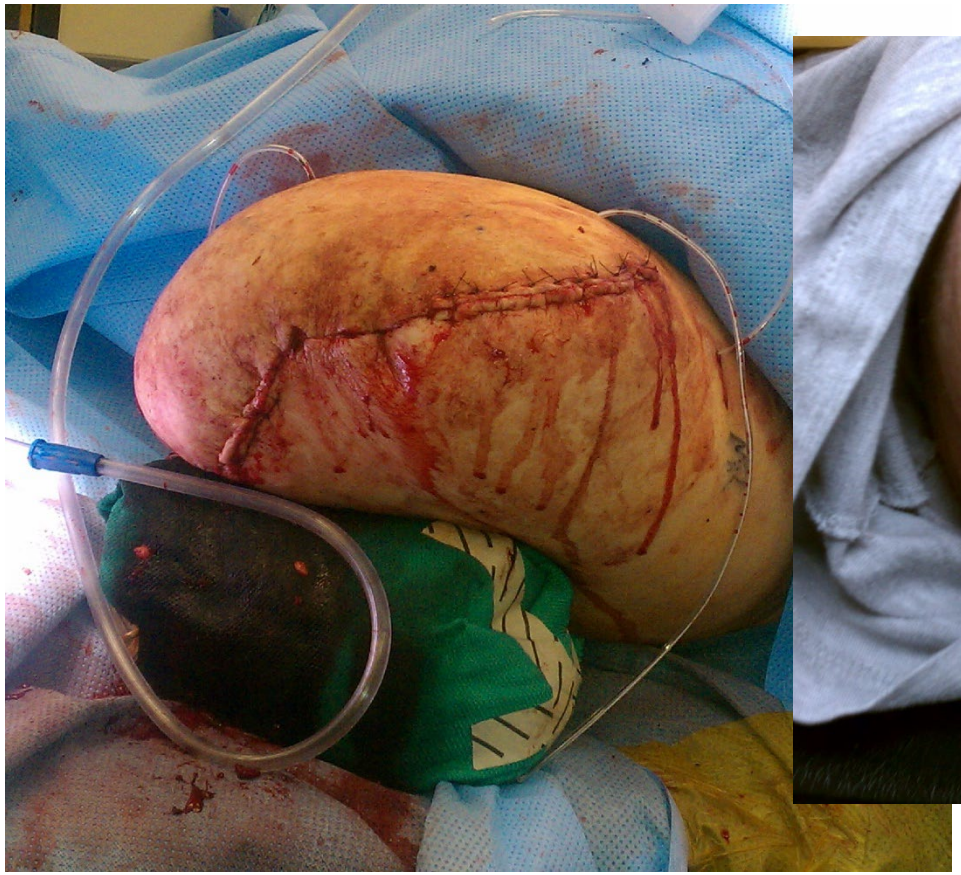
- Fish mouth incision
- Modify to not be end bearing if soft tissues allow

- Myodese adductors

- Myodese quad and hamstrings

- No myodesis = poor function and pain
  - Femur moves within muscular sleeve

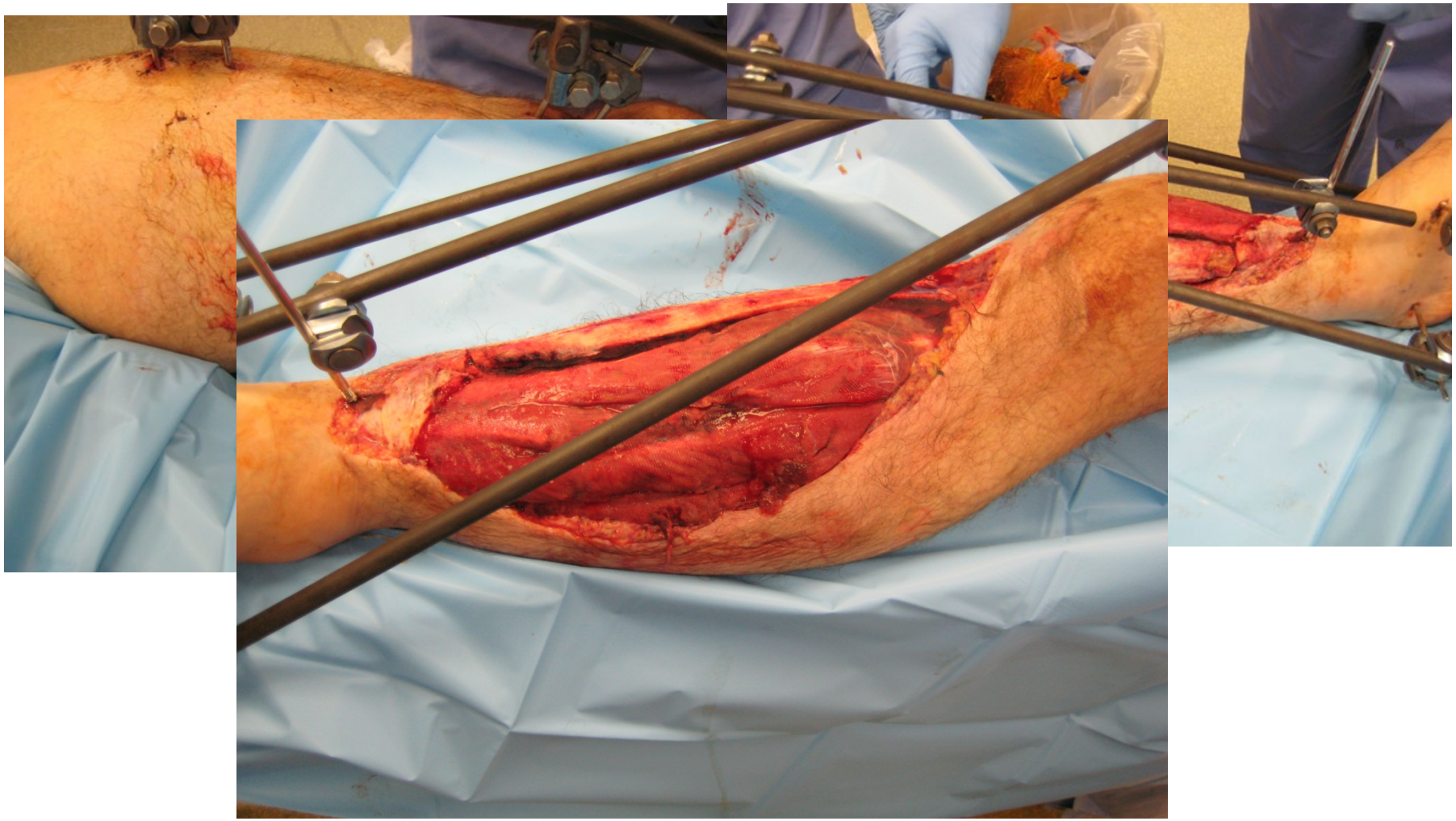
Above Knee Amputation



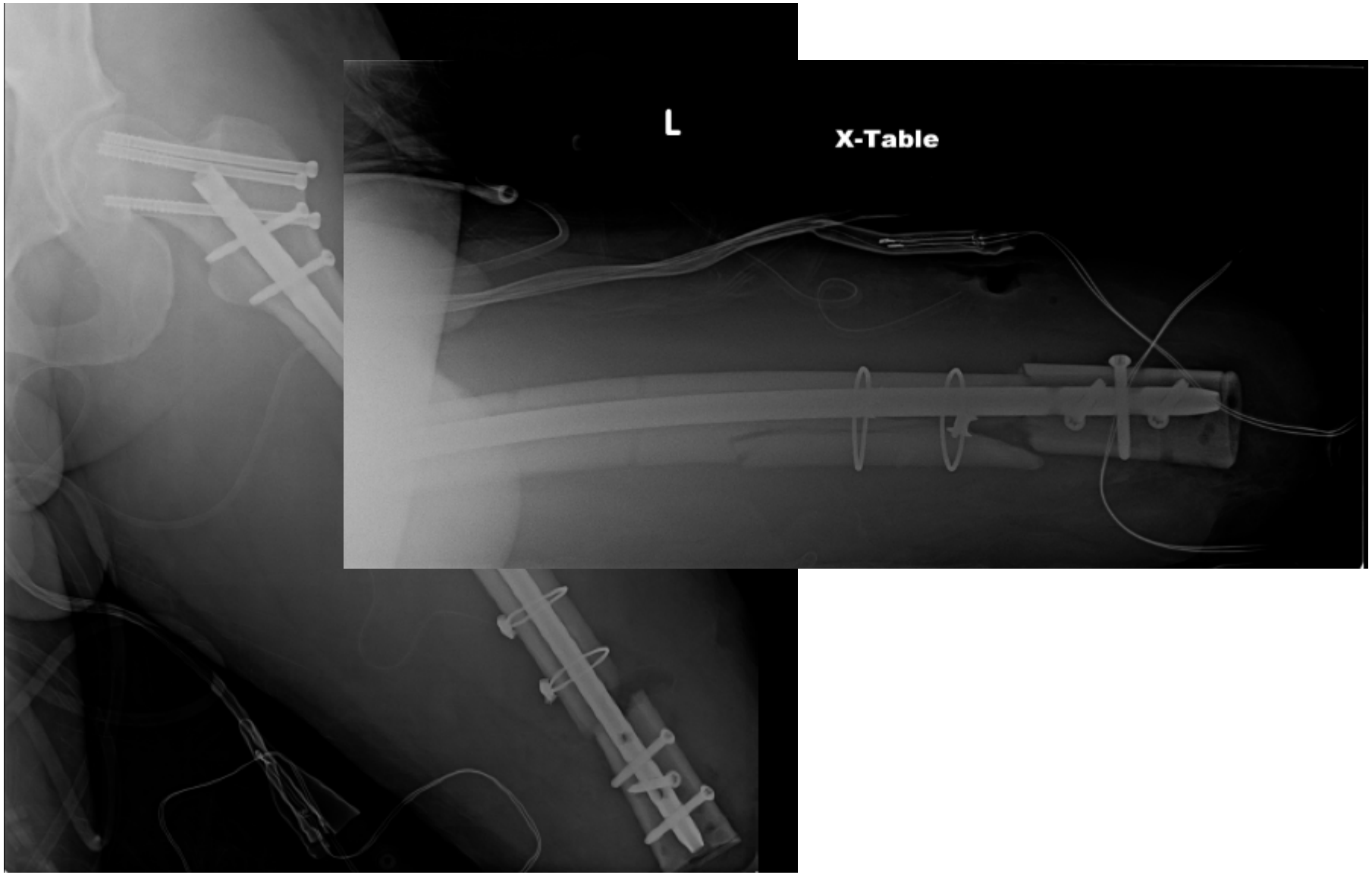
Case Example: Maintain length at all cost

- 32 y/o s/p MCC
- Left open tibial shaft fx
- Left open bicondylar tibial plateau fx
- Left open femoral shaft fx
- Left femoral neck fx
- Left clavicle fx
- Left ulna fx

Case Example



Case Example



Case Example

- Rides horses
- No residual pain

Hip Disarticulation

Indications

- Preservation of life
- Co-morbid pt with infection and sepsis
- Necrotizing fasciitis
- Non-ambulators (paraplegics)
- Advanced ischemic disease
- Tumor

Hip Disarticulation

- Problems
  - Wound management
  - Sitting balance
  - No prosthesis?
    - May choose not to wear
    - Use crutches anyway

Technique

- Lateral position
- Medial and lateral skin flaps
- Use muscles to fill dead space
- Wound complications

Hemipelvectomy

- Indications
  - Same as hip disarticulation
  - Tumor more common
  - More common in military recently
- Procedure of last resort
- Poor functional outcome

Technique

- Semi-lateral position
- Large posterior flap
- Keep as much of the hemi pelvis as possible for sitting balance

Complications

Amputation Site Breakdown

Early

- Delayed wound healing
  - Immunocompromised
  - Malnourished
  - Infection
- Marginal necrosis
  - Appropriate surgical technique
- 13% overall (20% BKA)

Amputation Site Breakdown

Late

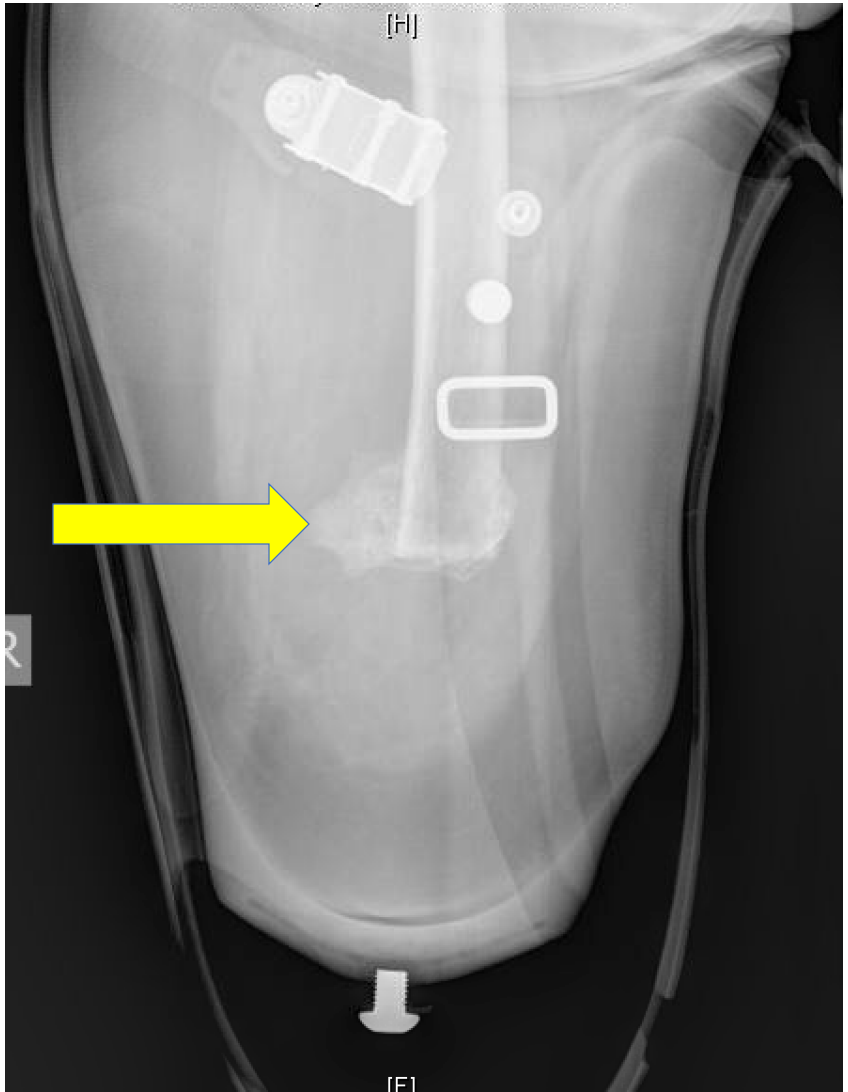
- Deep infection
  - Usually associated with PVD, DM
  - Trauma=34% rate
- Adherent skin
- Poor prosthetic fit

Infection

- Debridement
- Antibiotics
- Local wound care
- Secondary healing
  - Prolonged wound healing
- Revision amputation

Amputation Site Prominence

- Overgrowth
  - Traumatic
- Bone spur
- Muscle atrophy
- Failed myoplasty/myodesis
- Skin hypertrophy
- Bursitis
- Bulbous/floppy residual limb
  - Poor surgical technique



Amputation Site Prominence

Indications for Revision Amputation

- Poor prosthetic fit
- Limited function
- Pain
- Skin at risk

Neurological Complications

- Neuroma
  - 20-30% amputations
- Phantom limb pain
  - 53-100% of traumatic amputations

Neuroma

- All nerve transections form neuromas

- Painful
  - Positive Tinel’s

- Causes
  - Poor surgical technique
  - Scar formation
  - High pressure area

Neuroma

- Avoid
  - Nerve stump retracts into soft tissue away from scar and prominent areas
  - Can suture to muscle

- Management
  - Prosthetic adjustment
  - Injection
  - Scar massage
  - Surgical resection
    - Targeted muscle reinnervation

Phantom Limb Pain

- May be nonpainful

- Painful
  - Up to 85% in LE
  - ~40-69% in UE

Phantom Limb Pain

- Surgical
  - Dehydrogenated alcohol and marcaine into epineureum
- Non-surgical
  - Neurontin
    - Shown effective
  - Vitamin C?
  - Regional anesthetics perioperatively?

Joint Contracture

- Usually related to short lever arm
- Contracture release and tenolysis may be required if fixed deformity

Heterotopic Ossification/Bone Spur

- Associated with:
  - Severe trauma
  - Excessive manipulation of periosteum
  - Residual bone after osteotomy
- May require surgical resection if problematic
  - Recurrence of HO

Summary

- Several Indications for amputations
  - Consider your patient and all factors
- When possible, optimize your patient
- Preserve length is typically the correct answer
  - BKAs do better functionally than TMAs
  - Symes require less oxygen than TMAs
- Surgical technique is as important to complications as optimization

References

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